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DEPARTMENT OF DEFENSE STANDARD PRACTICE

ELECTRIC PLANT INSTALLATION STANDARD METHODS FOR SURFACE SHIPS AND SUBMARINES (CABLE)

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FOREWORD

1. This standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. This standard disseminates up-to-date information detailing requirements for standard installation methods for cable employed for submarine and surface ship electrical distribution systems.

3. These criteria are for application to new construction, conversion, and alteration of existing ships.

4. Comments, suggestions, or questions on this document should be addressed to Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy mil, with the subject line "Document Comment". Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla mil.

CONTENTS

PARAGRAPH PAGE

PARAGRAPH PAGE

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

FIGURE PAGE

1. SCOPE

1.1 Scope. This standard covers standard methods for cable preparation and end-sealing, entry to equipment and connectors, repair, and splicing.

1.1.1 Application. The installation methods in this document are intended to be used by all installing activities as required by contract, ship specifications, or similar implementing documents. These methods do not normally identify ship or type but do establish standards for cable installations in naval ships. The methods in this document are for new construction as well as for conversions, alterations, and repairs. It is the responsibility of the user activity to determine which method satisfies their requirements.

1.1.2 Cable specifications. Refer to the cable comparison handbook (MIL-HDBK-299) for guidance in substituting MIL-DTL-24643 cable for equivalent MIL-DTL-915 cable applications. All cable type designations specified herein, to be in accordance with MIL-DTL-24643, are preceded by the prefix "LS". The following cable types are in accordance with MIL-DTL-915 for use as outboard or portable applications and have no MIL-DTL-24643 equivalent:

DLT	TRF	MSPW	3PR-16
DSWS	TRXF	MSP	1Q-16
DSS	TSP	5SS	1TR-16
TSS	TSPA	TPUM	7SPR-16S
FSS	1SWF	1PR-A2OE	1SPR-16
7SS	2SWF	1PR-16	
JAS	MWF	7PR-16	
MCSF	S2S	2SPR-16	

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

COMMERCIAL ITEM DESCRIPTIONS

A-A-50552 - Fittings for Cable, Power, Electrical and Conduit, Metal, Flexible

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-915 - Cable, Electrical, for Shipboard Use, General Specification for

MIL-I-3064 - Insulation, Electrical, Plastic-Sealer

MIL-DTL-15659 - Terminal, Lug: Solder, Copper and Phosphor Bronze (see 4.5)

MIL-DTL-16036 - Switchgear, Power, Low Voltage, Naval Shipboard

MIL-T-16366 - Terminals, Electrical Lug and Conductor Splices, Crimp-Style

MIL-DTL-24640 - Cables, Lightweight, Low Smoke, Electric, for Shipboard Use, General Specification for

MIL-DTL-24643 - Cables, Electric, Low Smoke Halogen-Free, for Shipboard Use, General Specification for

MIL-DTL-24643/76 - Cable, Electrical, -20 °C to +105 °C, 5000 Volts, 133 Percent Rated, Type LS5KVTEPSG

MIL-DTL-32483 - Switchgear, Power, Hard-Mounted, Medium Voltage, Naval Shipboard

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-1310 - Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility, Electromagnetic Pulse (EMP) Mitigation, and Safety

MIL-STD-2003-4 - Electric Plant Installation Standard Methods for Surface Ships and Submarines (Cableways)

MIL-STD-2003-5 - Electric Plant Installation Standard Methods for Surface Ships and Submarines (Connectors)

MIL-STD-2042 - Fiber Optic Cable Topology Installation Standard Methods for Surface Ships and Submarines

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-299 - Cable Comparison Handbook, Data Pertaining to Electric Shipboard Cable

MIL-HDBK-454 - General Guidelines for Electronic Equipment

(Copies of these documents are available online at https://quicksearch.dla mil.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

S9086-KC-STM-010/300 - Naval Ships' Technical Manual Chapter 300, Electric Plant-General

S9300-A6-GYD-010 - Electrical Workmanship Inspection Guide for Surface Ships and Submarines

S9407-AB-HBK-010 - Handbook of Shipboard Electromagnetic Shielding Practices

SE000-01-IMB-010 - Navy Installation and Maintenance Book

T9070-AL-DPC-020/077-2 - NAVSEA Hazardous Material Avoidance Process

(Copies of these documents are available online via Technical Data Management Information System (TDMIS) at https://mercury.tdmis navy mil/ by searching for the document number without the suffix. Refer questions, inquiries, or problems to: DSN 296-0669, Commercial (805) 228-0669. These documents are available for ordering (hard copy) via the Naval Logistics Library at https://nll.navsup.navy.mil. For questions regarding the NLL, contact the NLL Customer Service at nllhelpdesk@navy mil, (866) 817-3130, or (215) 697-2626/DSN 442-2626.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

IEEE

IEEE 1637 - IEEE Guide to Select Terminations for Shielded Alternating-Current Power Cable Rated 5 kV - 46 kV

(Copies of this document are available online at www.ieee.org.)

NATIONAL AEROSPACE STANDARDS COMMITTEE (NA/NAS)

NASM77072 - Terminal, Lug, Solder Type, Phosphor Bronze Stamping, Locking Type, Flat, One Hole

NASM77073 - Terminal, Lug, Solder Type, Phosphor Bronze Stamping, Locking Type Flat, One Hole

(Copies of these documents are available online at www.aia-aerospace.org.)

SAE INTERNATIONAL

SAE-AS7928/1 - Terminals, Lug and Splices, Conductor, Crimp Style, Copper Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, for Thin Wall Wire, Type II Class 1 for 105 °C Total Conductor Temperature

SAE-AS7928/7 - Terminal Lug and Splices, Conductor, Crimp Style, Copper, Terminal Lug, Crimp Style, Copper, Uninsulated, Ring Tongue Type I, Class 1 for 175 °C Total Conductor Temperature

(Copies of these documents are available online at www.sae.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Cable repair. Cable repair refers to restoration of only the cable armor or the outermost cable sheath or, when specifically formally approved by NAVSEA, repair of insulation directly over conductors (see 4.1.12).

3.2 Flooding water levels and V-line. The definitions of flooding water levels and V-line, including flooding water level II (FWL-II), are in applicable ship specifications.

4. GENERAL REQUIREMENTS

4.1 Cable.

4.1.1 Cable slack. Where cables enter electrical equipment, a minimum of two inches of slack cable shall be provided in the cableway, permitting repairs to be made at the cable ends, avoiding cable replacement. Cable conductors shall also have two inches of slack inside the enclosure.

4.1.2 Supporting cables entering enclosures. Cables entering enclosures shall be secured in accordance with MIL-STD-2003-4. Cable bend radius shall not be less than allowed in 4.1.3.

4.1.3 Cable bend radius. Cable bend radius shall be in accordance with MIL-STD-2003-4.

4.1.4 Box connectors, electrical. Junction box or outlet connectors shall be in accordance with A-A-50552 type, class, and style listed or other connector as approved by NAVSEA.

a. Straight connector for single round cable type 1, class 1, style A.

b. Straight connector for duplex round cable type 1, class 1, style B.

c. 45-degree angle connector for single round cable type 1, class 1, style C.

d. 90-degree angle connector for single round cable type 1, class 1, style D.

4.1.5 Cable connection. Changes in conductor size other than at switchboards or panels shall be made by use of electrical enclosures, terminal boxes, or other equipment specified herein or on standard drawings. At the point of connection, the separation of conductors and the removal of sheathing shall be in accordance with the requirements specified herein and shall be kept to a minimum. On parallel cable runs, the length of sheath removed from each cable shall be equal.

4.1.6 Watertight cables. Surface ship cables terminating at the following equipment, located below FWL-II (see 3.2), shall be watertight. The watertightness of submarine new or replacement cables shall be in accordance with applicable ship specifications or NAVSEA-approved ship or class drawings. There are two acceptable methods for achieving watertightness of cables: installation of cables qualified to the watertightness requirements of MIL-DTL-24640 or MIL-DTL-24643 or end-sealing of cables in accordance with NAVSEA-approved drawings or methods in Appendix 1A.

a. Power and lighting switchboards (includes ship service, emergency, and load center switchboards).

b. Manual and automatic bus transfer equipment (whether mounted on a switchboard or panel or as an independent unit).

c. Distribution power and lighting panels supplied from two sources of power.

d. Degaussing switchboards, control panels, and power supplies except where they supply power to only one degaussing coil.

e. Watertight interior communication and weapons control equipment, including switchboards, control panels, and connection boxes, where water seepage into the unit would jeopardize undamaged operable portions of the system.

f. Top entrance cable to interior communication and weapons control switchboards of other than watertight construction.

g. In minesweepers only, degaussing.

h. Degaussing connection and through boxes having connections for more than one degaussing coil.

4.1.6.1 Watertight versus end-sealed cables. Watertight cables shall meet the watertight requirements of MIL-DTL-24640 or MIL-DTL-24643. For any new cable installation, use of watertight cables is the preferred method and shall be used unless end-sealing is approved for use by NAVSEA.

4.1.6.2 Watertight cable exceptions. Surface ship cables terminating at equipment designated need not be watertight where one or more of the following conditions apply:

a. Flexible cables to rotating structures.

b. Cables which do not pass through a watertight deck or bulkhead.

c. Cables which penetrate FWL-II but do not pass through a watertight deck or bulkhead below FWL-II (see 3.2).

d. Where water seepage into a unit of an interior communication or weapons control system through a damaged cable would result in no loss of function beyond that already sustained due to cable casualty.

e. In interior communication systems and weapons control systems.

f. Two-, three-, and four-conductor cable of size 9 and smaller for electronic, communication, and instrumentation applications.

4.1.7 Cable lead terminations. A cable lead termination shall be installed on each connected conductor.

4.1.7.1 Cable conductor lugs. Unless the cable leads are terminated by a connector or a mechanical connection, lugs shall be used to terminate cable leads. Lugs shall conform to MIL-T-16366 (solderless type), SAE-AS7928/1 (insulated barrel solderless type), SAE-AS7928/7 (uninsulated barrel solderless type), NASM 77072 (solder type), NASM 77073 (solder type), or MIL-DTL-15659 (solder type, see 4.5). Two-hole lug terminals should be used where there is a possibility of the lug turning or making contact with an adjacent lug. Lugs with holes in the crimp area may be used to allow for inspection that conductor has been properly inserted in the lug prior to crimping.

4.1.7.1.1 Solderless type lugs. Solderless type lugs shall be used for all lug applications except for equipment having requirements for solder type lugs or in specified electrical enclosures for which electrical clearances would be reduced below minimum standards by the use of solderless type lugs.

4.1.7.1.2 Plating of lugs. Unless approved by NAVSEA or shown on class specific drawings, cable lug contact surfaces shall be tin-plated or silver-plated over the entire conducting surface per the requirements of MIL-T-16366; the plating shall be tin for size 9 (9,000 circular mils) and smaller lugs. For high temperature applications, the plating shall be silver, regardless of connector size. When drilling holes in a lug is necessary, the drilling shall be done in a manner to avoid removing plating from the conducting surfaces.

4.1.7.1.3 Lugs for connecting to smaller component terminals. For connecting to smaller electrical terminals in components such as toggle switches, service receptacles, and light fixtures where terminal screws are captured such that through-hole lugs cannot be used, Thomas & Betts (now ABB), or equal (see 4.2), hook lugs and locking fork lugs that are compatible with the wire size may be used. For this application, connecting to terminal holes is not allowed.

4.1.7.2 Termination by connectors. For termination of cable conductors using connectors, see MIL-STD-2003-5.

4.1.7.3 Mechanical connections. Examples of conductor mechanical connections are applicable circuit breaker connections, threaded stud type cable terminals, split bolt terminals, main bus terminals in fuse boxes, and screw clamp terminals.

4.1.7.3.1 Solid conductor mechanical connections. Solid conductors may be directly attached to the mechanical connection for non-watertight applications or for connections to watertight cable (see 4.1.6).

4.1.7.3.2 Stranded conductor mechanical connections. For non-watertight application or for connections to watertight cable, stranded conductors intended for mechanical connections shall be terminated with ferrules unless the use of the ferrule will interfere with the ability to make the mechanical connection due to the resulting diameter of the conductor with the ferrule attached. Ferrules are used with stranded conductor wire to better contain the strands and prevent damage. Care should be taken to ensure that wire strands do not break during the termination and connection process. Ferrules are not required for conductors with area greater than 9,000 circular mils. The methods for applying the ferrules are shown in figure 1A20.

4.1.7.3.3 Mechanical connections for watertight applications. For watertight mechanical connections where new cable is to be installed, the new cable shall be watertight in accordance with 4.1.6. This requirement applies to ship new construction and to ship maintenance actions. For servicing, such as repairs or modifications, on mechanical connections to non-watertight cable, thimbles may be used as an alternative to cable replacement with approval from the Supervisor or by NAVSEA. For existing nuclear applications, NAVSEA 08 shall be contacted prior to making any changes to electrical connections with thimbles. When approved, installation of thimbles shall be in accordance with the methods in figure 1A22.

4.1.7.3.4 Use of insulating caps (wire nuts). For lighting and other low power system components, including fixtures, connection boxes, branch boxes, door switches, small appliances, and small motors with power rating less than 1 horsepower that are used for housekeeping, food service, laundry, and shop equipment, insulating caps (wire nuts) may be used instead of terminal board connections for 120 and 450 VAC systems where conductor size does not exceed 10 AWG. Wire nuts shall not be used in place of terminal board connections for Navy nuclear reactor plant, steam plant, or electric plant systems.

4.1.8 Cable entrance to machinery and equipment. Cable entry into non-watertight equipment shall be through the bottom or lower half of the side unless otherwise approved by NAVSEA. Non-watertight cable entry into non-watertight equipment, other than through the bottom or the side (if approved), shall have a drip loop or plastic sealer to prevent entry of water into the enclosure. Cables shall enter watertight equipment in locations best suited to disposition of the cable installation. Sufficient slack shall be allowed for cable connection to machinery to prevent damage to cables, due to vibration or shock, at locations where the cables pass from the structure of the ship to the machinery. Entry of cables into enclosures shall conform to the following:

a. Splashproof, spraytight, watertight submersible, and explosion-proof enclosures. Through stuffing tubes or approved multiple-cable penetrations for enclosures. Stuffing tubes may be of plastic types in place of metal types except when used with explosion-proof and submersible (over 50-foot depth) enclosures, or when the cable shielding requirements of MIL-STD-1310 apply.

b. All other types of enclosures. By specified cable clamp (see 4.1.4). Cable clamp shall be sealed with MIL-I-3064, Type HF, insulation, electrical, plastic-sealer to prevent entry of water dripping from above.

c. Cable entry into permanently mounted or portable enclosures of molded plastic or composite materials shall be by insulating type clamp or nylon stuffing tubes. Metallic type clamps shall not be used. See additional requirements on figures 1B3 and 1B4.

d. Cables entering propulsion system equipment from above or from the sides shall enter through stuffing tubes and shall be braced and secured to prevent dislodgment under vibration and shock stresses.

4.1.9 Cable entrance to switchboards. Switchboards designed in accordance with MIL-DTL-16036 and MIL-DTL-32483 provide for bringing cables in from either top or bottom or both as specified. The cable armor (when present), jacket, and shield shall be stripped to individual conductors to form a loop at each end of the wiring trunk to provide adequate flexibility and to meet the requirements for bending radius. Where the cable runs are very short and the use of two- or three-conductor cables is not practicable, single conductor cable may be used but the conductors shall be grouped together (triad arrangement for 3-phase circuits) for the entire run. A drip-proof (approximately no. 16 gauge) sheet steel enclosure shall be provided that will permit community entrance of the cables into the section enclosure. Weight of cable supported by the top of the switchboard structure shall be kept to a minimum. If the entire wiring trunk is enclosed, louvers shall be provided for ventilation, and provisions shall be made so that movement of the switchboard sections in any direction is not restricted by cables or the wiring track (see figure 1B1). Connections of ship cables to switchboards shall be made so that when any switchboard section is caused to move with respect to the ship structure, the inherent flexibility of the connecting cables will permit movement of the section in any direction without subjecting lug connections or cables to stress. Cable connections shall be so made that insulation distances within the switchboard are not reduced below the values required by MIL-DTL-16036 or MIL-DTL-32483. Where armored cable use is permitted, the armor shall be removed from that portion of all cables which are within the switchboard structure. See figure 1B1 for additional requirements for securing power cables in switchboards.

4.1.10 Cable connection to machinery and equipment. Sufficient slack shall be allowed to prevent damage to cables, due to vibration or shock, at locations where the cables pass from the structure of the ship to the machinery and equipment.

4.1.10.1 Cables connected to equipment and machinery provided with resilient mounts. Cables connected to equipment and machinery provided with resilient mounts shall have a minimum length between the equipment and the last point of support of the cable of 18 inches with sufficient slack to provide for flexibility and movement of the equipment under shock; sufficient slack shall be greater than or equal to the equipment's range of motion at the point of cable entry into the equipment (at least three inches of slack).

4.1.11 Cable splicing. Cables identified on figure 1E1 shall not be spliced without prior written approval from NAVSEA. Antenna system cables may be spliced where specific approval is requested and received on a case-by-case basis from NAVSEA. Other cables shall only be spliced for repair after the cognizant government technical authority has determined that the time and cost of replacing an existing cable with a new cable is excessive, that the existing cable is in good mechanical and electrical condition and that no more than one splice in the cable presently exists (i.e., when the repair is complete, there shall be a maximum of two splices in the cable). The preferred method of splicing MIL-DTL-915, MIL-DTL-24640, and MIL-DTL-24643 cable is to use heat-shrink technology as shown on figures 1E1, 1E2, and 1E3. The older splicing technology of tape wrap and poured epoxy molds shown in DOD-STD-2003-1, dated 24 June 1987, may still be used for polyethylene jacketed cables. Because of high temperature requirements placed on cables identified on figures 1E4 and 1E5, special taping methods are retained for these cables (refer to S9086-KC-STM-010/300).

4.1.11.1 Cable splicing for surface ship new construction modular construction. When surface ship modular construction techniques are used for ship construction, cable splicing is allowed at the modular construction boundaries. All requirements in 4.1.11 and Appendix 1E apply for modular construction splices. This includes the limitations on the cable applications where splicing is allowed and the limit of two splices per cable, including modular construction and repair splices. Cables that transit module boundaries shall be provided with sufficient length to enter adjacent modules and to support splicing. For best results, the ship cableway design should support the modular construction splicing method. The Supervisor shall review the splice procedure and shall inspect the splice after completion.

4.1.12 Cable repair. All Navy cables that are in good mechanical and electrical condition may be repaired except the following:

a. Cables for repeated flexing service.

b. Portable cable (shore power cables may be repaired).

c. DC bus tie cable on nuclear submarines.

d. Reactor plant system cable.

Cable jacket repair where conductor is not exposed is allowed in accordance with Appendix 1D, figures 1D1-1D6. Cable repair with conductor exposed requires prior formal NAVSEA approval and shall be in accordance with Appendix 1D, figure 1D7. The approval submittal to NAVSEA for cable repair versus replacement when conductor is exposed shall include objective evidence that the conductor is completely intact and the specific benefit to the Government of cable repair versus replacement.

Any repair of cable rated 5 kilovolts or greater requires NAVSEA approval.

4.1.13 Protection during welding or hot work. Cables in close proximity to welding or hot work shall be properly protected to ensure they are not damaged.

4.1.14 Flexing service cable segments. Flexing service cable shall be selected from MIL-HDBK-299. However, in some cases, commercial cable segments may need to be substituted close to the flexing site to meet lifetime cycling requirements. For these cases, the length of commercial cable shall be minimized to ensure that military cable, health, safety, and survivability requirements are met to the maximum practical extent. NAVSEA approval shall be obtained for any use of commercial cable segments for flexing cable service.

4.1.15 Cable insulation resistance testing. After cable replacement, repair, or splicing, the cable shall be insulation resistance tested in accordance with the methods in S9086-KC-STM-010/300. Acceptance criteria shall be in accordance with S9086-KC-STM-010/300. To ensure that satisfactory cable is being installed, the replacement cable may be insulation resistance tested in accordance with the methods in S9086-KC-STM-010/300 prior to cable replacement. The acceptance criteria should be the same as in the corresponding cable military specification.

4.2 Or equal. MIL-STD-2003 uses the terms “or equal” to permit the use of parts, components, or tools that are equivalent and can perform the same function as the specified products. The use of the equivalent product is allowed as long as the same functional characteristics, performance, equipment safety, personnel safety, suitability for marine service, life cycle cost, maintenance cost, and supportability are attained, and agreement is obtained from NAVSEA. The request for agreement for the use of “equal” products shall include data that supports that functional and performance equivalence is retained.

4.3 Consideration of electromagnetic shielding. For cable installations where electromagnetic shielding is required to be considered, the shielding practices of S9407-AB-HBK-010 shall be used.

4.4 Cable selection. Cables should be selected based on the guidance of MIL-HDBK-299. Cables used for interior ship applications shall be of the low smoke design in accordance with MIL-DTL-24643 and MIL-DTL-24640.

4.5 Inactive for new design documents. Some of the documents referenced in MIL-STD-2003-1 have been declared as inactive for new design by decision of the Department of Defense. Where replacement documents are designated, the replacement document is normally substituted for the inactive for new design document. Methods that reference inactive for new design documents shall not be used for new ship design unless approved by NAVSEA. Components and products produced in accordance with the inactive for new design documents shall not be used for new design of systems or equipment; however, this does not prohibit use for maintenance, repair, or resupply purposes.

4.6 Installation of fiber optic cables. Installation of fiber optic cables and blown fiber cables shall be in accordance with requirements of MIL-STD-2042 and this standard. For fiber optic cable installation, if there are conflicts between this standard and MIL-STD-2042, the requirements of MIL-STD-2042 take precedence.

4.7 Avoiding sharp edges. Tools for cutting plastic and metal cable wraps as part of wrapping cables should be selected to prevent sharp edges that could result in personnel injury and damage to equipment and cables.

4.8 Requirements for installation of cables associated with higher voltage systems. Due to physical and performance differences between higher voltage rated cables (5 kilovolts and greater) and lower voltage rated cables (less than 5 kilovolts), installation of higher voltage cables requires precautions in addition to the methods in this standard. The following requirements apply to the installation of higher voltage rated cables:

a. Installation instructions in the applicable ship drawings and in applicable ship specifications shall be followed.

b. The partial discharge (corona) inception voltage (CIV) and partial discharge (corona) extinction voltage (CEV) as defined in MIL-HDBK-454 shall not be reduced or degraded by cable installation.

c. IEEE 1637 should be consulted for methods for selecting terminations for shielded AC power cables to limit partial discharge. Termination methods, such as stress cones, may be necessary to limit partial discharge at the point of cable connection.

d. Proper cable type selection should be considered to limit the effect on the cable of partial discharge and the effect of complex waveforms from the power system. For example, the semiconductor tape layer required in MIL-DTL-24643/76 for type LS5KVTEPSG cable serves to control the partial discharge.

e. Cable grouping requirements of MIL-STD-2003-4 should be met to ensure cables operate within temperature and current limits.

f. Figures 1D9 and 1E6 include methods for insulation repair and splicing of higher voltage cables.

g. Figure 4C63, “Installation of medium and high voltage cableways”, of Appendix 4C of MIL-STD-2003-4 provides guidance for installation of higher voltage cables in cableways.

4.9 Workmanship and inspection guidance. For workmanship and inspection guidance associated with cable installation, see S9300-A6-GYD-010. For any conflict between this standard and S9300-A6-GYD-010, the requirements of this standard take precedence.

4.10 Installation of cables for electronic equipment. For guidance on installation of cables for electronic equipment, see SE000-01-IMB-010. For any conflict between this standard and SE000-01-IMB-010, the requirements of this standard take precedence.

4.11 Cable and conductor shielding. To ensure proper electromagnetic compatibility, cable and conductor shield installation shall meet the requirements of MIL-STD-1310. For any conflict between this standard and MIL-STD-1310, the requirements of MIL-STD-1310 take precedence.

4.12 Hazardous materials. Materials and products utilized to execute installation methods in this standard should avoid chemicals listed on the NAVSEA List of Targeted Chemicals (N-LTC) contained within T9070-AL-DPC-020/077-2. These chemicals pose significant risk to the user, environment, or both, and are deemed both undesirable and unsustainable by NAVSEA. NAVSEA is minimizing the use of hazardous materials in procedures such as those covered by this standard. Alternative materials should be considered for applications covered in this document to minimize the use of targeted chemicals. NAVSEA should be informed of the need for the use of any of the targeted chemicals prior to procedure execution.

4.13 The terms agreement or approval. Wherever such terms as “approved” or “agreement” are used without further qualification, it is the approval or agreement of the Supervising Authority or NAVSEA, as applicable, that is intended. In these cases, the approval request and the response shall be formal, in writing, and traceable. Existing methods allowed by applicable ship specifications, such as departures from specifications, are acceptable. The Supervising Authority, also referred to as the Supervisor, is defined in the applicable ship specifications.

5. DETAILED REQUIREMENTS

(See figures.)

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard specifies the requirements for cable preparation and end-sealing, cable entry to equipment, cable entry to connectors, cable repair, and cable splicing methods to be employed both on surface ships and submarines. Standard methods identified for electric plant installation are intended for new construction, conversion, and alteration of existing ships. The use of this standard will be specified in the contract, ship specifications, and similar implementing documents (such as COMUSFLTFORCOMINST 4790.3, Joint Fleet Maintenance Manual (JFMM) and S9086-KC-STM-010/300, Naval Ships' Technical Manual Chapter 300, Electric Plant-General).

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this standard.

6.3 Designation of electric plant installation standard methods figures. The electric plant installation standard method MIL-STD-2003-1 contains figures that depict standard methods that are applicable for general electric plant installation on both surface ships and submarines. The methods shown on the figures are grouped together in the following appendices to this standard. Each appendix provides requirements for similar functions.

MIL-STD-2003-1 (Cables)

A. Cable Preparation and End-Sealing (Appendix 1A)

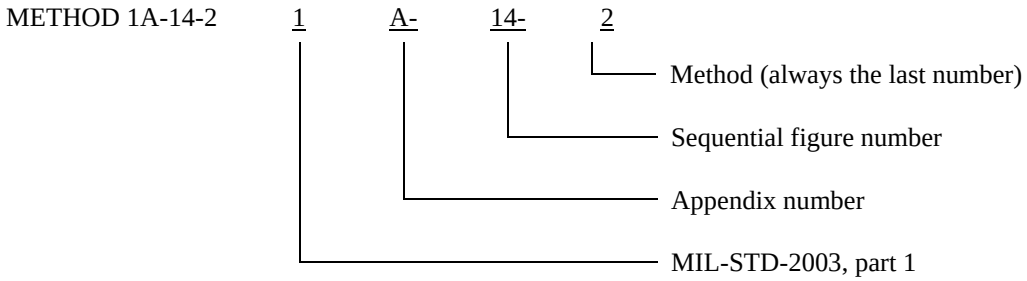
B. Cable Entry to Equipment (Appendix 1B)

C. Protection of Topside Connectors (Appendix 1C)

D. Repair of Damaged Cable (Appendix 1D)

E. Cable Splicing (Appendix 1E)

The methods shown on the figures are identified by the following alphanumeric designation system:



Thus, method 1A-14-2 identifies method 2, sequential number 14 in Appendix 1A of MIL-STD-2003-1.

6.4 Subject term (key word) listing.

Cable bend radius
Cable insulation resistance test
Cable lead termination
Cable preparation
Cable repair
Cable selection
Cable splicing
Connectors
Crimp
Electromagnetic shielding

End sealing
Equipment entry
Ferrules
Fiber optic cables
Flexing cables
Higher voltage cable
Lugs
Medium voltage cable
Solder
Solderless
Strapping
Thimbles
Topside connectors
Watertight
Workmanship and inspection

6.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

APPENDIX 1A – CABLE PREPARATION AND END-SEALING

A.1 SCOPE

A.1.1 Scope. This appendix describes procedures for cable end preparation and end-sealing. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

A.2 APPLICABLE DOCUMENTS

A.2.1 General. The documents listed in this section are specified in this appendix. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in this appendix, whether or not they are listed.

A.2.2 Government documents.

A.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

COMMERCIAL ITEM DESCRIPTIONS

A-A-208	-	Ink, Marking, Stencil, Opaque (Porous and Non-Porous Surfaces)
A-A-3097	-	Adhesives, Cyanoacrylate, Rapid Room Temperature-Curing, Solventless
A-A-59770	-	Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-915	-	Cable, Electrical, for Shipboard Use, General Specification for
MIL-Y-1140	-	Yarn, Cord, Sleeving, Cloth, and Tape-Glass
MIL-I-3064	-	Insulation, Electrical, Plastic-Sealer
MIL-I-3158	-	Insulation Tape, Electrical Glass-Fiber (Resin-Filled): and Cord, Fibrous-Glass
MIL-I-3190	-	Insulation Sleeving, Electrical, Flexible, Coated, General Specification for
MIL-I-3190/6	-	Insulation Sleeving, Electrical, Flexible, Coated, Class 200, Type D, Category C
MIL-T-16366	-	Terminals, Electrical Lug and Conductor Splices, Crimp-Style
MIL-PRF-17695	-	Insulation Tape, Electrical, Filler Type, Flameproof, Synthetic
MIL-I-19166	-	Insulation Tape, Electrical, High-Temperature, Glass Fiber, Pressure-Sensitive
MIL-I-24092	-	Insulating Varnishes and Solventless Resins for Application by the Dip Process
MIL-S-24235/7	-	Stuffing Tubes, Metal, and Packing Assemblies for Electric Cables, for Cast Enclosures, Pressureproof
MIL-S-24235/8	-	Stuffing Tubes, Metal, and Packing Assemblies for Electric Cables, for Sheet Metal Enclosures, Pressureproof
MIL-I-24391	-	Insulation Tape, Electrical, Plastic, Pressure-Sensitive
MIL-DTL-24640	-	Cables, Lightweight, Low Smoke, Electric, for Shipboard Use, General Specification for

MIL-DTL-24643 - Cables, Electric, Low Smoke Halogen-Free, for Shipboard Use, General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202 - Electronic and Electrical Component Parts

MIL-STD-2003-3 - Electric Plant Installation Standard Methods for Surface Ships and Submarines (Penetrations)

MIL-STD-2003-4 - Electric Plant Installation Standard Methods for Surface Ships and Submarines (Cableways)

(Copies of these documents are available online at https://quicksearch.dla.mil/.)

A.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM D4388 - Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes

ASTM F1836M - Standard Specification for Stuffing Tubes, Nylon, and Packing Assemblies (Metric)

(Copies of these documents are available online at www.astm.org.)

IPC

J-STD-006 - Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications

(Copies of this document are available online at www.ipc.org.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA HP 8 - Electrical and Electronic Cross-Linked, Modified Low-Smoke Polyolefin (XLPO) Insulated Hook-Up Wire, Types LS (rated 105°C; 600 V), ZHDM (rated 90°C; 600 V), ZHDH (rated 90°C; 600 V), ZH (rated 125°C; 600 V), and ZHX (rated 125°C; 1000 V)

(Copies of this document are available online at www nema.org.)

SAE INTERNATIONAL

SAE-AMS3573 - Resin, Polyurethane (EU) Casting Polyether-Type, Flexible, Solid Low-Temperature Resistant, 80 to 90

SAE-AS7928 - Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification for

SAE-AS21608 - Ferrule, Shield Terminating, Crimp Style

SAE-AS23053/4 - Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin 1/, Dual-Wall, Outer Wall Crosslinked

SAE-AS23053/5 - Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked

SAE-AS23053/15	-	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked
SAE-AS81765/1	-	Insulating Components, Molded, Electrical, Heat Shrinkable Polyolefin, Crosslinked, Semi-Rigid and Flexible
SAE-AS83519	-	Shield Termination, Solder Style, Insulated, Heat-Shrinkable, Environment Resistant, General Specification for

(Copies of these documents are available online at www.sae.org.)

A.2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

A.3 REQUIRED EQUIPMENT AND MATERIALS

A.3.1 Required equipment and materials. The required equipment and materials shall be as specified in each method.

A.4 NOTES AND PROCEDURES

A.4.1 Dimensions. For figures and tables in this appendix, all dimensions are in inches unless otherwise noted.

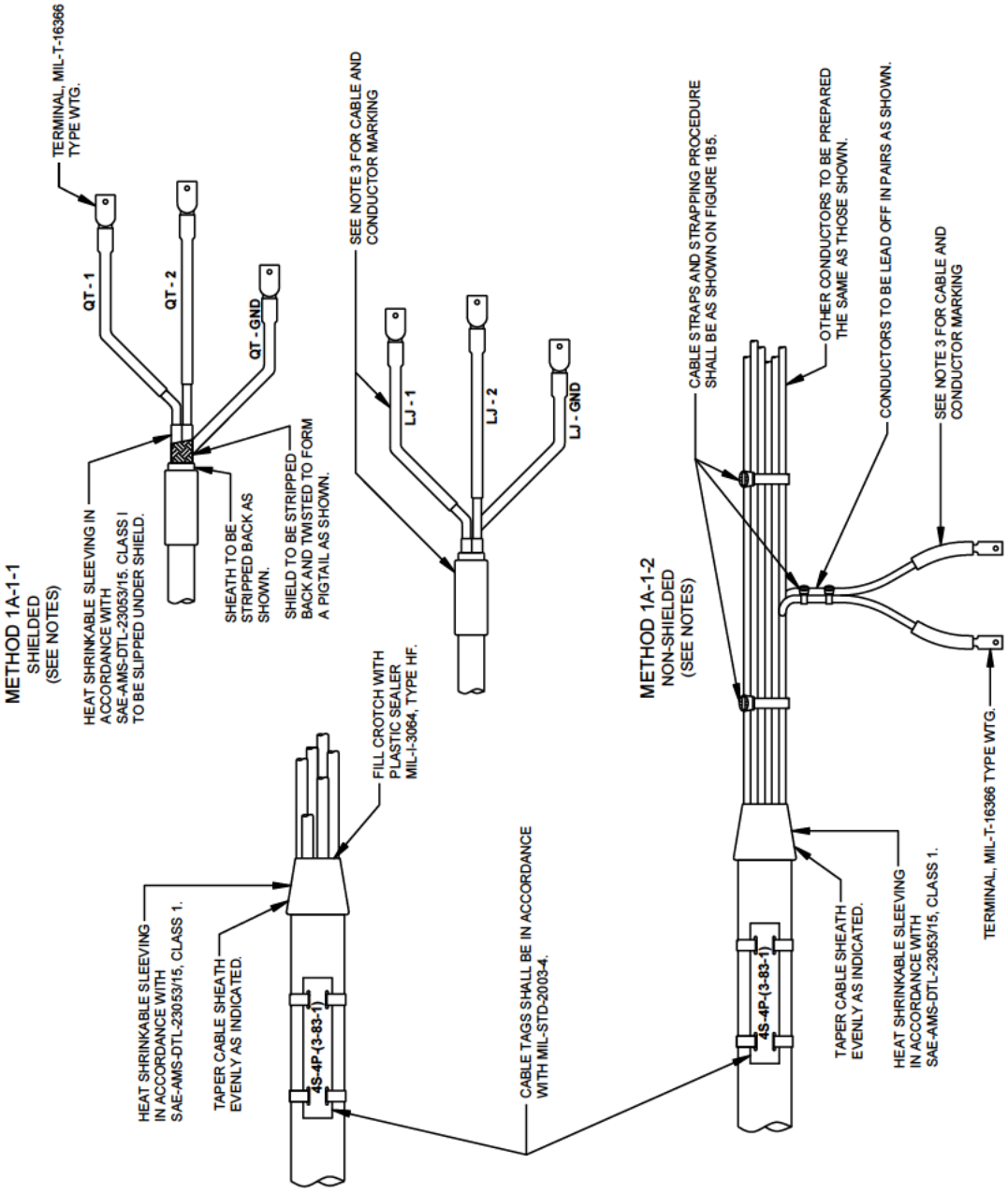
A.4.2 Figures. Table 1AI provides information for the figures in this appendix.

TABLE 1AI. Figures for cable preparation and end-sealing.

Figure number	Cable preparation and end-sealing	Page
1A1	Cable end preparation for open equipment (This method for guidance and use only when non-watertight cable has been approved for use by NAVSEA.)	16
1A2	Cable end preparation for open equipment (This method for guidance and use only when non-watertight cable has been approved for use by NAVSEA.)	17
1A3	Cable end preparation for enclosed equipment (This method for guidance and use only when non-watertight cable has been approved for use by NAVSEA.)	19
1A4	Cable end preparation for non-watertight equipment (This method for guidance and use only when non-watertight cable has been approved for use by NAVSEA.)	21
1A5	Attachment of solderless lugs to cables	24
1A6	Cable end-sealing with heat-shrinkable cable crotch boots (This method for guidance and use only when non-watertight cable has been approved for use by NAVSEA.)	26
1A7	Cable end-sealing with heat-shrinkable tubing (This method for guidance and use only when non-watertight cable has been approved for use by NAVSEA.)	29
1A8	Cable conductor end-sealing (This method for guidance and use only when non-watertight cable has been approved for use by NAVSEA.)	32

TABLE 1AI. Figures for cable preparation and end-sealing – Continued.

Figure number	Cable preparation and end-sealing	Page
1A9	Cable end-sealing with heat-shrinkable tubing and end caps for disconnected, deactivated, and unused cables	34
1A10	Cable end-sealing when exposed to weather	36
1A11	Cable end-sealing when exposed to weather	38
1A12	Cable end-sealing when exposed to weather	40
1A13	Cable end-sealing – disconnected and stored cable	41
1A14	Cable end-sealing for inboard pressure-proof installations on submarines	43
1A15	Cable end-sealing for inboard pressure-proof installations on submarines	45
1A16	End-sealing cables in coils or reels in covered stowage not subject to entrance of water	47
1A17	Grounding of shields of multiple conductor cables	48
1A18	Grounding of shields of multiple conductor cables	55
1A19	End preparation of position indicator type cables	65
1A20	Cable end preparation – screw clamp terminals (ferrules)	70
1A21	Cable end preparation for cables with wound conductor insulation	74
1A22	Installation of thimbles for mechanical end connections for end sealing	75



NOTES:

1. These methods cover protection and finish of cable ends entering open equipment (non-watertight cables without packing or end seals).
2. This method is for guidance and use only when non-watertight cable has been approved for use by NAVSEA.
3. See MIL-STD-2003-4 for cable and conductor wire marking requirements.

FIGURE 1A1. Cable end preparation for open equipment.

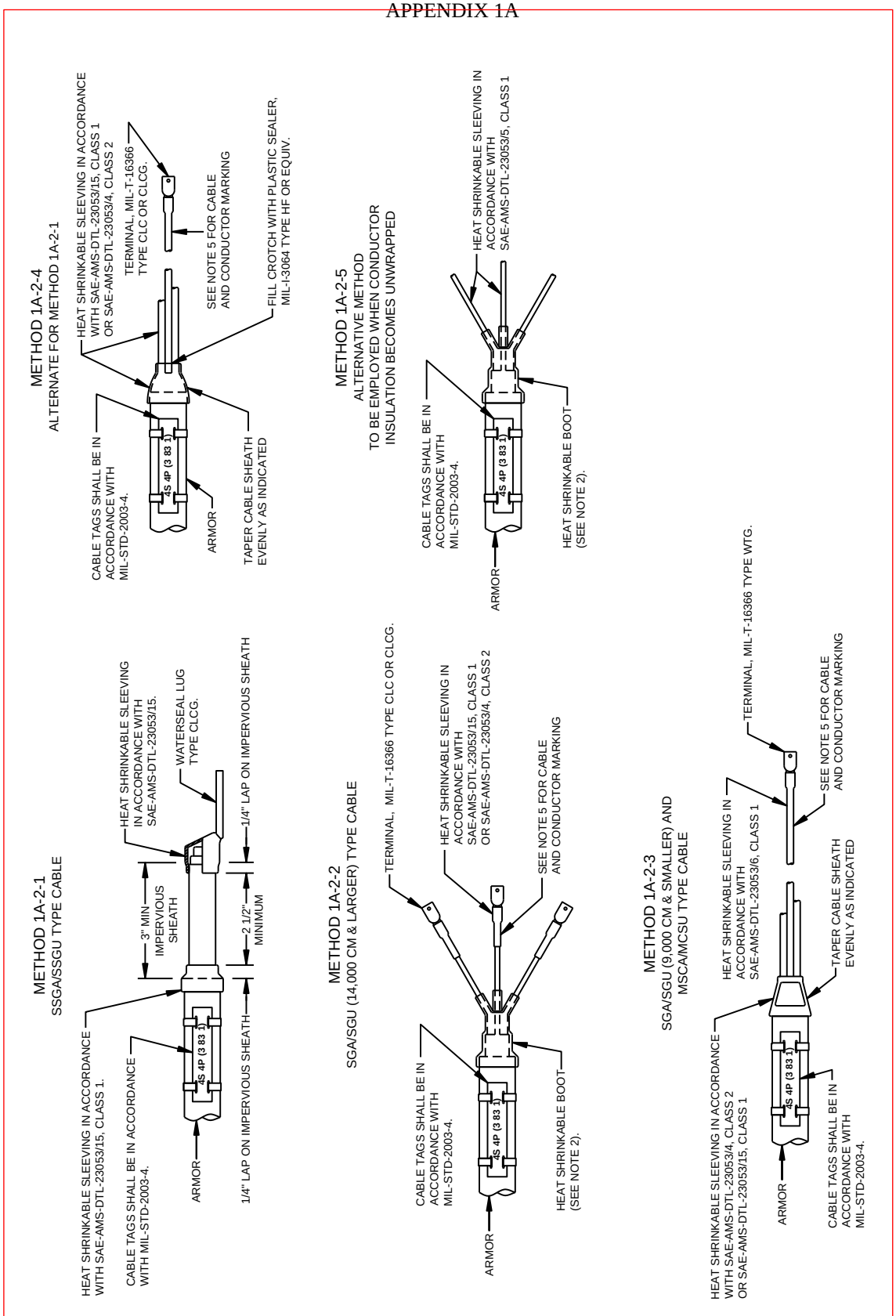
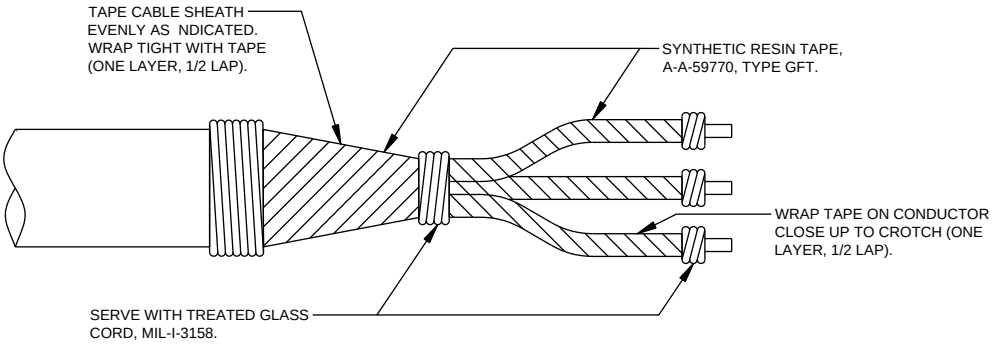
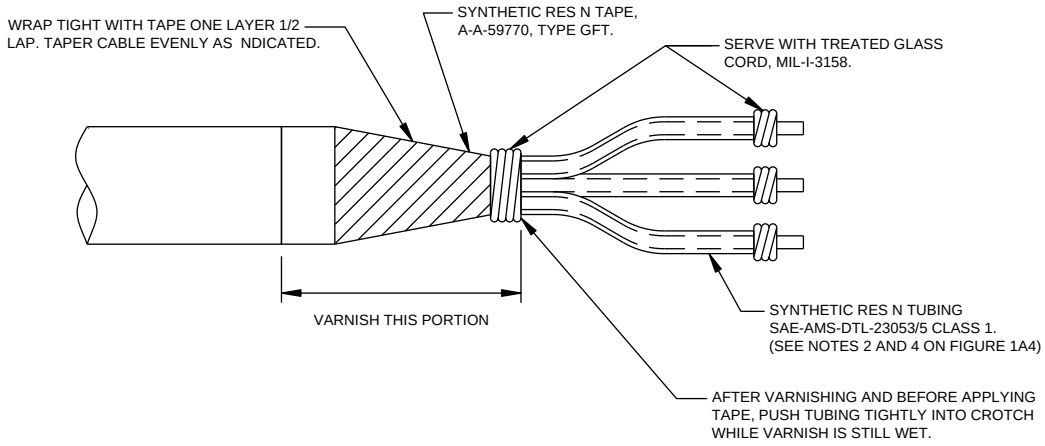


FIGURE 1A2. Cable end preparation for open equipment.

METHOD 1A-2-6
OPEN EQUIPMENT TAPE METHOD
(SEE NOTE 3)



METHOD 1A-2-7
OPEN EQU PMENT TAPE AND TUBING METHOD
(SEE NOTE 3)



NOTES:

1. These methods cover protection and finish of cable ends entering open equipment (watertight cables without packing).
2. Heat-shrinkable boots shall be as specified on figure 1A6 for end-sealing.
3. Methods 1A-2-6 and 1A-2-7 shall be used for cable ends inside equipment.
4. This method is for guidance and use only when non-watertight cable has been approved for use by NAVSEA.
5. See MIL-STD-2003-4 for cable and conductor wire marking requirements.

FIGURE 1A2. Cable end preparation for open equipment – Continued.

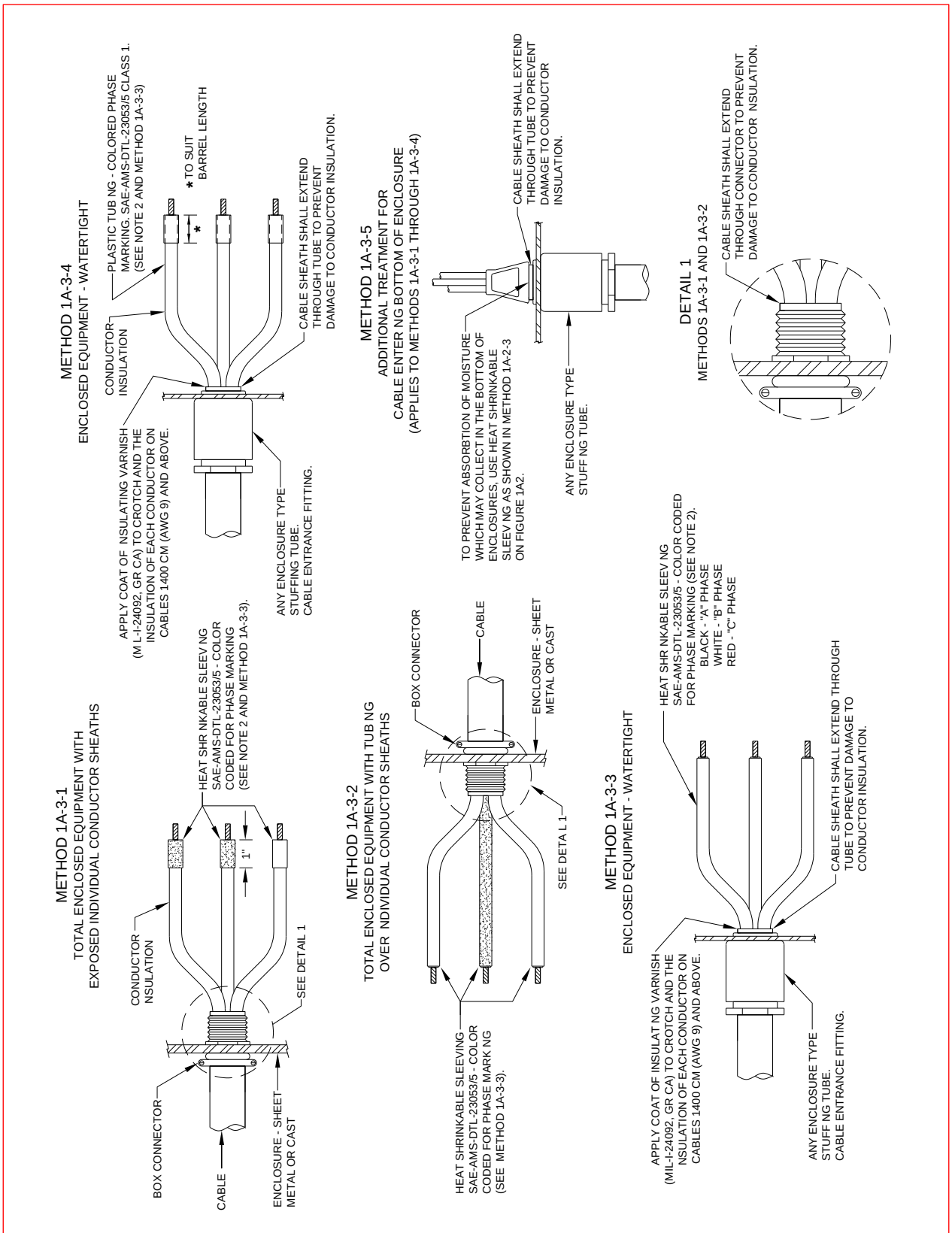


FIGURE 1A3. Cable end preparation for enclosed equipment.

NOTES:

1. These methods cover protection and finish of cable ends entering enclosed equipment.
2. See MIL-STD-2003-4 for requirements for cable and conductor wire marking.
3. These methods are for finishing the ends of all cable conductors not required to be end-sealed.
4. These methods are not to be construed as satisfactory for water sealing cable ends.
5. Color, heat-shrink tubing shall be SAE-AS23053/5, class 1.
6. Cable jacket shall extend a minimum of ⅛ inch beyond the equipment entrance fitting to prevent damage to the conductor insulation.
7. Additional protection is required for non-watertight cables entering through the bottom of enclosures. To prevent absorption of moisture that may collect in the bottom of enclosures, use heat shrink, insulating varnish, or plastic sealant.
8. Two-hole lug terminals should be used where there is a possibility of the lug turning or making contact with an adjacent lug.
9. This method is for guidance and use only when non-watertight cable has been approved for use by NAVSEA.

FIGURE 1A3. Cable end preparation for enclosed equipment – Continued.

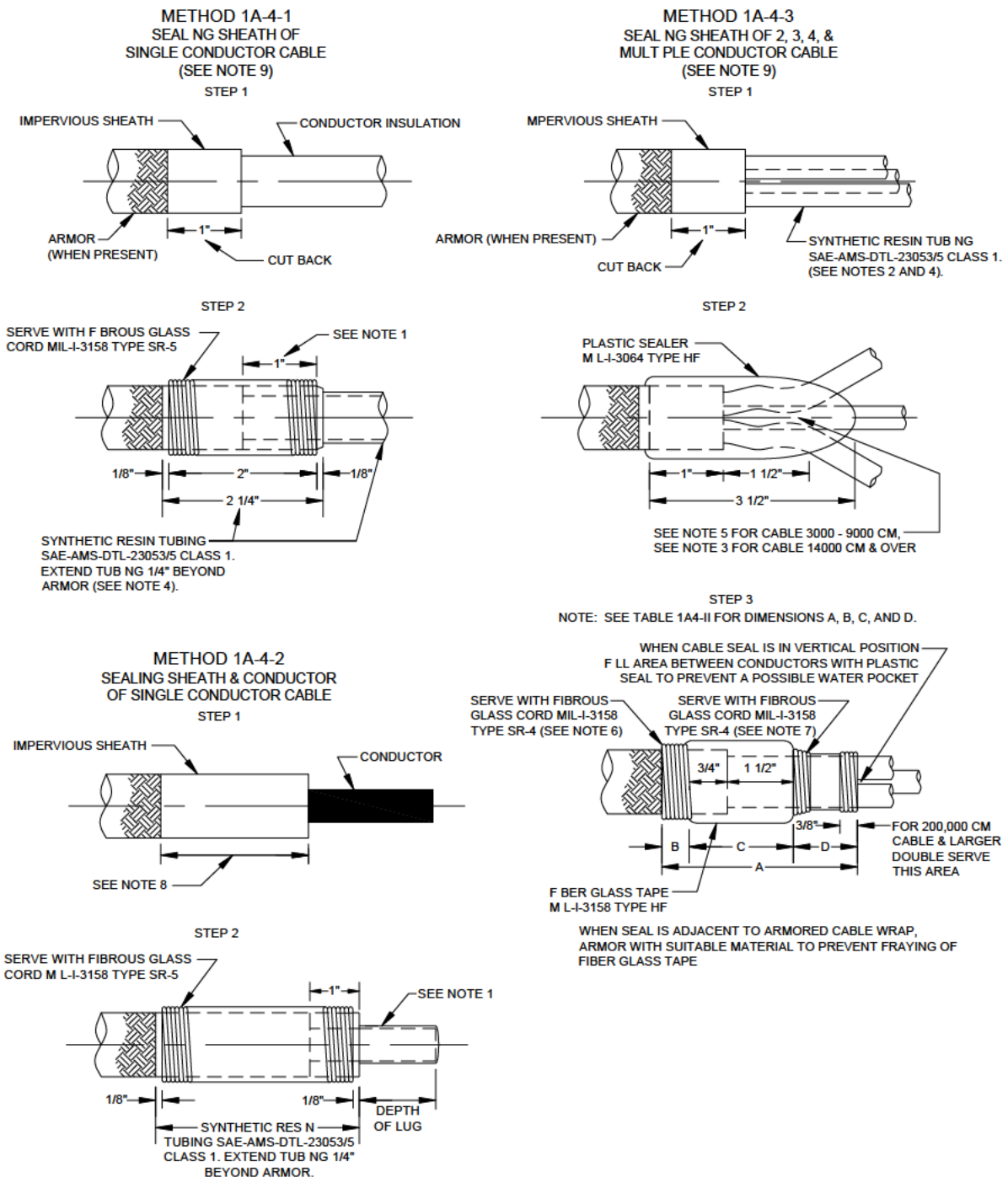


FIGURE 1A4. Cable end preparation for non-watertight equipment.

TABLE 1A4-I. Conductor size crossed to electrical insulating tubing size.

Size of MIL-DTL-915 cable (cir mils)	Inside diameter of synthetic resin tubing (SAE-AS23053/5, class 1) for use over		Size of MIL-DTL-24643 cable (AWG) see note below
	MIL-DTL-915 and MIL-DTL-24643 cables		
	Individual cable leads	Impervious sheath of single conductor cable	
3,000	0.162	0.250	16
4,000	0.250	0.375	14
9,000	0.280	0.375	10
14,000	0.320	0.500	9
23,000	0.360	0.500	7
30,000	0.400	0.750	5
40,000	0.430	0.750	4
50,000	0.450	0.750	3
60,000	0.520	0.750	2
75,000	0.570	0.750	1
100,000	0.630	1.000	0
125,000	0.680	1.000	00
150,000	0.760	1.000	000
200,000	0.820	1.000	0000
250,000	0.890	1.500	250 MCM
300,000	0.960	1.500	300 MCM
350,000	1.000	1.500	
400,000	1.100	1.500	
500,000	1.165	1.500	
650,000	1.225	1.500	
800,000	1.365	1.500	800 MCM
NOTE: AWG 16 and AWG 14 wire sizes are also applicable for MIL-DTL-24640 cable.			

TABLE 1A4-II. End-sealing.

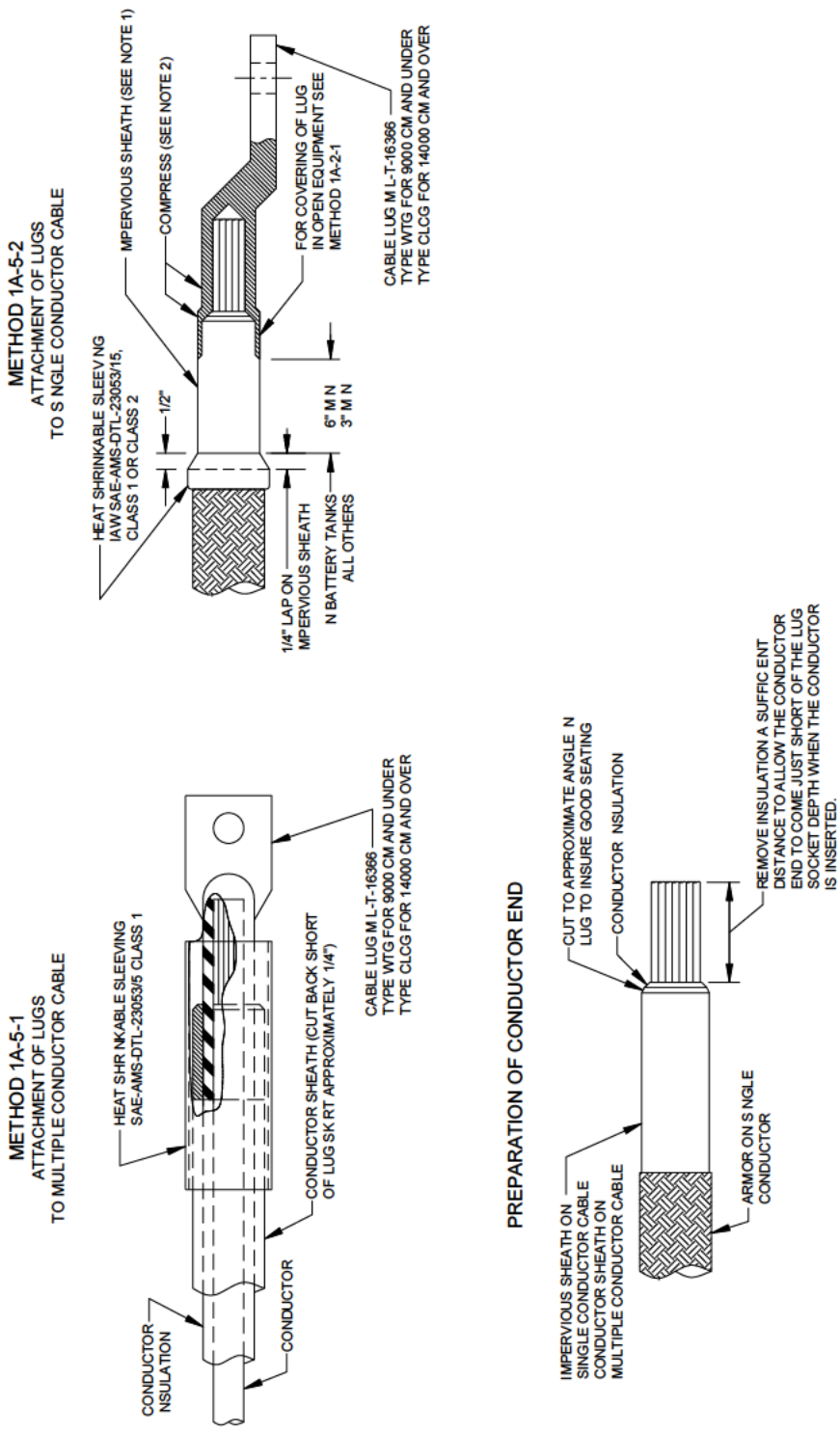
Finished dimensions				
Cable sizes (1,000 circular mils)	Dimensions (inches)			
	A	B	C	D
3 to 9 M-7 to M-10 TT-1 to TT-25	4¼	¾	2¼	1¼
14 to 100 M-14 to M-44 TT-30 to TT-60	5	¾	2¼	2
125 to 400	6	¾	2¼	3

FIGURE 1A4. Cable end preparation for non-watertight equipment – Continued.

PROCESS STEPS AND NOTES:

1. Build diameters indicated to inside diameter (I.D.) of synthetic tubing with synthetic resin tape, MIL-I-19166, ¾ inch wide × 0.010 inch thick and bonding agent. The bonding agent shall be allowed to dry before applying synthetic resin tape.
2. Synthetic resin tubing is not required for multiple conductor cable or 2, 3, and 4 conductor cable, 3,000 through 14,000 circular mils.
3. Spread conductors just above the crotch, and insert a ½-inch diameter ball against which the conductors shall be tightly squeezed. Removal of the ball will leave a permanent pocket in the crotch which will serve as a receptacle for plastic sealer. Proceed with sealing as described in note 7.
4. Synthetic resin tubing shall be slipped over conductor insulation, extending from well into the cable crotch to the end of the conductor.
5. Spread conductors and apply plastic sealer tightly in between individual conductors being sure that there is a cushion of plastic sealer around and between individual conductors. Pull conductors together, cover with two turns plus 1 inch overlap of glass tape, and serve tightly with fibrous glass cord. Coat with insulating varnish in accordance with MIL-I-24092, grade CA.
   NOTE: See table 1A4-II for dimensions A, B, C, and D.
6. This end to be served first, working from left to right.
7. This end to be served after note 6 has been accomplished. Work from right to left. This operation tends to force the plastic sealer tightly into the crotch of the cable and this action should be assisted by manipulating the plastic sealer ahead of the cord, with the hands as the serving progresses.
8. Cable armor, when present, shall be cut back and impervious sheath thoroughly cleaned of paint for a sufficient distance to prevent electrical creepage between armor and lug after cable is inserted.
9. Cable sheath end-sealing should be accomplished by the use of terminal tubes except where insurmountable difficulties prevent its use.
10. Various steps in these notes are for the purpose of end-sealing the cable when used in specific applications. These steps shall be dispensed with when approved watertight cable in accordance with MIL-DTL-24643 or MIL-DTL-24640 is used.
11. This method is for guidance and use only when non-watertight cable has been approved for use by NAVSEA.

FIGURE 1A4. Cable end preparation for non-watertight equipment – Continued.



NOTES:

1. When cable armor is present, it shall be sufficiently cut back and the impervious sheath thoroughly cleaned of paint over the distance indicated on detail to prevent electrical creepage between armor and lug.

FIGURE 1A5. Attachment of solderless lugs to cables.

NOTES (continued):

2. The solderless lug shall be crimped to the conductor. When watertight cable is not used, the lug skirt shall be compressed over the impervious sheath producing a watertight seal capable of withstanding 50 psi without leakage.
3. Watertight lugs, types WTG and CLCG, are not required when watertight cable is installed.

FIGURE 1A5. Attachment of solderless lugs to cables – Continued.

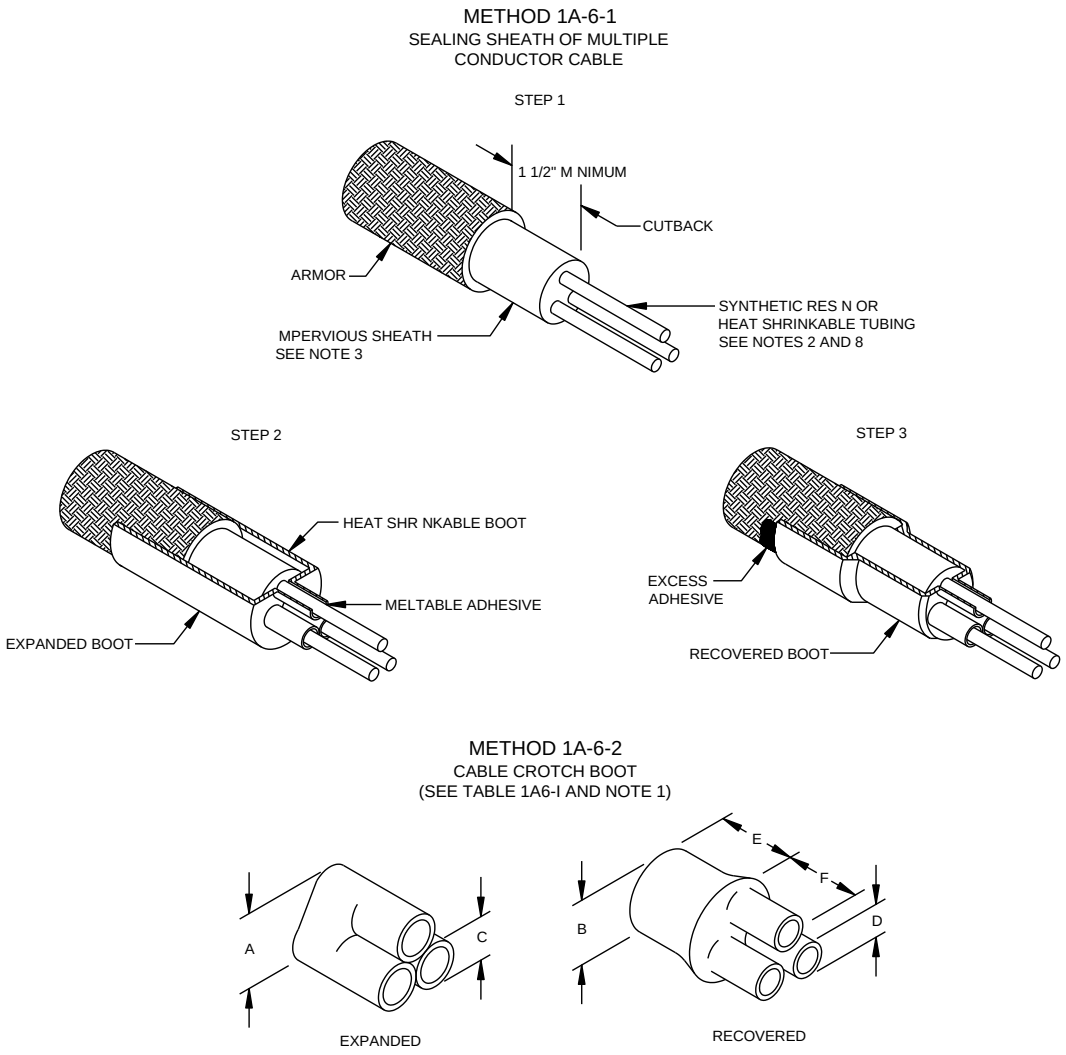
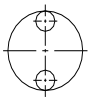
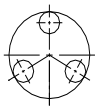
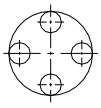
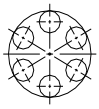


FIGURE 1A6. Cable end-sealing with heat-shrinkable cable crotch boots.

TABLE 1A6-I. Cable crotch boot dimensions (inches).

Boot style	Cable MCM	Part number	Cable entry I.D.		Conductor I.D.		Min. length		Min. wall
			Expanded A-dia min.	Recovered B-dia max.	Expanded C-dia min.	Recovered D-dia max.	Recovered		Recovered
							E (body)	F (legs)	
 2 Legs	3, 4, 6, 9 14, 23, 30 50, 75, 83, 100 200, 250, 300, 400	1A62-1 1A62-2 1A62-3 1A62-4	0.80 1.20 1.90 3.00	0.39 0.60 0.90 1.50	0.33 0.50 0.75 1.45	0.11 0.17 0.35 0.50	2.0 2.5 3.0 3.5	0.7 1.0 1.2 1.5	0.05 0.07 0.10 0.12
 3 Legs	3, 4, 6, 9 14, 23 42, 50, 75, 100 150, 200, 250, 300 400 500, 600	1A62-5 1A62-6 1A62-7 1A62-8 1A62-9 1A62-10 1A62-11	0.90 1.20 1.50 1.70 2.40 3.20 4.90	0.36 0.50 0.69 0.90 1.40 2.00 2.32	0.33 0.50 0.65 0.82 1.25 1.40 2.00	0.12 0.16 0.18 0.35 0.50 0.75 1.00	2.0 2.3 1.8 2.3 3.5 3.5 7.5	0.7 1.0 2.2 1.2 1.6 1.6 2.5	0.08 0.09 0.09 0.12 0.12 0.14 0.12
 4 Legs	3, 4, 6, 9 23 42, 50, 60 75, 100 133, 150, 200	1A62-12 1A62-13 1A62-14 1A62-15 1A62-16 1A62-17	0.90 1.25 1.75 2.35 2.65 5.25	0.47 0.80 0.98 1.00 1.40 3.00	0.28 0.50 0.79 1.00 1.20 1.35	0.11 0.19 0.28 0.35 0.53 0.55	2.0 2.3 2.3 6.8 3.5 6.0	0.75 1.0 1.2 1.7 1.5 3.0	0.05 0.09 0.14 0.14 0.14 0.13
 6 Legs	100, 125, 150, 200	1A62-18	2.39	1.45	0.80	0.35	3.4	2.0	0.10

NOTES:

1. Material for cable crotch boot shall be polyolefin, semi-rigid, non-burning, and shall conform to the requirements of SAE-AS81765/1. The cable crotch boot shall have an internal coating of adhesive which meets the adhesive requirements described on this sheet.
2. Heat-shrinkage tubing or synthetic resin tubing shall be slipped over conductor insulation, extending from well into the cable crotch to the end of the conductor. Heat-shrinkage tubing should be shrunk before crotch boot is positioned.
3. Cable armor, when present, shall be cut back to expose impervious sheath for a minimum of 1½ inches. Impervious sheath and conductor insulation shall be thoroughly cleaned of paint and any other foreign matter.
4. Slide crotch boot over section to be sealed as shown on drawing. Press crotch boot firmly into crotch of conductors.
5. Shrink part by applying heat, using a hot air blower (heat gun) or other heat source. Minimum recovery temperature is 250 °F (121.1 °C).
6. As heat is applied, move heat source back and forth over the part to be shrunk. For crotch boot, shrink from center to ends to avoid trapping air.
7. When crotch boot has recovered enough to assume the configuration of the item covered and excess adhesive appears at the ends of the crotch boot legs, discontinue heating. Additional heat will not make the part shrink more tightly.
8. Tubing is not required for cable 3,000 to 23,000 circular mils with extruded conductor insulation.

FIGURE 1A6. Cable end-sealing with heat-shrinkable cable crotch boots – Continued.

NOTES (continued):

9. Peel strength sample cable for testing shall be abraded with 80 grit sandpaper and solvent cleaned. Heat-shrink sample tubing over cable sheath, then cut in half the length of the cable. Measure the peel strength of the heat-shrink tubing material to cable sheath with a tensile testing machine. The loose ends of the shrink tubing and cable sheath shall be attached to opposite grips of an autographic tensile testing machine with a capacity such that the tension at failure is not more than 85 percent and not less than 15 percent of the full scale. The rate of grip separation shall be 2 inches per minute and shall be uniform at all times. The adhesion in pounds shall be automatically recorded on a chart as a continuous curve for a minimum of 6 inches of grip separation. The adhesion value shall be calculated by averaging the maximum and minimum forces required to separate the shrink tubing from the cable sheath and shall be reported in pounds per inch of width.

Tests	**Requirement**
Adhesion	
To chloroprene	15 pounds per inch of width minimum
To polyolefin	15 pounds per inch of width minimum

10. This method is for guidance and use only when non-watertight cable has been approved for use by NAVSEA.

Adhesive requirements

1. Test strips ¾ inch by 4.5 inches shall be cut from the boot (see note 1).
2. The strips are bonded together using standard methods.
3. The bonded strips shall be kept at room temperature for approximately 8 hours.
4. The bonded strips are then hung in a 140 °F (60 °C) oven in a t-peel position (see illustration) with a 2-pound weight attached for 8 hours.
5. After 8 hours, there shall be no delamination.

ADHESIVE REQU REMENTS LLUSTRATION

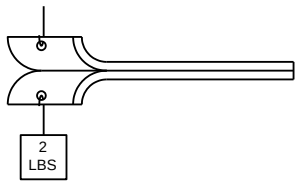


FIGURE 1A6. Cable end-sealing with heat-shrinkable cable crotch boots – Continued.

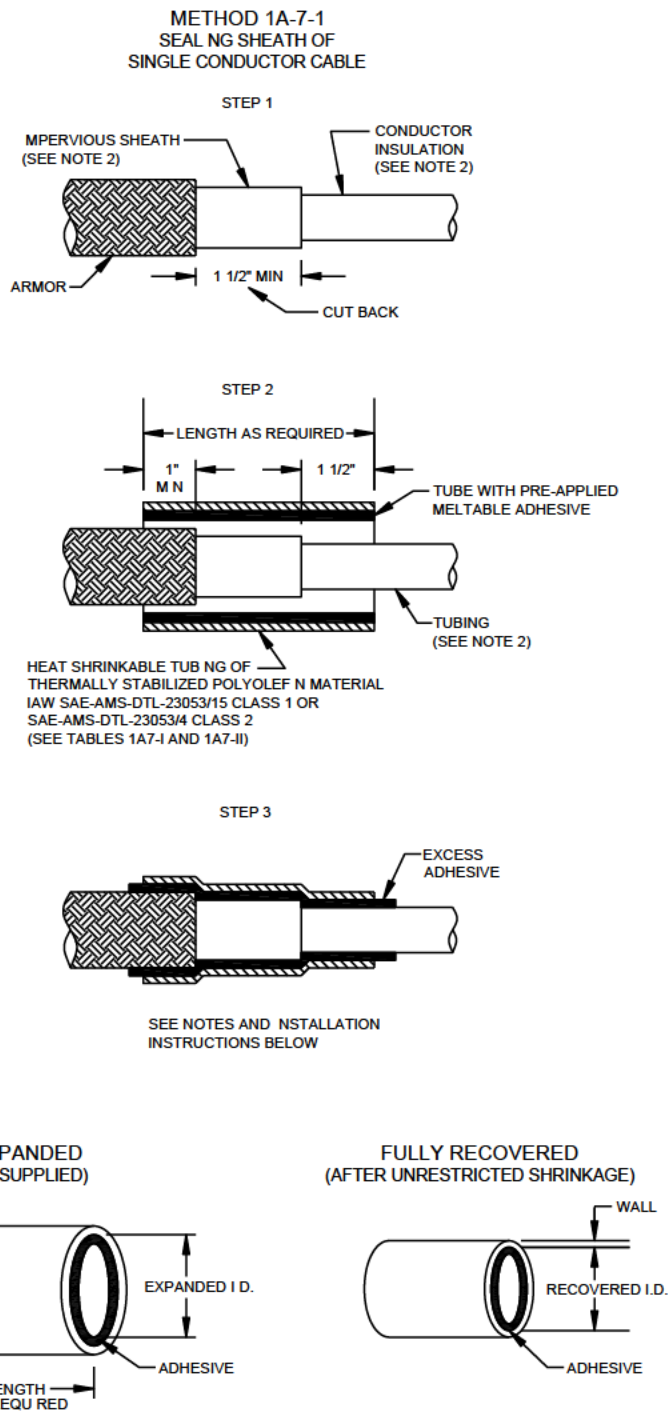


FIGURE 1A7. Cable end-sealing with heat-shrinkable tubing.

TABLE 1A7-I. Sealing tubing dimensions (with adhesive) (intended use: repair of heavy cables, splices where approved, and moisture sealing).

Military part number (class 1)	Tube size for SSGA cable size range (MCM)	Inside diameter (max.)	Fully recovered	
			Inside diameter (max.)	Wall thickness
MS23053/15-101-0	3-40	0.750	0.220	0.105
MS23053/15-102-0	50-150	1.100	0.375	0.120
MS23053/15-103-0	200-250	1.500	0.500	0.140
MS23053/15-104-0	Greater than 500	2.000	0.750	0.155
MS23053/15-105-0		3.000	1.250	0.155
MS23053/15-106-0		4.000	1.750	0.155

TABLE 1A7-II. Sealing tubing dimensions (with adhesive) (intended use: encapsulating or moisture sealing).

Military part number (class 2)	Expanded	Fully recovered	
	Inside diameter (max.)	Inside diameter (max.)	Wall thickness
MS23053/4-201-0	0.238	0.029	0.125
MS23053/4-202-0	0.355	0.029	0.187
MS23053/4-203-0	0.475	0.030	0.250
MS23053/4-204-0	0.712	0.035	0.375
MS23053/4-205-0	0.950	0.042	0.500
MS23053/4-206-0	1.425	0.047	0.750

FIGURE 1A7. Cable end-sealing with heat-shrinkable tubing – Continued.

TABLE 1A7-III. Tubing dimensions (without adhesive) (intended use: wire color coding, marking, and identification).

Military part number (class 1)	Expanded	Fully recovered	
	Inside diameter (max.)	Inside diameter (max.)	Wall thickness
MS23053/5-105-*	0.187	0.093	0.20
MS23053/5-106-*	0.250	0.125	0.25
MS23053/5-107-*	0.375	0.187	0.25
MS23053/5-108-*	0.500	0.250	0.25
MS23053/5-109-*	0.750	0.375	0.30
MS23053/5-110-*	1.000	0.500	0.35
MS23053/5-111-*	1.500	0.750	0.40
MS23053/5-112-*	2.000	1.000	0.45
MS23053/5-113-*	3.000	1.500	0.50
MS23053/5-114-*	4.000	2.000	0.55

NOTES:

Heat-shrinkable tubing dimension notes

A. Expanded dimensions include factory-applied adhesive.
B. All dimensions are nominal.
C. Tolerances shall be in accordance with SAE-AS23053/15, class 1; SAE-AS23053/4, class 2; or SAE-AS23053/5, class 1.
D. Recommended lengths are minimums.
E. Wall dimension does not include adhesive.
F. Dimensions are in inches.
G. The (*) symbol refers to the color code number.

0 – black 5 – green

2 – red 9 – white

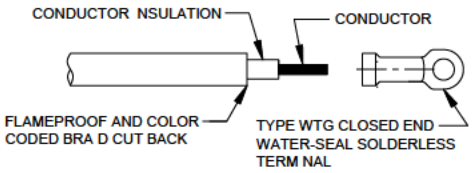
Notes and installation instructions

1. Tubing shall conform to SAE-AS23053/15, class 1, or SAE-AS23053/4, class 2.
2. Cable armor, when present, shall be cut back a minimum of 1½ inches to expose impervious sheath. Impervious sheath and conductor insulation shall be thoroughly cleaned of paint and any other foreign matter.
3. Slide tube over section to be sealed as shown on drawing. Position tube to ensure minimum overlap on armor, when present, as shown in step 2 on the figure.
4. Shrink part by applying heat using hot air blower, heat gun, or other heat source. Minimum recovery temperature is 250 °F (121.1 °C).
5. As heat is applied, move heat source back and forth over part to be shrunk. Shrink tube from center to ends to avoid trapping air.
6. When the tube has recovered enough to assume the configuration of the item covered and adhesive appears at the ends of the sealant tube, discontinue heating. Additional heat will not make the part shrink more tightly.
7. This method is for guidance. Use only when non-watertight cable has been approved for use by NAVSEA.

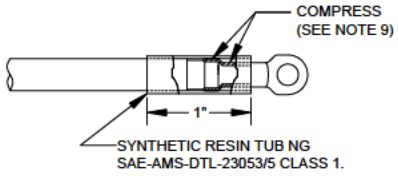
FIGURE 1A7. Cable end-sealing with heat-shrinkable tubing – Continued.

METHOD 1A-8-1
ATTACHMENT OF CLOSED END TERMINALS
TO MULT PLE & 2, 3, & 4, 3000 TO 9000 CM
CONDUCTOR CABLE

PREPARATION OF CONDUCTOR

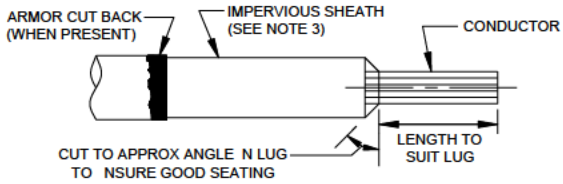


TERM NAL ATTACHED TO CONDUCTOR

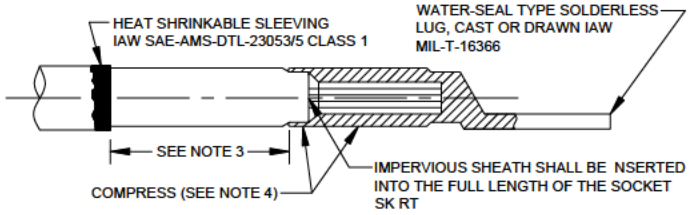


METHOD 1A-8-2
ATTACHMENT OF WATER-SEAL SOLDERLESS
LUG TO SINGLE CONDUCTOR CABLE

PREPARATION OF CABLE END



WATER-SEAL LUG ATTACHED TO CABLE



NOTES:

1. Build diameters indicated to I.D. of synthetic tubing for distances indicated with synthetic resin tape in accordance with MIL-I-19166. Paint with bonding agent and allow to dry before applying synthetic resin tape.
2. Cut conductor insulation back so that the lug body fits tightly up against the insulation. No gap is permitted.
3. Cable armor, when present, shall be cut back and impervious sheath thoroughly cleaned of paint for a sufficient distance to prevent electrical creepage between armor and lug after cable is inserted.

FIGURE 1A8. Cable conductor end-sealing.

NOTES (continued):

4. The solderless lug shall be secured to the cable conductor by approved methods. The skirt of the lug shall be compressed over the impervious sheath or tubing by approved methods producing a watertight seal capable of withstanding 50 psi without leakage.
5. Build conductor to fit I.D. of synthetic tubing with synthetic resin tape in accordance with MIL-I-19166.
6. The sealing of terminal ends of telephone twisted pair conductors is not required. The crotch of the cable, however, shall be treated the same as for all multiple conductor cable.
7. Synthetic resin tubing shall be slipped over conductor insulation, extending from well into the cable crotch to the end of the conductor.
8. Synthetic resin tubing is not required for multiple conductor cable or 2, 3, and 4 conductor cable 3,000 to 9,000 circular mils.
9. Prepare cable ends as shown, including cutting color-coded braid or glass back a sufficient distance to clear skirt of terminal when installed. Then slip a piece of synthetic tubing 0.150 inch in diameter, 1 inch long over cable end. Insert wire into terminal and secure the barrel of terminal to copper conductor by approved methods. Then compress the skirt of terminal to the impervious sheath of cable by approved methods capable of withstanding 30 psi without leakage. Slide synthetic tubing over terminal for approved crimping tool. Use appropriate crimping tool, Thomas & Betts (now ABB), or equal (see 4.2).
10. See 4.1.7.3.3 for restrictions on use of thimbles for electrical connections. Crimped lugs are required for all non-mechanical power panel and switchboard electrical cable connections (see 4.1.7).
11. This method is for guidance and use only when non-watertight cable has been approved for use by NAVSEA.

FIGURE 1A8. Cable conductor end-sealing – Continued.

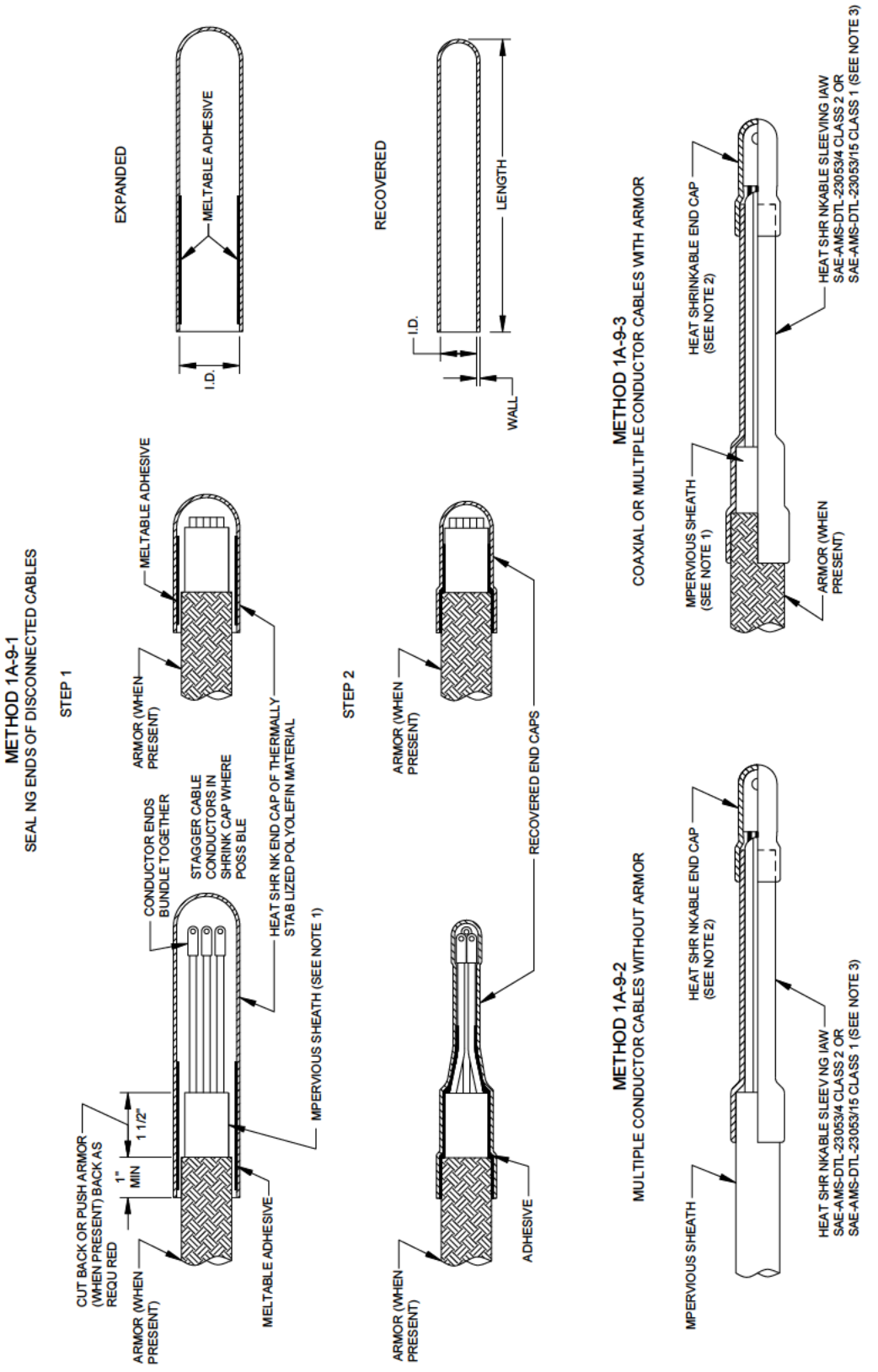


FIGURE 1A9. Cable end-sealing with heat-shrinkable tubing and end caps for disconnected, deactivated, and unused cables.

TABLE 1A9-I. End cap dimensions.

Cable size cir mils (MCM)	Expanded I.D.	Length min.	I.D. max.	Wall nom.
3-40	0.35	1.2	0.18	0.06
	0.81	2.4	0.37	0.08
50-150	1.00	2.7	0.45	0.09
200-500	1.55	3.6	0.71	0.10
650 and greater	2.00	4.0	0.90	0.11
	3.30	4.5	1.50	0.12

NOTES:

Heat-shrinkable dimension notes:

A. Expanded dimensions include factory applied adhesive.
B. All dimensions are nominal.
C. Recommended lengths are minimums.
D. Wall dimensions do not include adhesive.

Notes and installation instructions:

1. Cable armor (when present) shall be cut back to expose impervious sheath for 1½ inches. Impervious sheath and conductor insulation shall be thoroughly cleaned of paint and any other foreign matter.
2. Slide end cap over section to be sealed as shown on drawing. Position end cap to ensure 1-inch minimum overlap on armor (when present) as shown in step 1 of method 1A-9-1.
3. Shrink part by applying heat using a hot air blower (heat gun) or other source. Minimum recovery temperature is 250 °F (121.1 °C).
4. As heat is applied, move source back and forth over part to be shrunk. Shrink end cap from closed end to open end to avoid trapping air.
5. When end cap has recovered enough to assume the configuration of the item covered and excess adhesive appears at the end of the cap, discontinue heating. Additional heat will not make the part shrink more tightly.
6. End caps shall conform to SAE-AS81765/1 and table 1A9-I.

FIGURE 1A9. Cable end-sealing with heat-shrinkable tubing and end caps for disconnected, deactivated, and unused cables – Continued.

METHOD 1A-10-1

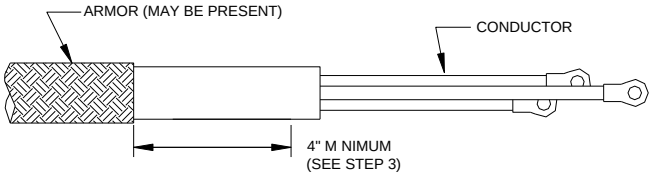
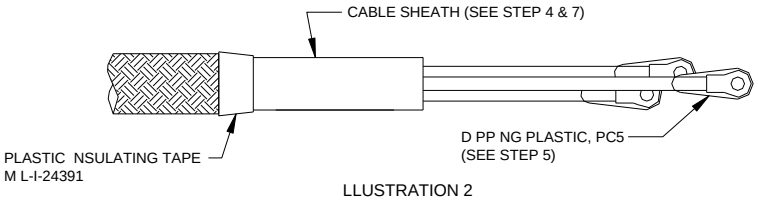
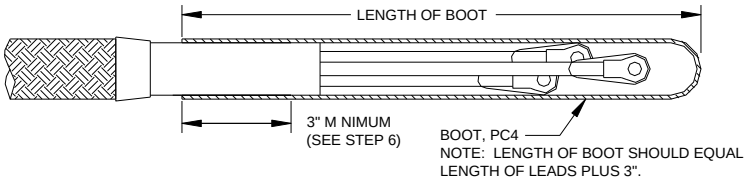


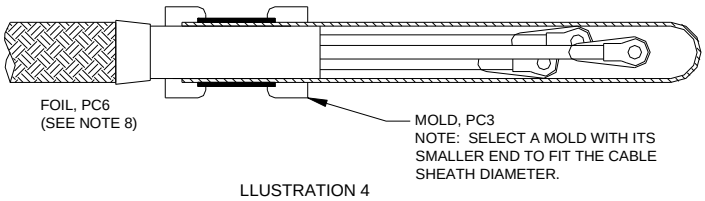
ILLUSTRATION 1



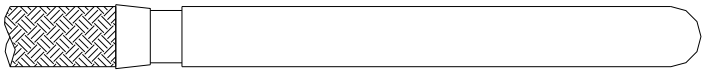
LLUSTRATION 2



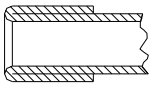
LLUSTRATION 3



LLUSTRATION 4



LLUSTRATION 5



BOOT MAY BE FOLDED BACK, AS SHOWN,
TO CREATE MORE PRESSURE IN MOLD
FOR A BETTER SEAL NG EFFECT.

ILLUSTRATION 6

WHEN OVERSIZE BOOT IS USED, PULL
OPPOSITE SIDES AND FOLD OVER AS
SHOWN.

LLUSTRATION 7

Weather Sealing Steps:

1. Disconnect cable from equipment.
2. Take megger readings of cable and record for reference.
3. Complete step 3 only when armor is present. Push the armor back a minimum of 4 inches from the end of the cable sheath (illustration 1) and tape the armor in place (illustration 2). The armor should be retained in its entirety so that it may be replaced for shielding.

FIGURE 1A10. Cable end-sealing when exposed to weather.

Weather Sealing Steps (continued):

4. Clean the cable sheath by scraping with a knife, sandpaper, or a wire brush. Then clean thoroughly with an applicable solvent in accordance with local methods for end-sealing.
5. Dip ends of conductors (with or without lugs attached) in hot dip insulating material in accordance with local methods for end-sealing (illustration 2). The coating thus provided protects the conductors. The insulation can be easily stripped from the conductors when the cable is to be reactivated.
6. Place a boot, in accordance with local methods for end-sealing, of the proper size over the cable (illustration 3). This boot should extend at least 3 inches over the cable sheath.
7. Brush solvent, in accordance with local methods for end-sealing, on areas of boot and cable sheath that are to be joined.

NOTE: Steps 8-11 may be replaced with a local method for clamping the boot.

8. Wrap foil, in accordance with local methods for end-sealing, over the boot and cable sheath (illustration 4).
9. Place a proper size mold, in accordance with local methods for end-sealing, over the foil, boot, and sheath. Then tighten the mold clamps (illustration 4).
10. Apply thermostatically controlled heater, in accordance with local methods for end-sealing, over the metal section of the mold. The heating time is generally 4 to 5 minutes. However, the heating time will depend on ambient temperature and cable size. Remove the heater.
11. Allow the mold to cool approximately 5 minutes. Then remove mold and foil (illustration 5).

NOTE:

1. Heat-shrink end caps, method 1A-13-3, may be used as alternate to method 1A-10-1.

FIGURE 1A10. Cable end-sealing when exposed to weather – Continued.

METHOD 1A-11-1
MULT PLE CONDUCTOR CABLES
WITH AND WITHOUT ARMOR

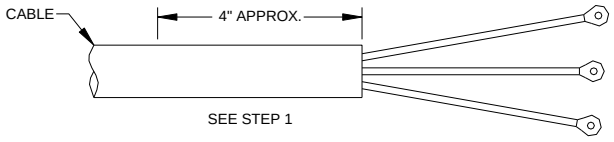
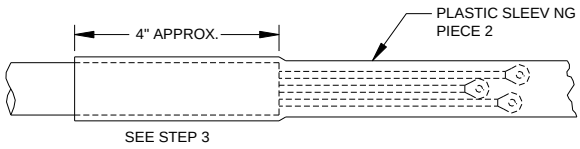
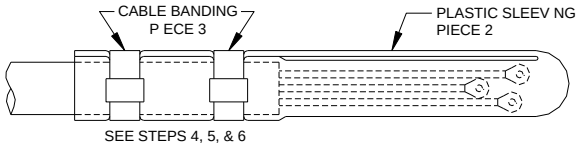


ILLUSTRATION 1



LLUSTRATION 2



LLUSTRATION 3

Weather Sealing Steps for Method 1A-11-1:

1. Disconnect cable from equipment. Push cable armor, when present, back about 6 inches (out of way of sealing area) and secure with a wrapping of plastic tape or secure with heat-shrink sleeving as shown on figure 1A9. Separate and straighten the conductors and liberally apply a sealing compound (PC 1) on the conductors (especially where the conductors enter the cable) and approximately 4 inches back on the cable (see illustration 1).
2. Place a heat-shrinkable end cap of the proper size from table 1A9-I, over each of the conductor ends and shrink to conform. Heat-shrinkable sleeving in accordance with SAE-AS23053/4, class 2 with crimped end may be used as an alternate conductor insulation.
3. Slide the plastic sleeving (PC 2) over the conductors and approximately 4 inches back onto the cable (see illustration 2).
4. Double back and cut the plastic sleeving allowing sufficient length of sleeving so that the conductors do not double back and overlap onto the cable (see illustration 3).
5. Shape the loose end of the sleeving to the cable and install the cable bands (PC 3) (see illustration 3).
6. Apply the sealing compound onto the cable around the ends of the plastic sleeving.

FIGURE 1A11. Cable end-sealing when exposed to weather.

METHOD 1A-11-2

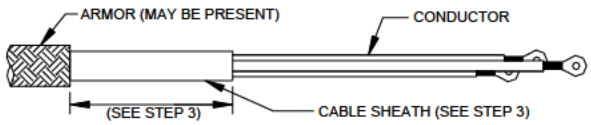


ILLUSTRATION 1

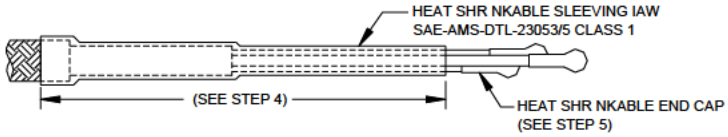


ILLUSTRATION 2

ILLUSTRATION 3

Steps for Method 1A-11-2:

1. Disconnect cable from equipment.
2. Take megger readings of cable and record for future reference.
3. Push the armor (when present) back a minimum of 1½ inches from the end of the cable sheath (illustration 1) and clean cable sheath by scraping with a knife, sandpaper, or a wire brush, then clean thoroughly with solvent. The armor should be retained in its entirety so that it may be replaced for shielding.
4. Secure armor (when present) in place with heat-shrinkable sleeving (illustration 2). Sleeving shall be cut to a length that will allow 1-2 inches to overlap with cable armor and heat-shrinkable end cap, depending upon the size of cable.
5. ~~Place a heat-shrinkable end cap of the proper size from table 1A9-I over each of the conductor ends, and~~ shrink to conform (illustration 2). Heat-shrinkable sleeving in accordance with SAE-AS23053/4, class 2 with crimped end may be used as an alternate conductor insulation.
6. Place a heat-shrinkable end cap of the proper size, in accordance with method 1A-9-1 over cable end and shrink to conform (illustration 3).

List of material:

PC 1, Sealing compound – Sealing compound shall be an electrical insulating adhesive sealant which does not produce corrosive acid during the cure process.

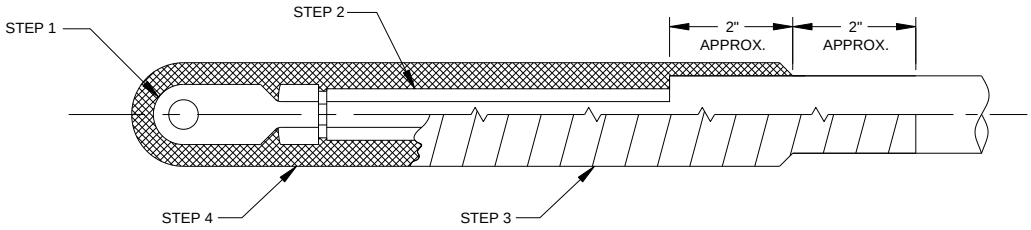
PC 2, Plastic sleeving – SAE-AS23053/5, class 1.

PC 3, Cable banding – CRES. See MIL-STD-2003-4, figure 4C22, "Cable clamps for single cableway on steel and aluminum decks and bulkheads".

PC 4, Banding buckle – CRES.

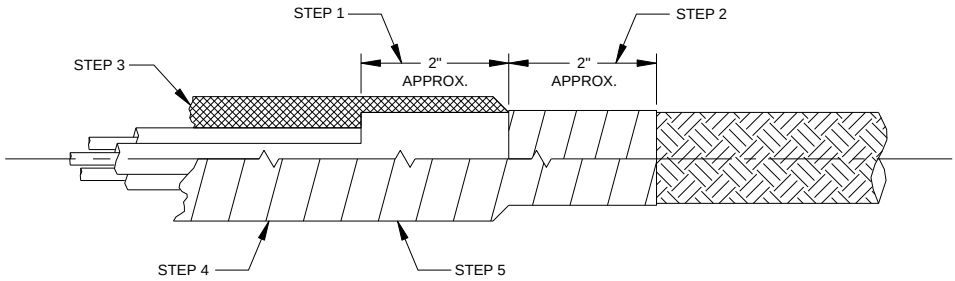
FIGURE 1A11. Cable end-sealing when exposed to weather – Continued.

METHOD 1A-12-1
MULTIPLE CONDUCTOR CABLES WITHOUT ARMOR



1. Disconnect cable from equipment. Individual conductors may be balled together, twisted, or left straight.
2. Mold flameproof insulating Neoprene filler tape, MIL-PRF-17695, around bunched individual conductors and extend approximately 2 inches over cable sheath.
3. Apply two servings (min.) half-lapped of plastic electrical insulating adhesive tape, 1 inch wide, MIL-I-24391.
4. Coat entire seal with three coats of Neoprene cement.

METHOD 1A-12-2
MULT PLE CONDUCTOR CABLES WITH ARMOR



1. Disconnect cable from equipment. Remove armor a minimum of 2 inches from the end of jacket.
2. Seize armor end with one serving half-lapped of plastic electrical insulating adhesive tape, 1 inch wide, MIL-I-24391.
3. Mold flameproof insulating Neoprene filler tape, MIL-PRF-17695, around cable end and individual conductors as applicable for cable type.
4. Apply two servings (min.) half-lapped of plastic electrical insulating adhesive tape, 1 inch wide, MIL-I-24391.
5. Coat entire seal with three coats of Neoprene cement.

NOTES:

1. Alternate method of sealing may be used in accordance with the local method for end-sealing except on coaxial cable. Heat-shrinkable sleeving shall be cut to a length that will allow 1-2 inches of overlap with cable insulation and heat-shrinkable end cap, depending upon the size of the cable.
2. For selection and installation instructions of heat-shrinkable end caps, see method 1A-9-1.

FIGURE 1A12. Cable end-sealing when exposed to weather.

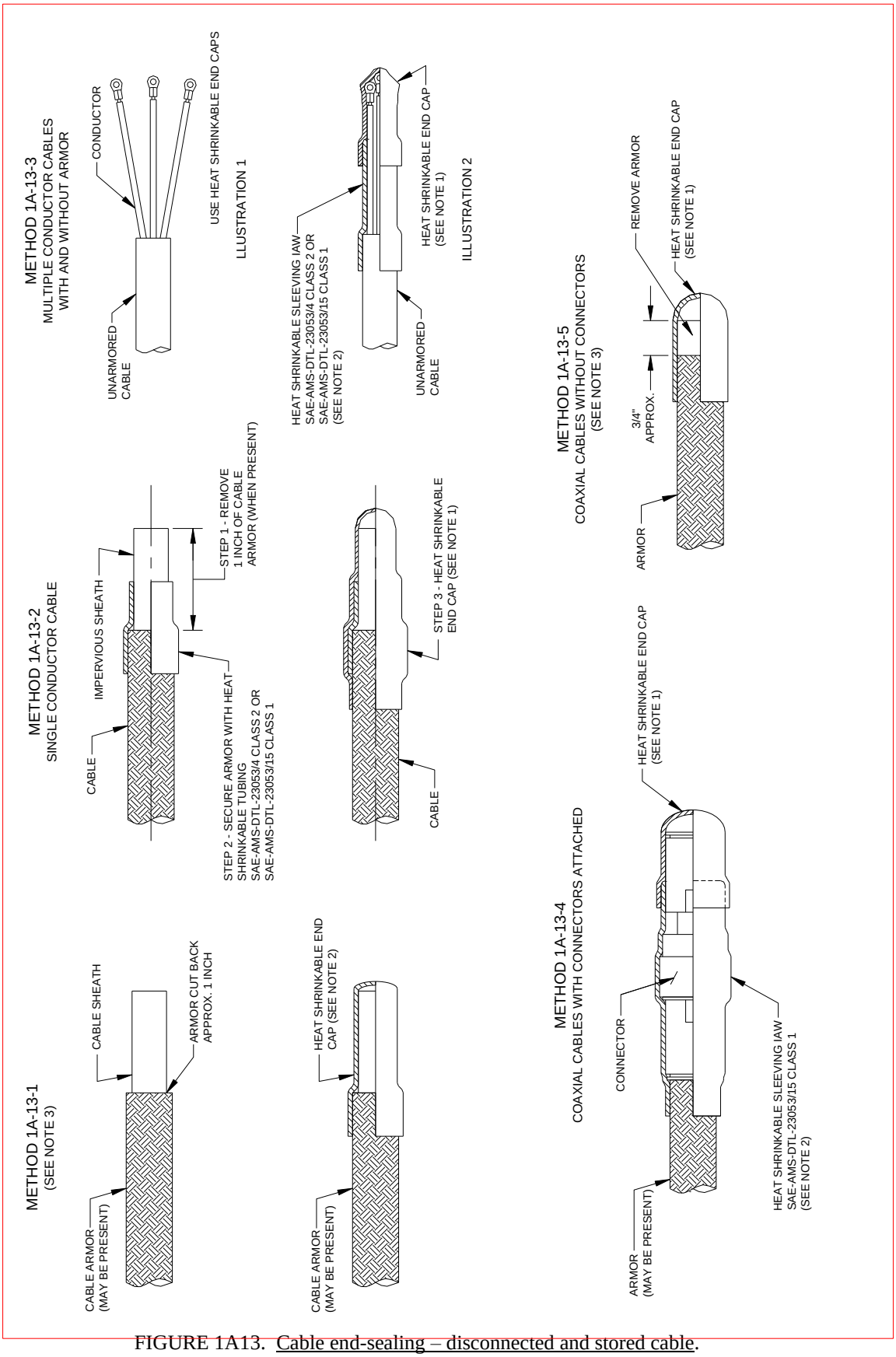


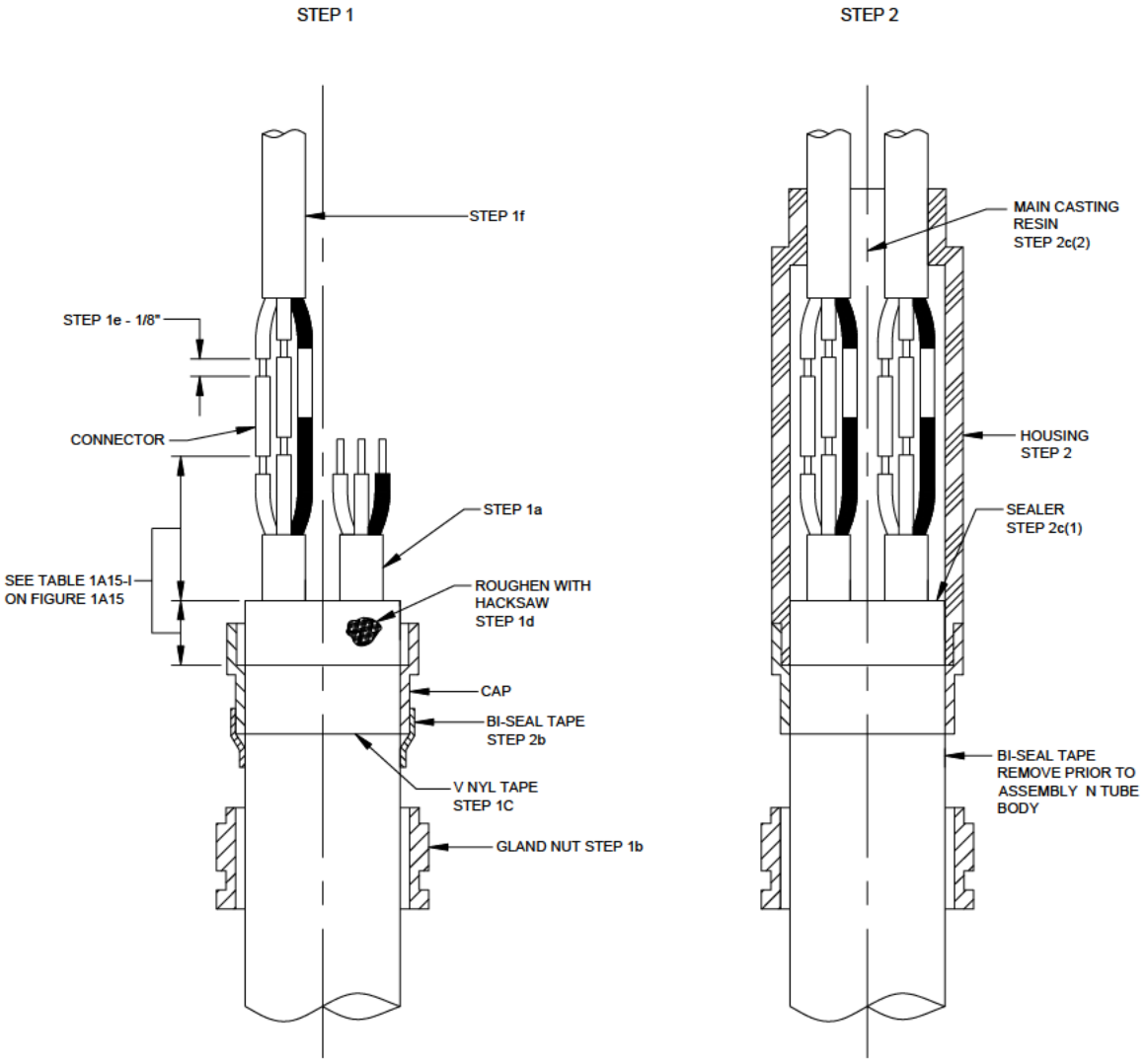
FIGURE 1A13. Cable end-sealing – disconnected and stored cable.

NOTES:

1. For selection and installation instructions of heat-shrinkable end caps, see method 1A-9-1.
2. Heat-shrinkable sleeving shall be cut to a length that will allow 1-2 inches of overlap with cable insulation and heat-shrinkable end cap, depending upon the size of cable.
3. This method applies to cable coils or reels stored in a covered location not subject to entrance of water or moisture.

FIGURE 1A13. Cable end-sealing – disconnected and stored cable – Continued.

METHOD 1A-14-1



Instructions:

Step 1:

a. Prepare cable end by exposing wires and cutting back armor, when present, as indicated.
b. Slide gland nut and cap onto the cable.
c. Cut back armor (when present) as indicated and secure with tape as required.
d. Roughen up exposed area of cable sheath with a hacksaw blade.
e. Crimp insulated connectors on the conductors leaving ⅛ inch of the bare conductor exposed. On shielded conductors, cut and fray the shielding back, twist together and treat as a separate conductor as indicated.
f. Crimp extension wires to the connectors in the same manner as indicated above, maintaining proper color coding, or labeling for identification.
NOTE: Extension wires may be obtained by stripping a section of cable similar to that being end-sealed.

FIGURE 1A14. Cable end-sealing for inboard pressure-proof installations on submarines.

Instructions (continued):

Step 2:

a. Roughen the interior housing with abrasive cloth or paper.
b. Position cap and housing together on cable as indicated. Secure cap in place with tape to prevent resin from leaking through.
c. With cap and housing assembled as shown, clamp the assembly in a vertical position (cable end down, extension wires up). Fill cables with casting epoxy resin in accordance with SAE-AMS3573. Allow the mixture to settle for 20 minutes and pour in more mixture to bring the level to the top of the housing.
d. Allow the epoxy filled assembly to set for approximately four hours at a temperature above 60 °F (15.5 °C). The assembly can then be installed in the stuffing tube. If at any time during the curing process the ambient temperature falls between 40 °F and 60 °F (4.4 °C and 15.5 °C), allow the assembly to set for 8 hours prior to installation in its stuffing tube.

Mixing instructions:

1. Materials: Follow manufacturer's instructions.
2. Precautions:
   a. Caution should be used to ensure that all materials and parts used in this process are clean and free of grease, oil, and other deleterious matter prior to use. The mixing containers used for the epoxy resin and activator should be clean and should be discarded after use.
   b. The following safety precautions should be followed to protect personnel from toxic effects of the amine activator:
      (1) Avoid contact with the skin and eyes. Use protective skin creams, gloves, and goggles as necessary. Use soap and water to remove the activator from the skin. The eyes should be rinsed with copious amounts of fresh water and medical aid obtained.
      (2) Do not inhale fumes. Ample ventilation should be provided to reduce toxic vapor concentrations.
      (3) Good housekeeping is very important. Promptly clean up all drippings, waste, and deposits on tools.
      (4) If any individual worker shows a personal sensitivity to the epoxy resin or activator, he or she should be removed immediately from this work and referred to the medical department.
3. Epoxy resin: Follow manufacturer's instructions.

NOTES:

1. Vinyl electrical tape should be ½ inch wide, conforming to MIL-I-24931.
2. Bi-seal self bonding tape shall be in accordance with ASTM D4388.
3. Tubes shall be in accordance with MIL-S-24235/7 and MIL-S-24235/8.

FIGURE 1A14. Cable end-sealing for inboard pressure-proof installations on submarines – Continued.

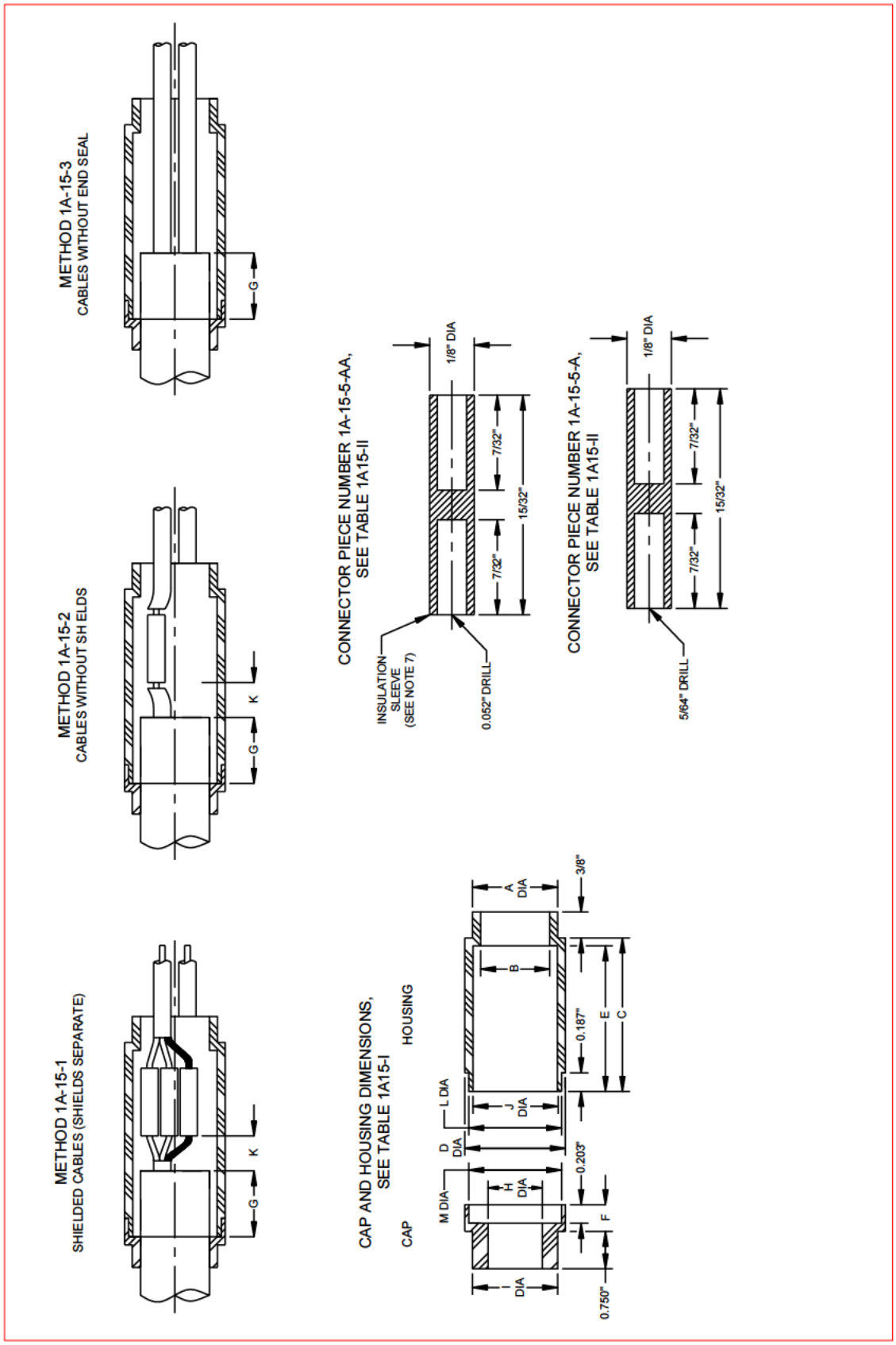


FIGURE 1A15. Cable end-sealing for inboard pressure-proof installations on submarines.

TABLE 1A15-I. Table of dimensions.

PC no.	Tube size	A	B	C	D	E	F	G	H	I	J	K	±0.001 L	±0.001 M
1A-15-4-A	A	0.548	0.437	1.582	0.833	1.500	0.250	½	0.40	0.687	0.625	¼	0.719	0.723
1A-15-4-B	B	0.734	0.625	1.625	1.045	1.500	0.312	½	0.69	0.844	0.812	¼	0.908	0.910
1A-15-4-C	C	0.984	0.875	2.000	1.351	1.875	0.312	½	0.89	1.125	1.125	⅜	1.250	1.254
1A-15-4-D	D	0.984	0.875	2.594	1.351	2.489	0.312	½	1.00	1.125	1.125	⅜	1.250	1.254
1A-15-4-E	E	1.203	1.082	2.000	1.583	1.875	0.312	½	1.11	1.437	1.375	⅜	1.469	1.473
1A-15-4-F	F	1.545	1.437	2.000	2.015	1.875	0.312	½	1.20	1.710	1.807	7⁄16	1.901	1.905

NOTES:

1. End-seals shown on this figure are intended for use on non-watertight cables.
2. Epoxy end-seals shall not be used on any outboard cables.
3. Non-watertight cables which start and terminate within a compartment or which penetrate the pressure hull through a pin-type connector (see MIL-STD-2003-3, figure 3E1, “Cable connections through pressure hulls of submarines”) do not require end-sealing.
4. Watertight cables shall be utilized whenever possible. The use of non-watertight cables shall be resorted to only when watertight cables are not available or when the desired electrical characteristics cannot be obtained in watertight cables.
5. Material for cap and housing (PC 1A-15-4) shall be a low halogen, low smoke, non-PVC, rigid material.
6. Material for connector (PC 1A-15-5) shall conform to MIL-T-16366. Insulation may be loose fitting plastic sleeving in accordance with SAE-AS23053/5, class 1.
7. Ream “H” dimensions on cap PC 1A-15-4 to obtain a snug fit on outside diameter (O.D.) of cable.
8. Tubes shall be in accordance with MIL-S-24235/7 and MIL-S-24235/8.

TABLE 1A15-II. Cable assignment.

Tube size	Cable	O.D.	Connector PC no.	Cap and housing assembly
A	LSDSG-3	0.40	1A-15-5A	1A-15-4A
B	LSTTRS-2	0.69	1A-15-5AA	1A-15-4B
B	LSTTRS-4	0.75	1A-15-5AA	1A-15-4B
C	LSTTRS-6	0.89	1A-15-5AA	1A-15-4C
D	LSTTRS-8	1.00	1A-15-5AA	1A-15-4D
E	LSTTRS-10	1.09	1A-15-5AA	1A-15-4E
E	LSTTRS-12	1.11	1A-15-5AA	1A-15-4E
F	LSTTRS-16	1.20	1A-15-5AA	1A-15-4F

FIGURE 1A15. Cable end-sealing for inboard pressure-proof installations on submarines – Continued.

METHOD 1A-16-1

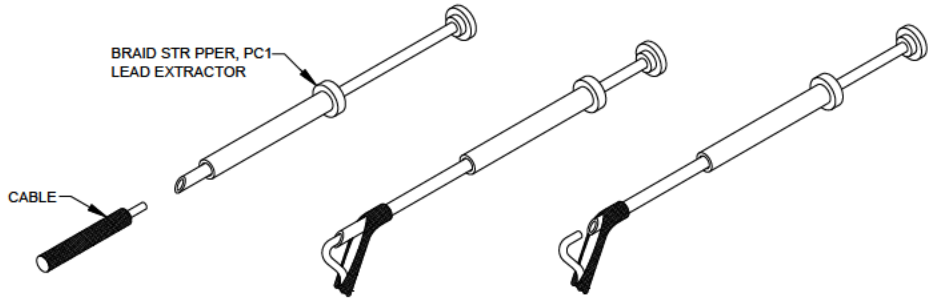
END SEALING OF CABLES IN COILS OR REELS IN COVERED STOWAGE NOT SUBJECT TO ENTRANCE OF WATER SHALL BE ACCOMPLISHED BY A METHOD APPROVED BY A LOCAL SUPERVISOR OF SHIPBUILDING OR NAVAL SHIPYARD.

FIGURE 1A16. End-sealing cables in coils or reels in covered stowage not subject to entrance of water.

General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure

1. The following is a method for separating the braid from shielded wire conductors.

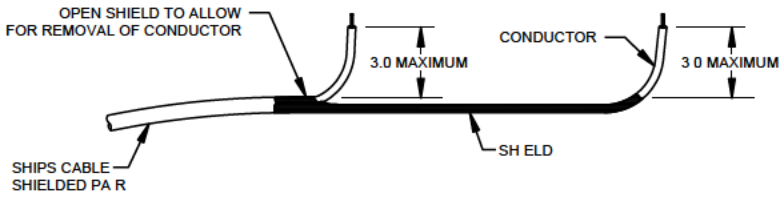
METHOD OF SEPARATING THE BRAID FROM SHIELDED WIRE CONDUCTORS



   a. Slide the pointed tube between the cable insulation and the metal braid.
   b. Bend cable at right angles until point of tube protrudes through the braid and by movement of tool enlarges the hole until of sufficient size to accept the insulated core.
   c. Insert plunger and push core back through the hole in the braid as illustrated.

2. For shielded cable pairs, the maximum distance between the shield termination and all points of the conductor termination shall not exceed 3.0 inches as shown in the following illustration.

EXTRACTING CONDUCTORS FROM A SHIELD



3. Shield grounding wire shall be green and shall be in accordance with ANSI/NEMA HP 8. Gauge shall be equal to or greater than the associated conductor wire gauge. For cable AWG, see table 1A17-I.
4. All uninsulated shield terminators shall be insulated using polyolefin heat-shrinkable tubing to SAE-AS23053/5. See the following illustration for guidance.

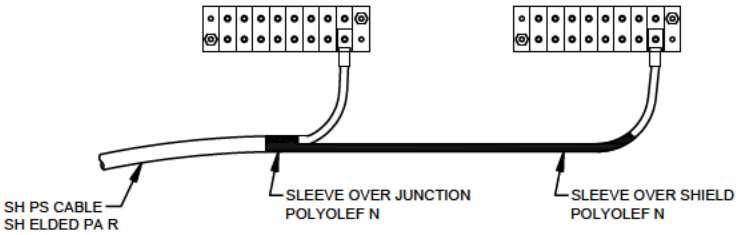
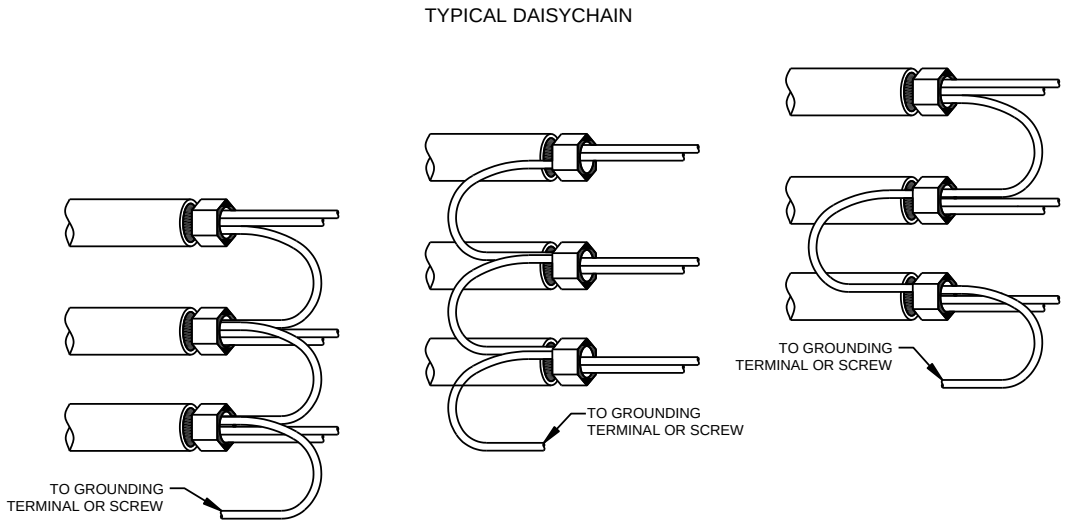


FIGURE 1A17. Grounding of shields of multiple conductor cables.

General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure (continued)

5. Shield ground wire, once attached, shall have lugs installed in accordance with this standard.
6. Multiple shields may terminate using a single wire by daisychaining. Daisychaining may be accomplished using wraparounds, solder sleeves, or compression rings. Grounding wire may be a single wire or individually cut and stripped wires. See the following illustration for guidance and variations for daisychaining.



7. Shield grounding shall be accomplished by one of the following methods:
   a. Compression ring method over multi-conductor cable with double fold (method 1A-17-1) or no-fold (method 1A-17-2)
   b. Compression ring method over multi-conductor cable with single fold (method 1A-18-1)
   c. Cable shield over multiple or single conductor cable (method 1A-18-2)
   d. Conductor shields combined with cable shield inside jacket (method 1A-18-3)
   e. Conductor shields combined with cable armor added to unarmored cable (method 1A-18-4)
   f. Wraparounds (method 1A-18-6)
   g. Solder sleeves (method 1A-18-7)
   h. Hand solder (method 1A-18-8)

TABLE 1A17-I. Cross reference between cable types and sleeve types.

Cable	T & B (now ABB) wraparound		T & B (now ABB) inner/outer			AWG
	Color/RSK No.	Die no.	Inner/GSB No.	Outer/GSC No.	Tool #	
1XMSO-ALL	RED/101	WT101A	YEL/058	PRP/149	WT201	22
2SWF-ALL	BLU/201	WT201F	GRN/124	YEL/205	WT211	22
2XS-ALL	BLU/201	WT201D	RED/109	BLU/175	WT203	22
2XSA-ALL	BLU/201	WT201D	RED/109	BLU/175	WT203	22
2XSAOW-ALL	BLU/201	WT201F	RED/109	BLU/175	WT203	22
2XSAW-ALL	BLU/201	WT201F	RED/109	BLU/175	WT203	22
2XSAWA-ALL	BLU/201	WT201F	RED/109	BLU/175	WT203	22
2XSOW-ALL	BLU/201	WT201F	BLU/149	YEL/261	WT211	18

FIGURE 1A17. Grounding of shields of multiple conductor cables – Continued.

TABLE 1A17-I. Cross reference between cable types and sleeve types – Continued.

Cable	T & B (now ABB) wraparound		T & B (now ABB) inner/outer			AWG
	Color/RSK No.	Die No.	Inner/GSB No.	Outer/GSC No.	Tool #	
2XSW-ALL	BLU/201	WT201F	BLU/149	YEL/261	WT211	18
2XSWA-ALL	BLU/201	WT201F	BLU/149	YEL/261	WT211	18
3XSOW-ALL	BLU/201	WT201F	BLU/149	YEL/261	WT211	18
3XSW-ALL	BLU/201	WT201F	BLU/149	YEL/261	WT211	18
3XSWA-ALL	BLU/201	WT201F	BLU/149	YEL/261	WT211	18
LS1SWA-ALL	YEL/301	WT301G	BLU/149	PRP/225	WT209	22
LS1SWU-ALL	YEL/301	WT301G	BLU/149	PRP/225	WT209	22
LS2SA-ALL	BLU/201	WT201C	TIN/128	RED/194	WT206	22
LS2SJ-12	GRN/401	WT401K	TIN/287	RED/405	WT218	12
LS2SJ-14	GRN/401	WT401K	TIN/219	YEL/312	WT215	14
LS2SJ-16	YEL/301	WT301J	BLU/194	BLU/287	WT214	16
LS2SJ-18	YEL/301	WT301H	TIN/165	YEL/261	WT211	18
LS2SJ-20	YEL/301	WT301G	BLU/149	YEL/261	WT211	20
LS2SJ-22	BLU/201	WT201E	ORG/134	GRN/219	WT208	22
LS2SJA-12	GRN/401	WT401K	TIN/287	RED/405	WT218	12
LS2SJA-14	GRN/401	WT401K	TIN/219	YEL/312	WT215	14
LS2SJA-16	YEL/301	WT301J	BLU/194	BLU/287	WT214	16
LS2SJA-18	YEL/301	WT301H	TIN/165	YEL/261	WT211	18
LS2SJA-20	YEL/301	WT301G	BLU/149	YEL/261	WT211	20
LS2SJA-22	BLU/201	WT201E	ORG/134	GRN/219	WT208	22
LS2SU-ALL	YEL/301	WT301G	TIN/128	RED/194	WT206	22
LS2SUS-ALL	YEL/301	WT301G	TIN/128	RED/194	WT206	22
LS2SWA-ALL	YEL/301	WT301G	GRN/124	RED/194	WT206	22
LS2SWAU-ALL	YEL/301	WT301G	GRN/124	RED/194	WT206	22
LS2SWU-ALL	YEL/301	WT301G	TIN/219	BLU/287	WT214	18
LS2SWUA-ALL	YEL/301	WT301G	TIN/219	BLU/287	WT214	18
LS3SA-ALL	GRN/401	WT401K	TIN/219	BLU/287	WT214	18
LS3SJ-12	GRN/401	WT401K	TIN/287	RED/405	WT216	12
LS3SJ-14	GRN/401	WT401K	TIN/219	YEL/312	WT215	14
LS3SJ-16	YEL/301	WT301J	BLU/194	BLU/287	WT214	16
LS3SJ-18	YEL/301	WT301H	TIN/165	YEL/261	WT211	18
LS3SJ-20	YEL/301	WT301G	BLU/149	YEL/261	WT211	20
LS3SJ-22	BLU/201	WT201E	ORG/134	GRN/219	WT208	22

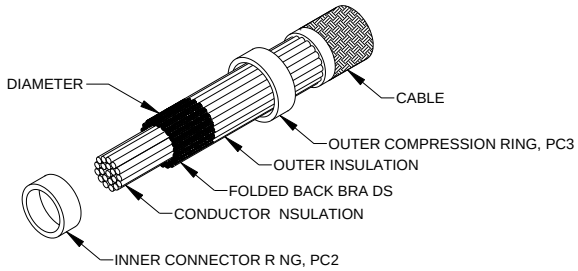
FIGURE 1A17. Grounding of shields of multiple conductor cables – Continued.

TABLE 1A17-I. Cross reference between cable types and sleeve types – Continued.

Cable	T & B (now ABB) wraparound		T & B (now ABB) inner/outer			AWG
	Color/RSK No.	Die No.	Inner/GSB No.	Outer/GSC No.	Tool #	
LS3SJA-12	GRN/401	WT401K	TIN/287	RED/405	WT216	12
LS3SJA-14	GRN/401	WT401K	TIN/219	YEL/312	WT215	14
LS3SJA-16	YEL/301	WT301J	BLU/194	BLU/287	WT214	16
LS3SJA-18	YEL/301	WT301H	TIN/165	YEL/261	WT211	18
LS3SJA-20	YEL/301	WT301G	BLU/149	YEL/261	WT211	20
LS3SJA-22	BLU/201	WT201E	ORG/134	GRN/219	WT208	22
LS3SU-ALL	GRN/401	WT401K	TIN/219	BLU/287	WT214	18
NOTE: Equivalent sleeves may be used (see 4.2).						

FIGURE 1A17. Grounding of shields of multiple conductor cables – Continued.

METHOD 1A-17-1
CONDUCTOR SH ELDS OF MULTI-CONDUCTOR CABLE
(DOUBLE FOLD METHOD)
SEE 1A-18-1 - SINGLE FOLD BACK
AND 1A-17-2 - NO FOLD BACK



Observe the applicable above, “General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure.”

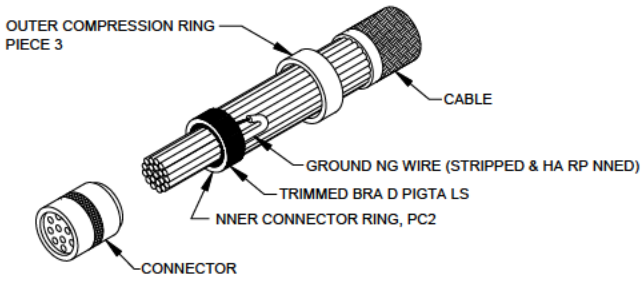
Step 1 – Preparation of shielded conductors:

The inner conductor is pushed through the braid and the braid folded back. This may be done with a blunt instrument or with lead extraction tool shown above. Flatten the braid pigtail by hand, and fold back against the cable bundle.

Step 2 – Selection of ring size:

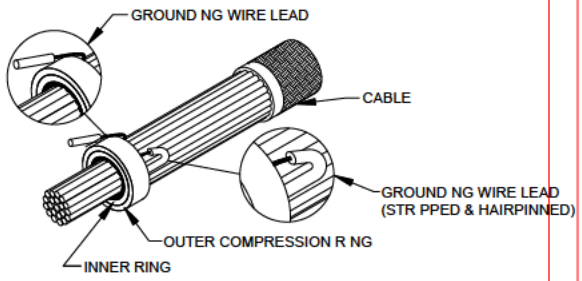
The inner collector ring PC 2, outer compression ring PC 3, and the compression die PC 4 sizes shall be selected from table 1A17-I or determined by measuring the diameter of the bundle over the folded back braids. The collector ring with the inside diameter nearest the diameter of the cable is selected with the matching set of compression ring and compression die collector, and compression rings and compression die are matched by color coding.

FIGURE 1A17. Grounding of shields of multiple conductor cables – Continued.



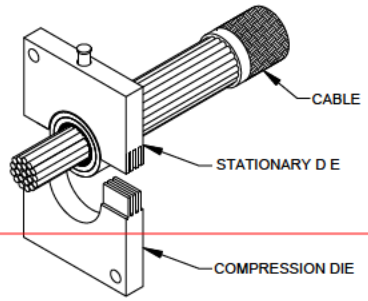
Step 3 – Assembling of rings:

The outer compression ring is slipped back over the folded back braids. The inner collector ring is placed over the braids so that the collector ring is as close to the folded end of the braid as possible. Fold the exposed ends of the braid pigtails over the collector ring, evenly distribute the braids around the periphery of the collector ring. Trim the ends of the pigtails even with the edge of the ring.



Step 4 – Positioning compression ring:

Position the compression ring over the folded back braids. Carefully locate the outer ring in the center of the inner ring. Insert the grounding lead or leads between the braids and the outer compression ring.

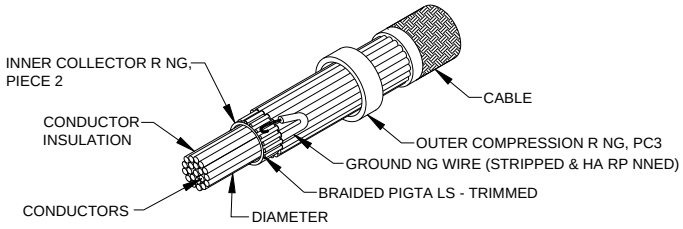


Step 5 – Compression:

The assembly is then placed in the installing tool and the compression ring is forced into the stationary die. The compression is completed when the pump bypasses or the gauge reads 9600 psi.

FIGURE 1A17. Grounding of shields of multiple conductor cables – Continued.

METHOD 1A-17-2
CONDUCTOR SHIELDS OF MULTI-CONDUCTOR CABLE
(NO FOLD BACK)



Observe the applicable above, "General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure."

Step 1 – Preparation of shielded conductors:

Prepare shielded conductors as for double-folded method 1A-17-1, step 1 except do not fold back braid pigtails.

Step 2 – Selection of ring size:

Select the inner collector ring PC 2 from table 1A17-I or with the inside diameter nearest to the diameter of the conductor bundle under braid pigtails. Compression ring PC 3 and compression die PC 4 shall be selected with matching color code.

Step 3 – Assembly of rings:

Slide outer compression ring over cable bundle. Place inner ring under the braid pigtails. Flatten pigtails by hand and evenly distribute around the periphery of the inner ring. Trim excess braids even with front edge of ring. Position outer compression ring over braids and insert grounding lead between braid and outer ring. Carefully locate the outer ring in the center of the inner ring.

Step 4 – Compression:

Select the proper compression die and compress the assembly as for the double-fold method 1A-17-1, step 5.

List of material:

The following material shall be Thomas & Betts (now ABB), Shield-Kon Shielded Cable Connectors, or equal (see 4.2):

PC 1, Lead extractor – Size as required.

PC 2, Inner collector ring – Size as required (see table 1A18-I).

PC 3, Outer compression ring – Size as required (see table 1A18-I).

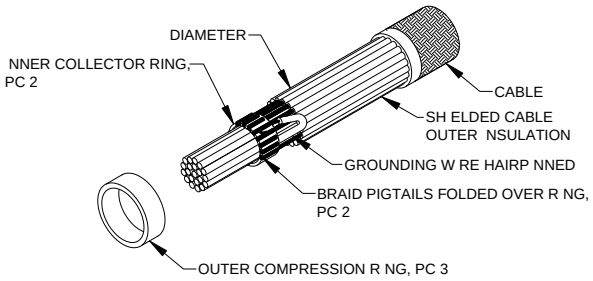
PC 4, Installing die – Size as required.

NOTES:

1. Tests for grounding ring connectors in figure 1A18 (method 1A-18-5) and note 1 in figure 1A18 shall apply.
2. The use of wire, solder, and heat shrink is an acceptable method and may be used when applicable to terminate gross and individual shields.

FIGURE 1A17. Grounding of shields of multiple conductor cables – Continued.

METHOD 1A-18-1
CONDUCTOR SHIELDS OF MULTI-CONDUCTOR CABLE
(S NGLE FOLD METHOD)



Observe the applicable figure 1A17 “General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure.”

Method 1A-18-1

Step 1 – Preparation of shielded conductors:

Prepare shielded conductors as for double-folded method 1A-17-1, step 1 except do not fold back braid pigtails.

Step 2 – Selection of ring size:

Select the inner collector ring PC 2 with the inside diameter in accordance with table 1A17-I or nearest to the diameter of the conductor bundle over braids before pigtailing. Compression ring PC 3 and compression die PC 4 shall be selected with matching color code.

Step 3 – Assembly of rings:

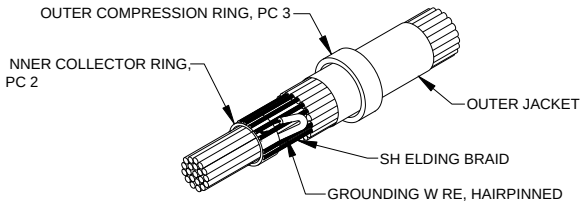
Place the inner collector ring over the cable bundle. Flatten the braid pigtails by hand and fold back over inner collector ring. Evenly distribute the pigtails around the periphery of the ring. Trim excess braid even with the back edge. Position outer compression ring over the braids. Insert grounding lead between braid and outer ring. Carefully locate the outer ring in the center of the inner ring.

Step 4 – Compression:

Select the proper compression die, and compress the assembly in accordance with method 1A-17-1, step 5.

FIGURE 1A18. Grounding of shields of multiple conductor cables.

METHOD 1A-18-2
CABLE SHIELD OVER MULT PLE OR SINGLE CONDUCTOR CABLE



Observe the applicable figure 1A17 "General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure."

Method 1A-18-2

Step 1 – Preparation of shielding braid:

Strip back outside insulation or jacket without cutting, nicking, or breaking braid strands.

Step 2 – Selection of ring size:

Select the rings in accordance with the single fold forward method 1A-17-2, step 2.

Step 3 – Assembly of rings:

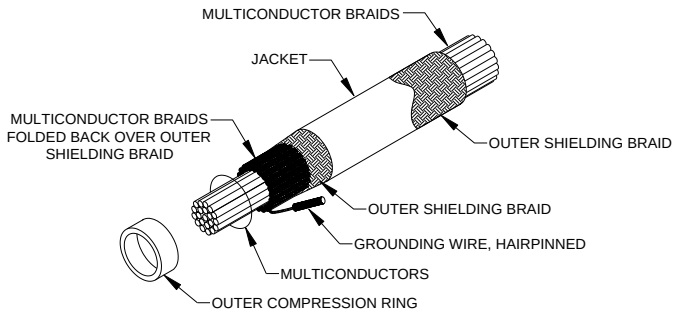
Slide outer ring over braid bundle. Trim braid to approximately 1½ inches from jacket and fan slightly. Slide inner ring over bundled conductors and under braids. Insert grounding lead between braid and outer ring as outer ring is assembled over braided shield. Carefully locate the outer ring in the center of the inner ring.

Step 4 – Compression:

Select the proper compression die, and compress the assembly in accordance with the double-folded method 1A-17-1, step 5.

FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

METHOD 1A-18-3
CONDUCTOR SHIELDS COMB NED WITH
CABLE SH ELD INS DE JACKET



Observe the applicable figure 1A17 “General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure.”

Method 1A-18-3

Step 1 – Preparation of shielded conductors:

Trim braid to approximately 1½ inches from jacket and fan slightly. Prepare shielded conductors as for double-folded method 1A-17-1, step 1 except do not fold back braid pigtails.

Step 2 – Selection of ring size:

Select the rings in accordance with the double-fold method 1A-17-1, step 2, figure 1A17.

Step 3 – Assembly of rings:

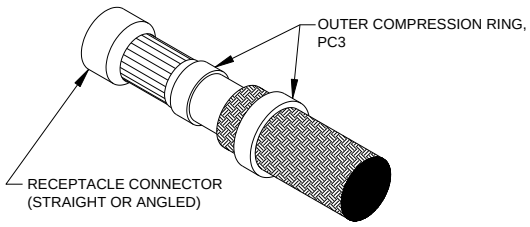
Place the inner collector ring over the cable outer shield. Then fold the outer shield back over the inner ring. Flatten the braid pigtails by hand and fold back over the outer shield and inner ring. Place outer compression ring over the shield and braids. Insert grounding lead between braids and outer ring. Carefully locate the outer ring in the center of the inner ring. (NOTE: The inner ring cannot be seen in the above illustration as it is beneath the folded shields.)

Step 4 – Compression:

Select the proper compression die, and compress the assembly in accordance with the double-fold method 1A-17-1, step 5, figure 1A17.

FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

METHOD 1A-18-4
CONDUCTOR SHIELDS COMBINED WITH
CABLE ARMOR OR WITH ARMOR ADDED
TO UNARMORED CABLE



Observe the applicable figure 1A17 “General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure.”

Method 1A-18-4

Step 1 – Ring assembly for the multi-conductor braid:

Fold the outer shielding braid back to allow the multi-conductor braid to be banded by method 1A-18-1 (methods 1A-17-1 and 1A-17-2 on figure 1A17).

Step 2 – Assembly of third ring:

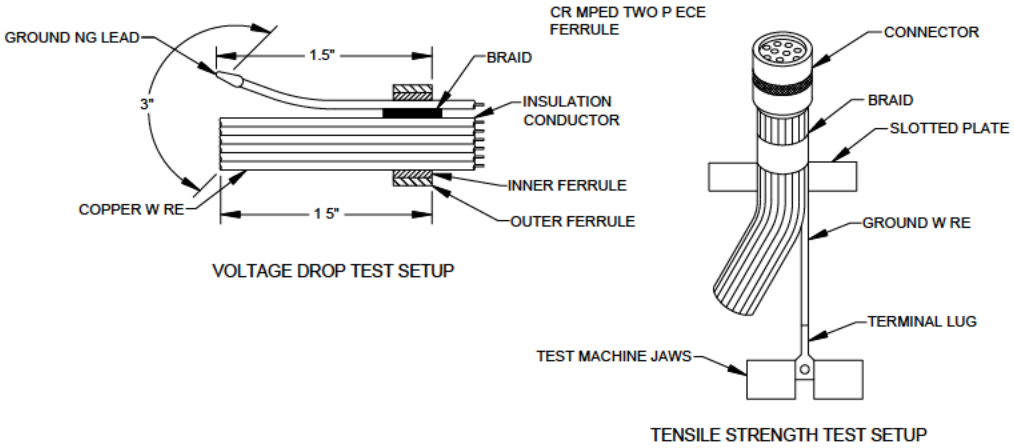
A second outer ring is placed over the outer shielding braid. This ring shall be large enough to go over the assembly in step 1 plus the outer braid. Fold the outer shielding braid over the compressed grounding ring. Trim outer braid even with the inner ring. Carefully locate the outer ring in the center of the grounding assembly.

Step 3 – Compression:

Select the proper compression die, and compress the second outer ring over the first outer ring.

FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

METHOD 1A-18-5
TESTS FOR GROUNDING RING CONNECTORS



VOLTAGE DROP TEST SETUP

TENSILE STRENGTH TEST SETUP

Method 1A-18-5

Step 1 – Voltage drop test:

Conduct a voltage drop test across the compressed connection from the intersection of the tongue and the barrel of the grounding wire terminal lug to a point on each shield wire using one ampere for test currents with assembly at room temperature to determine compliance with table 1A18-I.

Step 2 – Temperature cycling:

Prepare connections with minimum and maximum braid shield fill and subject them to alternate heating-cooling cycles. Complete the cycle by heating to 300 °F (148.8 °C) in air circulation over for 30 minutes, cooling to 85 °F (29.4 °C) for 30 minutes. Perform voltage drop, step 1, before and after heat cycling to indicate quality of the joint.

Step 3 – Tensile strength:

The tensile strength between the ground wire and compression rings and individual braids and rings shall be in accordance with table 1A18-I.

FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

TABLE 1A18-I. Voltage drop and tensile strength test criteria.
see step 1 (voltage drop test) and step 3 (tensile strength)

Inner collector ring		Outer compression ring		⅛" braid approx. no. braids	Number ground leads	Average mV drop 1 amp	Average tensile strength (lbs.)
I.D.	O.D.	I.D.	O.D.				
0.430	0.500	0.590	0.670	5 to 14	2 #20 STR	1.03	39.6
0.550	0.620	0.710	0.790	5 to 17	2 #20 STR	1.04	33.9
0.670	0.750	0.840	0.920	5 to 20	2 #20 STR	0.77	35.9
0.810	0.880	1.010	1.090	5 to 23	2 #20 STR	0.86	38.6
0.920	1.000	1.130	1.210	5 to 27	2 #20 STR	0.89	30.0
1.040	1.120	1.250	1.330	5 to 30	2 #20 STR	0.83	39.0
1.222	1.192	1.332	1.412	5 to 34	2 #20 STR	0.82	36.0
1.224	1.294	1.440	1.520	5 to 37	2 #20 STR	0.90	36.5
1.353	1.423	1.563	1.643	5 to 41	2 #20 STR	0.87	35.4
1.425	1.545	1.670	1.750	5 to 43	2 #20 STR	0.73	31.0
1.550	1.670	1.795	1.875	5 to 47	2 #20 STR	0.70	31.0
1.675	1.795	1.920	2.000	5 to 52	2 #20 STR	0.71	30.0
1.800	1.920	2.045	2.125	5 to 56	2 #20 STR	0.71	30.0
1.925	2.045	2.170	2.250	5 to 62	2 #20 STR	0.69	29.0

NOTES:

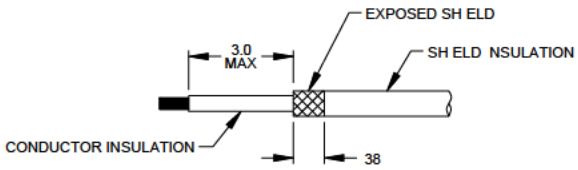
1. Installing activity shall run dielectric and insulation resistance on samples of each different ring size and method for each typical cable type to ascertain no damage is being done to conductor or cable insulation. Dielectric and insulation resistance tests are in accordance with MIL-STD-202, methods 301 and 302.
2. The use of wire, solder, and heat shrink is an acceptable method and may be used when applicable to terminate gross and individual shields.

FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

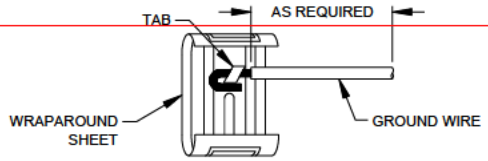
Method 1A-18-6
Cable Shield Termination Using Wraparounds, SAE-AS21608

Observe the applicable figure 1A17 "General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure."

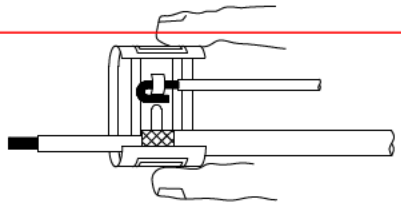
1. Remove a sufficient amount of the braided copper shield to allow for separation of conductor(s), maximum of 3.0 inches to the point of termination. Remove approximately 0.38 inch of insulation covering braided copper shield.



2. Select a wraparound sheet corresponding to the cable type from table 1A17-I. Strip a sufficient length of insulation from a length of insulation from a length of ground wire. Hook the bared end of the ground wire onto the wraparound tab as shown in the following illustration. Use needle nose pliers, or equivalent, to bend the tab back over the wire.



3. Place the exposed shield into the bottom of the wraparound sleeve. Center the exposed cable shield. Shape the wraparound to the cable by squeezing the wraparound closed with fingers or pliers. The top of the wraparound shall overlap the bottom.



4. Ensure that the ground wire and shield are in their proper place within the wraparound. Insert the wraparound assembly into the crimping tool with the ground wire towards the upper die and compress the assembly.

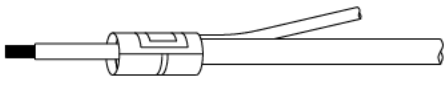
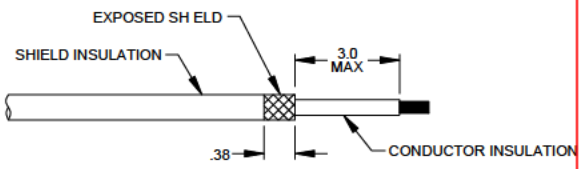


FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

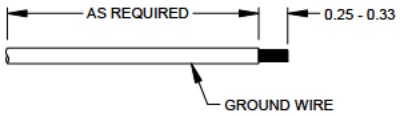
Method 1A-18-7
Cable Shield Termination Using Solder Sleeves, SAE-AS83519

Observe the applicable figure 1A17 "General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure."

1. Remove a sufficient amount of the braided copper shield to allow for separation of conductor(s), maximum of 3.0 inches to the point of termination. Remove approximately 0.38 inch of insulation covering braided copper shield.



2. Strip ground wire as shown in the following illustration.



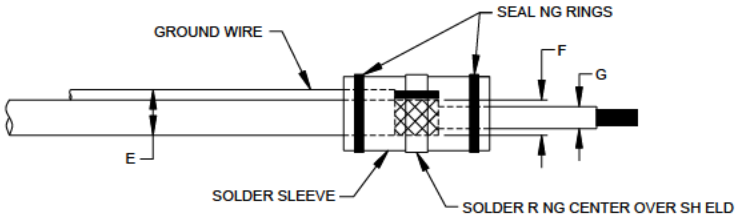
3. Select the proper size solder sleeve from table 1A18-II.

TABLE 1A18-II. Solder sleeve sizes.

Part no.	Marking code	Cable dimension		
		E max.	F min.	G min.
M83519/1-1	SO101R	0.105	0.035	0.020
M83519/1-2	SO102R	0.145	0.055	0.030
M83519/1-3	SO103R	0.200	0.085	0.050
M83519/1-4	SO104R	0.255	0.130	0.070
M83519/1-5	SO105R	0.300	0.170	0.100

FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

4. Center the solder sleeve solder ring over the exposed cable shield. Insert the ground wire into the solder sleeve as shown in the following illustration.



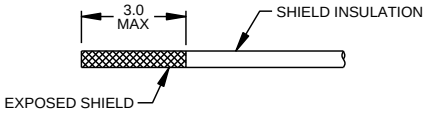
5. Shrinking instructions: Caution - do not overheat the sleeve to prevent the underlying conductor insulation from being damaged.
   a. Prepare heating tool, UNGAR 7966C, Raychem CV 5300, or equal (see 4.2).
   b. Start by heating the entire length of the sleeve to start the shrinking.
   c. Apply heat to the solder ring at the center of the sleeve. Continue to apply heat to the solder ring until it disappears and flows evenly throughout the ground wire and shield.
   d. If required, finish heating by applying heat to the sealing rings at each end of the sleeve.
   e. Inspect the sleeve to ensure the sleeve is not burnt, split, or punctured; that the solder ring has completely disappeared; and that there exists a fillet of solder between the conductor and the shield.

FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

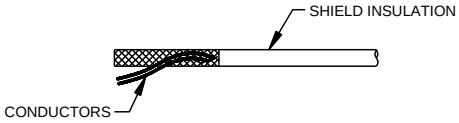
Method 1A-18-8
Cable Shield Termination Using Hand Soldering

Observe the applicable figure 1A17 "General Requirements, Procedures, and Precautions for Grounding of Cable Shields Within an Enclosure."

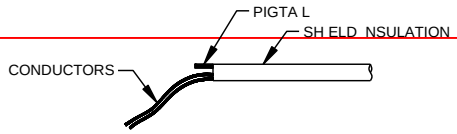
1. Remove insulation over the shielded cable a maximum of 3.0 inches using care not to damage the underlying braid.



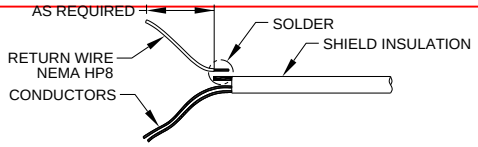
2. Open a hole in the braid as close as practicable to the insulation. Pull conductors through the hole.



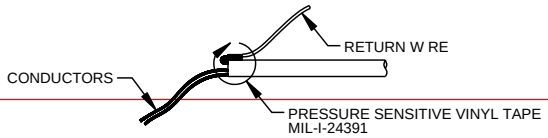
3. Stretch and twist the braid into a solid piece forming a pigtail.



4. Cut back the pigtail to approximately 0.5 inch. Strip 0.5 inch of insulation from a 4.0-inch piece of shield return wire that is in accordance with ANSI/NEMA HP 8. Wire gauge should be equal or greater than the conductor gauge. Solder the exposed part of the wire to the shield pigtail. Use care not to damage the wire insulation.



5. Fold back the solder joint onto the shield insulation and wrap with insulating tape.



6. Double back the ground wire over the tape and secure with heat shrink tubing. Tubing shall overlap exposed wire/shield by 0.5 inch on each side.

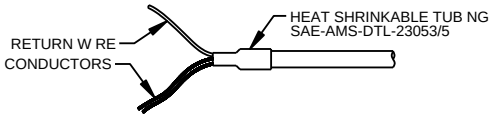


FIGURE 1A18. Grounding of shields of multiple conductor cables – Continued.

METHOD 1A-19-1

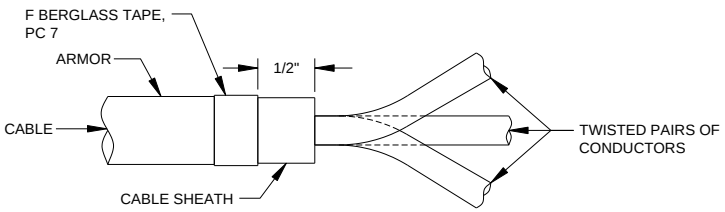


ILLUSTRATION 1
END PREPARATION OF CABLE SHEATH

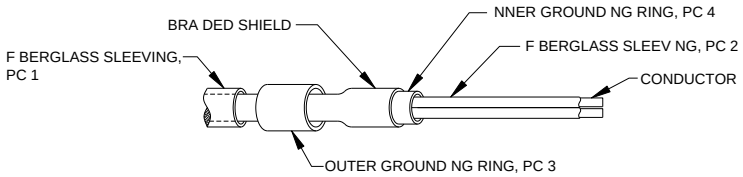


ILLUSTRATION 2
PREPARATION OF CONDUCTORS

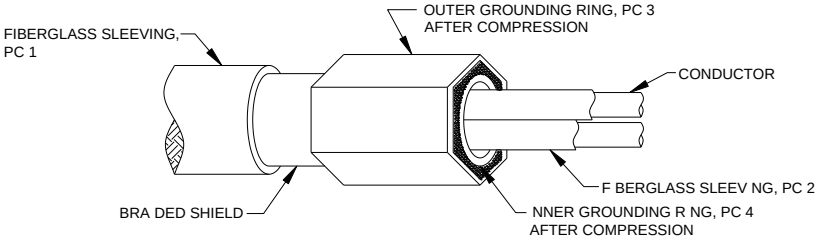


ILLUSTRATION 3
PREPARING BRAIDED SHIELD TERM NATION
WHEN GROUNDING IS NOT REQUIRED

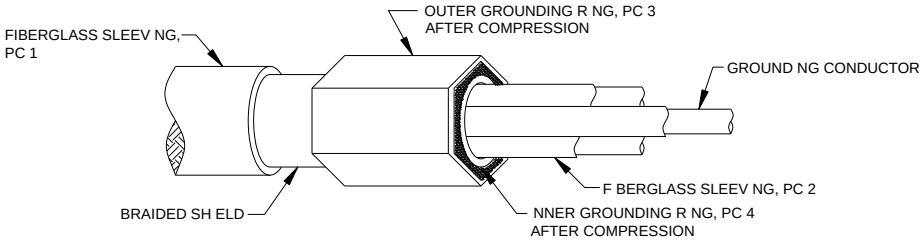


ILLUSTRATION 3A
PREPARING BRAIDED SHIELD WHEN
GROUNDING IS REQUIRED

FIGURE 1A19. End preparation of position indicator type cables.

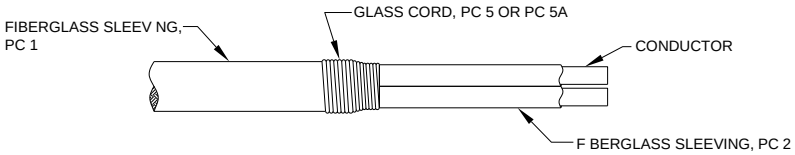


ILLUSTRATION 4
END PREPARATION OF BRAIDED SH ELD
(GROUND NG CONDUCTOR NOT SHOWN)

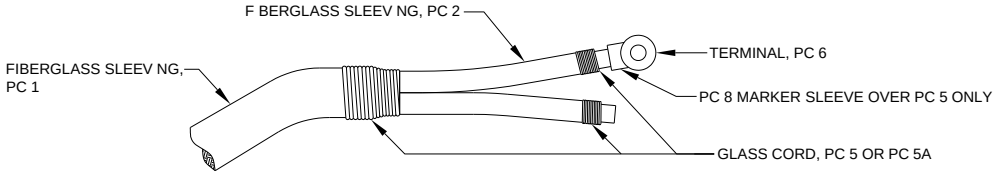
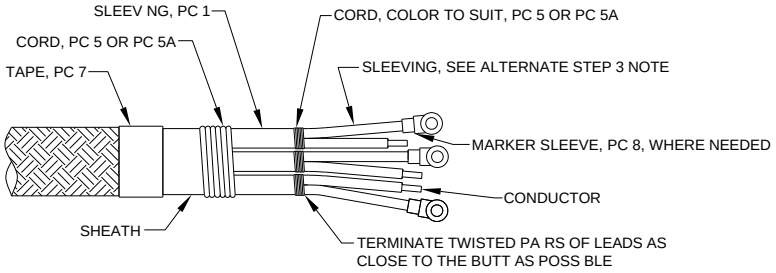


ILLUSTRATION 5
END PREPARATION OF CONDUCTOR
(GROUND NG CONDUCTOR NOT SHOWN)



LLUSTRATION 6
PREPARING BRAIDED SHIELD TERMINATION
WHEN GROUNDING IS NOT REQUIRED

FIGURE 1A19. End preparation of position indicator type cables – Continued.

End preparation of position indicator (PI) type cables (see table 1A19-I)

Step 1 (see illustration 1):

If the cable is armored, wrap cable with plastic tape at point where cable armor is to be cut. Cut through tape and armor being careful not to injure the rubber cable sheath. Remove the tape from the excess armor and slip the armor off end of cable. Remove the remainder of plastic tape and replace with fiberglass tape (PC 7). Cut cable sheath ½ inch from end of glass tape and remove along with all other material outside of the glass braid (over the braided shield) on each shielded pair. The glass braid shall only be cut back (and secured with tape, PC 7) as necessary to install outer grounding ring (PC 3) on shield.

Step 2 (see illustration 2):

Remove a sufficient length of the braided shield to allow for separation of individual conductors. Enclose shielded pair of conductors with fiberglass sleeving (PC 1). Length to be cut shall be determined by distance from butt of cable to ½ inch beyond braided shield. Force length of fiberglass sleeving toward butt far enough for end of sleeving to clear end of braided shield and secure temporarily with plastic tape. Slide outer grounding ring (PC 3) over conductors and braided shield. Enclose separate conductors with fiberglass sleeving (PC 2). Slide inner grounding ring (PC 4) over fiberglass sleeving enclosing conductors to a point where braided shield may be drawn over inner ring. See figures 1A17 and 1A18.

Step 3 (see illustration 3):

Draw the braided shield and the outer grounding ring (PC 3) over the inner grounding ring (PC 4) to a point where their edges are in alignment. Be certain that the fiberglass sleeving (PC 2) on conductors is well under the inner grounding ring (PC 4). Compress grounding rings in place using a Thomas & Betts (now ABB) tool, or equal (see 4.2).

Step 3A (see illustration 3A):

When grounding of braided shield is required, a grounding conductor at least as large in circular mil area as the individual conductor shall be used and the bare portion of the conductor shall be inserted between the shielded braid and the outer ring and included in the compression process. Where grounding takes place at equipment end of cable, and high temperature is a factor, grounding conductor shall be of PI cable.

Step 4 (see illustration 4):

Remove plastic tape from fiberglass sleeving (PC 1). Draw sleeving over compressed grounding ring and conductors and serve with glass cord (PC 5 or 5A). Sleeving shall also be served with glass cord (PC 5 or 5A) at butt end of cable.

Step 5 (see illustration 5):

Secure terminal (PC 6) to conductor. Draw conductor sleeving down and secure to terminal with insulation grip of terminal, for Type WTG terminal only. Serve conductor sleeving with glass cord (PC 5 or 5A) at terminal connection.

Alternate method (see illustration 6):

As an alternate to use of inner and outer rings, use size 11 (or size to suit) fiberglass sleeving (PC 2A). Use on the individual leads extending ¼ inch under the copper braid of the twisted pairs. Cover the overlapped joint with tape (PC 7) and serve with glass cord (PC 5 or 5A) over tape.

FIGURE 1A19. End preparation of position indicator type cables – Continued.

TABLE 1A19-I. List of materials.

PC no.	Description	Matl spec	Matl reqt	NSN or MFG PT no. (see 4.2)	Remarks (see 4.2)
1	Fiberglass sleeving, single wall, natural color, size 3 (or size to suit)	MIL-I-3190/6	Class 200, type D, catalog C	Bentley-Harris Mfg Co. catalog no. 0203001M, or equal	Silicone oil impregnated in lieu of silicone rubber coated (see notes 2 and 8)
2	Fiberglass sleeving, single wall, natural color, size 12 (or size to suit)	MIL-I-3190/6	Class 200, type D, catalog C	Bentley-Harris Mfg Co. catalog no. 0212006M, or equal	Silicone oil impregnated in lieu of silicone rubber coated (see note 8)
2A	Fiberglass sleeving, single wall, natural color, size 11 (or size to suit)	MIL-I-3190/6	Class 200 type D, catalog C	Bentley-Harris Mfg Co. catalog no. 0211001M, or equal	Silicone oil impregnated in lieu of silicone rubber coated
3	Outer grounding ring	-	-	Thomas & Betts (now ABB) style GSC, or equal	Pre-insulated type uni-rings shall not be installed where the temperature may exceed 250 °F
4	Inner grounding ring	-	-	Thomas & Betts (now ABB) style GSB-X, or equal	Pre-insulated type unirings shall not be installed where the temperature may exceed 250 °F (see note 5)
5	Glass cord, 0.020 to 0.026 diameter (prior to treatment), natural color	MIL-Y-1140	Type EC9-2U	-	For high temperature application over 200 °F (93 °C) (see material note M1)
5A	Glass cord, colors: black, green, red and white	MIL-I-3158	Type SR-5	-	For temperature application less than 200 °F (93 °C) (see note 1)
6	Lug terminal, WT or WTG	MIL-T-16366 or SAEAS7928	Type 1	-	See note M2
7	Fiberglass tape, pressure sensitive	A-A-59770	Type GFT	-	Either tape may be used except that the A-A-59770 tape shall not be installed where the temperature may exceed 250 °F
	Silicone tape, pressure sensitive	MIL-I-19166	-	-	
8	Marker sleeve, size to suit	MIL-I-3190/6	Class 200, type D, category C	-	See material note M3 and note 9. Raychem HT-SCE, or equal, may be substituted.
9	Indelible ink	A-A-208	-	-	Or equal for printing on marker sleeves
10	Varnish, synthetic	-	-	AC-43	Manufactured by John C. Dolph Company, or equal

FIGURE 1A19. End preparation of position indicator type cables – Continued.

Material notes:

M1. Cord shall be silicone treated in place of cord color-coding for conductor ends. Use marker sleeves (PC 8) over short sleeving of PC 5 as shown on illustrations 5 and 6. Mark with appropriate designation by stamping or hand lettering with marking ink (and then baking or sealing with Teflon spray) or by an equal (see 4.2) (approved) high temperature method. Where conductor sleeving is secured with insulation grip of terminal, the short sleeving of PC 5 may be omitted.

M2. Lug terminals on conductors for resistance temperature detectors and valve position transmitters or other units where ambient temperature is 347 °F (175 °C) or above shall be silver-plated.

M3. Mark with appropriate designation by stamping or hand lettering with marking ink (and then baking or sealing with Teflon spray) or by an equal (see 4.2) (approved) high temperature method.

NOTES:

1. Synthetic resin tubing SAE-AS23053/5, class 1, may be used in lieu of glass cord for finishing conductor ends in enclosures where normal temperatures are anticipated.
2. Fiberglass sleeving, PC 1 (only), shall not be required in components such as connection boxes and switchboards where possibility of mechanical damage is not evident.
3. Wire identification marking ink should be type 6646, purple, manufactured by the Markem Machine Co., Keene, N.H., or equal (see 4.2).
4. Use of stuffing tubes installed in reactor equipment exposed to high temperature is shown on figure 1B7.
5. Select the proper inner grounding ring (PC 4) to be 0.005 to 0.010 larger than the conductor insulation and fiberglass sleeving, PC 2. The outer grounding ring (PC 3) should be selected for a snug fit over the braided shield (allowing for the inner grounding ring, PC 4, braided shield and grounding wire or wires).
6. Lug terminals (PC 6), type 1 or WT, shall be crimped and then soldered to the conductor for all primary plant resistance temperature detector cables. Solder type at detector end shall be Sb5-W-R-P3 (IPC/EIA J-STD-006) and type Sn60-W-R-P3 (IPC/EIA J-STD-006) at the terminal box end of the cable.
7. PI cable handling: Due to the nature of its construction, PI cable is more susceptible to internal damage when handled improperly than are other types of cable. Therefore, the following general handling requirements shall be strictly adhered to for PI cable.
   a. Never bend the cable tighter than its minimum bend radius.
   b. Whenever removing cable from a reel or coiling or uncoiling pre-cut lengths, exercise extreme care to ensure that the cable is not kinked or twisted.
   c. Always unroll cable from a reel or coil since looping it off the side causes harmful kinks.
   d. Never use mechanical means, such as rope or chain falls, to pull cable taut.
   e. Ensure that cables are protected from mechanical damage at all times, especially in areas where personnel would be likely to step on or place objects upon the cable.
8. PC 1 and PC 2 may be silicone rubber treated fiberglass sleeving in accordance with MIL-I-3190.
9. For temperature applications less than 200 °F (90 °C), sleeving in accordance with SAE-AS23053/5, class 1 may be used in lieu of PCs 1, 2, and 8. When using sleeving in accordance with SAE-AS23053/5, class 1, the use of glass cord (PC 5 and PC 5A) or varnish (PC 10) is not required.
10. Use of glass cord (PC 5 and PC 5A) is not required when silicone rubber treated fiberglass sleeving is used for PC 1 and 2. The sleeving shall be secured by varnish (PC 10) applied to crotch of cable and conductors (if grounding is not required) and allowed to dry before installing sleeving.
11. The use of wire, solder, and heat shrink is an acceptable method and may be used when applicable to terminate gross and individual shields.

FIGURE 1A19. End preparation of position indicator type cables – Continued.

Method 1A-20-1
Cable End Preparation – Screw Clamp Terminals (Ferrules)

1. This method shall be used when the equipment to be connected uses mechanical connectors. Mechanical connectors are defined as threaded stud type cable terminals, split bolt terminals, main bus terminals in fuse boxes or screw clamp terminals such as circuit breaker connections.
2. The ferrules are used with stranded conductor wire to better contain the strands and prevent damage. Ferrules are not required for conductors with area greater than 9,000 circular mils.
3. See table 1A20-I for a list of ferrules and some common manufacture part numbers.
4. Strip wire insulation lengths to allow the end of the wire to be flush with the end of the ferrule. See table 1A20-I for recommended strip lengths (see detail A).
5. Place the metal shaft of the ferrule into the crimping tool. Compress the tool to crimp along the length of the ferrule. The shape of the crimp depends on the tool used. See table 1A20-I for list of recommended crimping tools. The brand of the crimping tool does not need to match to the brand of ferrule (see detail C).
6. If two wires are to connect to the same terminal point, twin (or double) wire ferrules shall be used (see detail E).

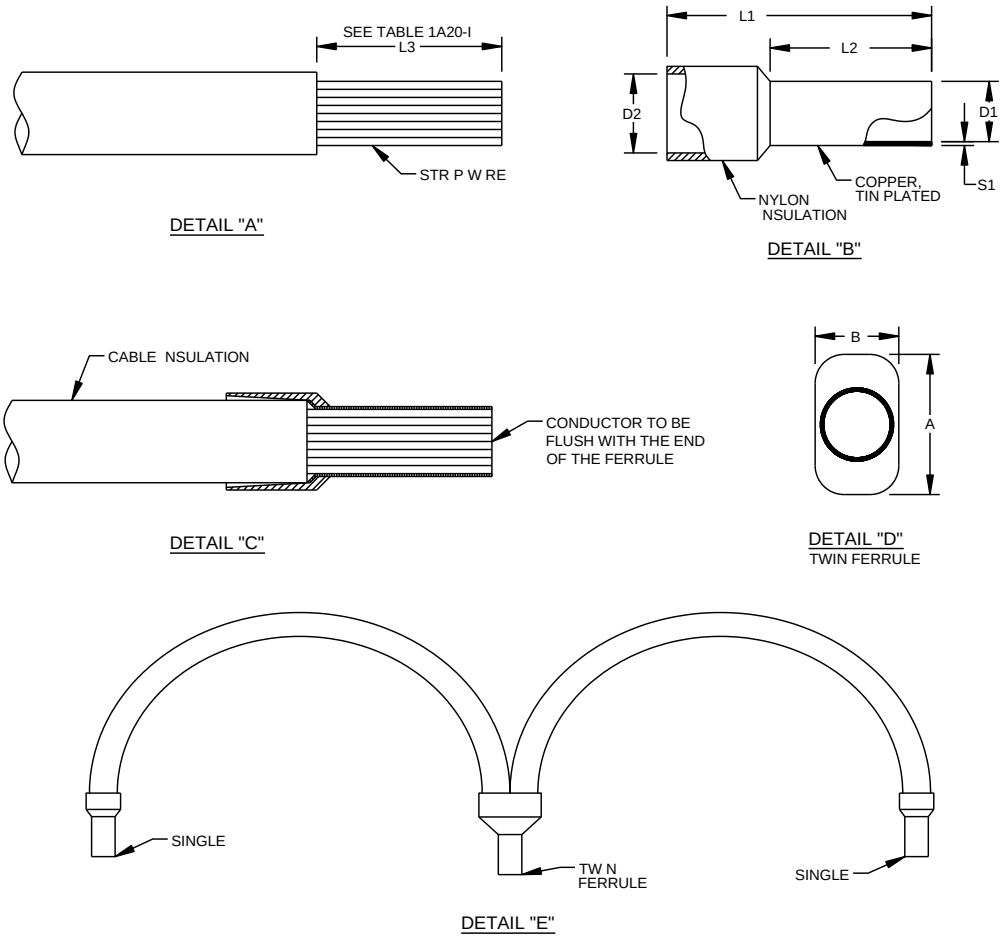


FIGURE 1A20. Cable end preparation – screw clamp terminals (ferrules).

TABLE 1A20-I. Selection of clamp terminal and tools for single barrel screw clamp terminals.

Wire AWG	mm^2	Thomas & Betts 1/ Part # 3/	SPC part # 3/	Weidmuller 3/	Color	L1 (mm)	L2 (mm)	D1 (mm)	D2 (mm)	S1 (mm)	L3, strip length (inches)	Thomas & Betts 1/ Tools 3/	Weidmuller Tools 3/
26	0.14	F4004	-	-	Gray	10.5	6.0	0.8	2.0	0.25	0.315-0.354	T3, ERG4	PZ6
26	0.14	F4005	-	-	Gray	12.5	8.0	0.8	2.0	0.25	0.394-0.433	T3, ERG4	PZ6
24	0.25	F4006	-	9021010000	Yellow	10.5	6.0	0.8	2.0	0.25	0.315-0.354	T3, ERG4	PZ6
24	0.25	F4007	-	9021020000	Yellow	12.5	8.0	0.8	2.0	0.25	0.394-0.433	T3, ERG4	PZ6
22	0.34	F4008	-	9025750000 2/	Purple	10.5	6.0	0.8	2.0	0.25	0.315-0.354	T3, ERG4	PZ6
22	0.34	F4009	-	9025770000 2/	Purple	12.5	8.0	0.8	2.0	0.25	0.394-0.433	T3, ERG4	PZ6
20	0.50	F2020	SPC4504	9019000000	White	11.5	6.0	1.1	2.5	0.15	0.315-0.354	T1, T3, ERG4	PZ3, PZ4, PZ6
20	0.50	F2021	SPC4505	9019010000	White	13.5	8.0	1.1	2.5	0.15	0.394-0.433	T1, T3, ERG4	PZ3, PZ4, PZ6
20	0.50	F2022	SPC4506	9019020000	White	15.5	10.0	1.1	2.5	0.15	0.473-0.512	T1, T3, ERG4	PZ3, PZ4, PZ6
20-18	0.75	F2023	SPC4507	9019030000	Gray	12.0	6.0	1.3	2.8	0.15	0.315-0.354	T1, T3, ERG4	PZ3, PZ4, PZ6
20-18	0.75	F2024	SPC4508	9019040000	Gray	14.0	8.0	1.3	2.8	0.15	0.394-0.433	T1, T3, ERG4	PZ3, PZ4, PZ6
20-18	0.75	F2025	SPC4509	9019050000	Gray	16.0	10.0	1.3	2.8	0.15	0.473-0.512	T1, T3, ERG4	PZ3, PZ4, PZ6
20-18	0.75	F2026	SPC4510	9019060000	Gray	18.0	12.0	1.3	2.8	0.15	0.551-0.590	T1, T3, ERG4	PZ3, PZ4, PZ6
18	1.00	F2027	SPC4511	9019070000	Red	12.5	6.0	1.5	3.0	0.15	0.315-0.354	T1, T3, ERG4	PZ3, PZ4, PZ6
18	1.00	F2028	SPC4512	9019080000	Red	14.5	8.0	1.5	3.0	0.15	0.394-0.433	T1, T3, ERG4	PZ3, PZ4, PZ6
18	1.00	F2029	SPC4513	9019100000	Red	16.5	10.0	1.5	3.0	0.15	0.473-0.512	T1, T3, ERG4	PZ3, PZ4, PZ6
18	1.00	F2030	SPC4514	9019110000	Red	18.5	12.0	1.5	3.0	0.15	0.551-0.590	T1, T3, ERG4	PZ3, PZ4, PZ6
16	1.50	F2031	SPC4516	9019120000	Black	14.5	8.0	1.8	3.4	0.15	0.394-0.433	T1, T3, ERG4	PZ3, PZ4, PZ6
16	1.50	F2032	SPC4517	9019130000	Black	16.5	10.0	1.8	3.4	0.15	0.473-0.512	T1, T3, ERG4	PZ3, PZ4, PZ6
16	1.50	F2033	SPC4518	9019140000	Black	18.5	12.0	1.8	3.4	0.15	0.551-0.590	T1, T3, ERG4	PZ3, PZ4, PZ6
16	1.50	F2034	SPC4519	9019150000	Black	24.5	18.0	1.8	3.4	0.15	0.787-0.826	T1, T3, ERG4	PZ3, PZ4, PZ6
14	2.50	F2035	SPC4520	9019160000	Blue	15.0	8.0	2.3	4.2	0.15	0.394-0.433	T1, T3, ERG4	PZ3, PZ4, PZ6
14	2.50	F2036	SPC4521	9019170000	Blue	19.0	12.0	2.3	4.2	0.15	0.551-0.590	T1, T3, ERG4	PZ3, PZ4, PZ6

FIGURE 1A20. Cable end preparation – screw clamp terminals (ferrules) – Continued.

TABLE 1A20-I. Selection of clamp terminal and tools for single barrel screw clamp terminals – Continued.

Wire AWG	mm^2	Thomas & Betts [1/] Part # [3/]	SPC part # [3/]	Weidmuller [3/]	Color	L1 (mm)	L2 (mm)	D1 (mm)	D2 (mm)	S1 (mm)	L3, strip length (inches)	Thomas & Betts [1/] Tools [3/]	Weidmuller Tools [3/]
14	2.50	F2037	SPC4522	9019180000	Blue	25.0	18.0	2.3	4.2	0.15	0.787-0.826	T1, T3, ERG4	PZ3, PZ4, PZ6
12	4.00	F2038	SPC4523	9019190000	Gray	17.5	10.0	2.9	4.8	0.20	0.473-0.512	T3, ERG4	PZ3, PZ4, PZ6
12	4.00	F2039	SPC4524	9019200000	Gray	20.0	12.0	2.9	4.8	0.20	0.551-0.590	T3, ERG4	PZ3, PZ4, PZ6
12	4.00	F2040	SPC4525	9019210000	Gray	26.0	18.0	2.9	4.8	0.20	0.787-0.826	T3, ERG4	PZ3, PZ4, PZ6
10	6.00	F2041	SPC4526	9019220000	Yellow	20.0	12.0	3.6	6.2	0.20	0.551-0.590	T3, ERG4	PZ3, PZ6, PZ16
10	6.00	F2042	SPC4527	9019230000	Yellow	25.0	18.0	3.6	6.2	0.20	0.787-0.826	T3, ERG4	PZ3, PZ6, PZ16
8	10.00	F2043	SPC4528	9019240000	Red	21.0	12.0	4.6	7.5	0.20	0.551-0.590	T3, ERG4	PZ16
8	10.00	F2044	SPC4529	9019250000	Red	27.0	18.0	4.6	7.5	0.20	0.787-0.826	T3, ERG4	PZ16
6	16.00	F2045	SPC4530	9019260000	Blue	23.0	12.0	6.0	8.8	0.20	0.551-0.590	ERG4	PZ16
6	16.00	F2046	SPC4531	9019270000	Blue	29.0	18.0	6.0	8.8	0.20	0.787-0.826	ERG4	PZ16
4	25.00	F2047	SPC4532	9019280000	Yellow	29.0	16.0	7.5	11.1	0.20	0.709-0.748	ERG4	PZ50
4	25.00	F2048	SPC4533	-	Yellow	31.0	18.0	7.5	11.0	0.20	0.787-0.826	ERG4	PZ50
4	25.00	F2049	SPC4534	9019300000	Yellow	35.0	22.0	7.5	11.0	0.20	0.945-0.984	ERG4	PZ50
2	35.00	F2050	-	9019310000	Red	30.0	16.0	8.5	12.5	0.20	0.709-0.748	ERG4	PZ50
2	35.00	F2051	-	9019320000	Red	32.0	18.0	8.5	12.5	0.20	0.787-0.826	ERG4	PZ50
2	35.00	F2052	-	9019330000	Red	39.0	25.0	8.5	12.5	0.20	1.063-1.102	ERG4	PZ50
1/0	50.00	F2053	-	9019340000	Blue	36.0	20.0	10.5	15.0	0.35	0.866-0.905	ERG4	PZ50
1/0	50.00	F2054	-	9019350000	Blue	41.0	25.0	10.5	15.0	0.35	1.063-1.102	ERG4	PZ50

NOTES:

[1/] Thomas & Betts is now ABB.

[2/] Non-standard color - turquoise.

[3/] Table information is for specific supplier clamp terminals and crimp tools. Equivalent parts and tools may be used as allowed by 4.2.

FIGURE 1A20. Cable end preparation – screw clamp terminals (ferrules) – Continued.

TABLE 1A20-II. Selection of clamp terminal and tools for twin barrel screw clamp terminals.

Wire AWG	mm^2	Thomas & Betts 1/ Part # 2/	Weidmuller 2/	Color	L1 (mm)	L2 (mm)	D1 (mm)	A (mm)	B (mm)	S1 (mm)	L3, strip length (inches)	Thomas & Betts 1/ Tools 2/	Weidmuller Tools 2/
2×20	2×0.50	F8000	9037380000	White	15.0	8.0	1.5	4.5-5.0	3.0	0.15	0.394-0.433	T3	PZ3, PZ4, PZ6
2×20	2×0.50	-	9037390000	White	17.0	10.0	1.4	4.5-5.0	3.0	0.15	0.473-0.512	T3	PZ3, PZ4, PZ6
2×20	2×0.50	-	9037400000	White	19.0	12.0	1.4	4.5-5.0	3.0	0.15	0.551-0.590	T3	PZ3, PZ4, PZ6
2×18	2×0.75	F8001	9037410000	Gray	15.0	8.0	1.8	5.1-5.5	3.0	0.15	0.394-0.433	T3	PZ3, PZ4, PZ6
2×18	2×0.75	F8002	9037420000	Gray	17.0	10.0	1.8	5.1-5.5	3.0	0.15	0.473-0.512	T3	PZ3, PZ4, PZ6
2×18	2×0.75	-	9037430000	Gray	24.0	18.0	1.7	5.1-5.5	3.0	0.15	0.787-0.826	T3	PZ3, PZ4, PZ6
2×17	2×1.00	F8003	9037440000	Red	15.0	8.0	2.0	5.4-5.8	3.2	0.15	0.394-0.433	T3	PZ3, PZ4, PZ6
2×17	2×1.00	F8005	-	Red	17.0	10.0	2.0	5.4-5.8	3.2	0.15	0.473-0.512	T3	PZ3, PZ4, PZ6
2×17	2×1.00	-	9037450000	Red	19.0	12.0	2.0	5.4-5.8	3.2	0.15	0.551-0.590	T3	PZ3, PZ4, PZ6
2×16	2×1.50	F8006	9037470000	Black	16.0	8.0	2.2-2.3	6.4-6.5	3.6	0.15	0.394-0.433	T3	PZ3, PZ4, PZ6
2×16	2×1.50	F8007	9037480000	Black	20.0	12.0	2.2-2.3	6.4-6.5	3.6	0.15	0.551-0.590	T3	PZ3, PZ4, PZ6
2×16	2×1.50	-	9037490000	Black	26.0	18.0	2.2-2.3	6.4-6.5	3.6	0.15	0.787-0.826	T3	PZ3, PZ4, PZ6
2×14	2×2.50	F8008	9037500000	Blue	18.5	10.0	2.8-2.9	7.5-8.0	4.5	0.15	0.473-0.512	T3	PZ3, PZ4, PZ6
2×14	2×2.50	-	9037510000	Blue	21.0	12.0	2.8-2.9	7.5-8.0	4.5	0.15	0.551-0.590	T3	PZ3, PZ4, PZ6
2×14	2×2.50	F8009	-	Blue	21.5	13.0	2.8-2.9	7.5-8.0	4.5	0.15		T3	PZ3, PZ4, PZ6
2×14	2×2.50	-	9037520000	Blue	27.0	18.0	2.8-2.9	7.5-8.0	4.5	0.15	0.787-0.826	T3	PZ3, PZ4, PZ6
2×12	2×4.00	F8010	9037530000	Gray	22-23	12.0	3.5-3.8	8.6-9.0	5.2	0.15-0.2	0.551-0.590	ERG4/6mm Die	PZ3, PZ4, PZ6
2×10	2×6.00	F8011	9037550000	Yellow	23-25	12-14	4.5-4.9	9.6-11.4	6.2	0.20	-	ERG4/10mm Die	PZ3, PZ4, PZ6

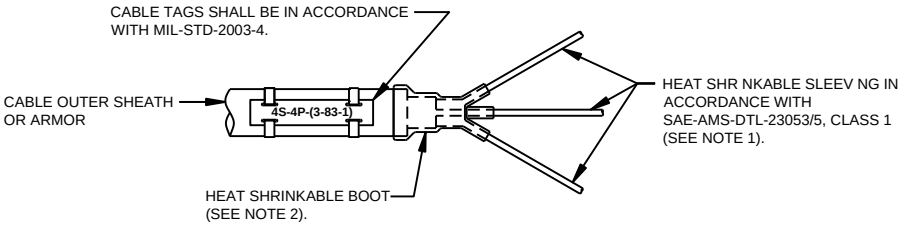
NOTES:

1/ Thomas & Betts is now ABB.

2/ Table information is for specific supplier clamp terminals and crimp tools. Equivalent parts and tools may be used as allowed by 4.2.

FIGURE 1A20. Cable end preparation – screw clamp terminals (ferrules) – Continued.

Method 1A-21-1



NOTES:

1. This method may be used for a wound (non-extruded) type conductor insulation that can become unwrapped.
2. Silicon rubber glass tape or other wound (non-extruded) type conductor insulation shall have phase colored heat shrink (sleeving) in accordance with SAE-AS23053/5, class 1 slipped over conductor insulation, extending from well into the crotch boot to the end of the cable. Sleeving meeting the requirements of SAE-AS23053/5 can be found in table 1A4-I based on conductor size.
3. Heat-shrinkable boots shall be as specified in table 1A6-I and Note 1 of figure 1A6 to capture the sleeving covering the conductor insulation.
4. Use notes 2 through 7 of figure 1A6 as installation notes.

FIGURE 1A21. Cable end preparation for cables with wound conductor insulation.

General Notes:

1. This method provides instructions for attaching thimbles to cable ends for the purpose of end sealing mechanical connections to non-watertight cables. Mechanical connectors are defined as threaded stud type cable terminals, split bolt terminals, main bus terminals in fuse boxes or screw clamp terminals such as circuit breaker connections. Thimbles are connectors that end seal cables of non-watertight construction to prevent water flow thru the cable and protect against cross compartment flooding.
2. The restrictions on use of this method stated in 4.1.7.3.3 shall apply, including the approval for use.

Installation Steps:

1. See table 1A22-I for a list of thimbles and crimp tools and some common manufacturer part numbers. Equivalent thimbles or crimp tools may be used as long as the equivalency requirements of 4.2 are met.

THIMBLE DETAIL

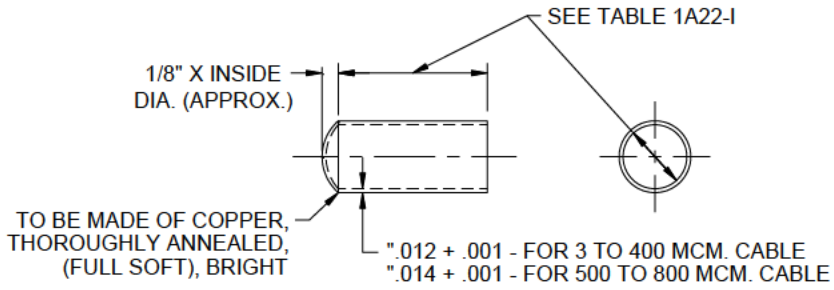


Illustration 1

2. Cut conductor insulation back so that the thimble fits tightly up against the insulation. No gap is permitted. See ~~table 1A22-I~~.

PREPARATION OF CONDUCTOR

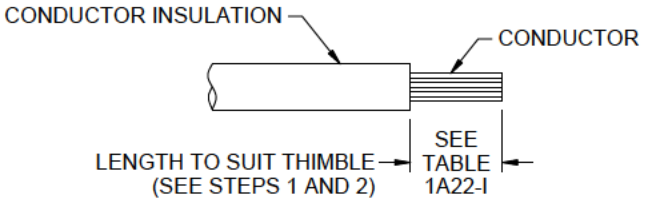


Illustration 2

3. Insert thimble referenced in table 1A22-I. Ensure thimble fits snug to conductor.
4. Crimp the thimble using crimp tools referenced in table 1A22-I. Due to the various thimble lengths, multiple crimp cycles may be required along the thimble when using type I and type II crimp tools. Do not crimp within ⅛ inch from the closed end of the thimble and the open end where the thimble will be covered by heat shrinkable tubing. After crimping, ensure the thimble has no visible cracks in the base metal.

FIGURE 1A22. Installation of thimbles for mechanical end connections for end sealing.

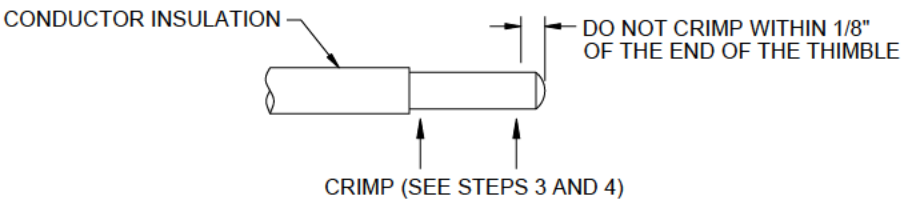


Illustration 3

5. Apply heat shrinkable tubing in accordance with SAE-AS23053/4 or SAE-AS23053/15 over the crimped thimble as shown in illustration 4.

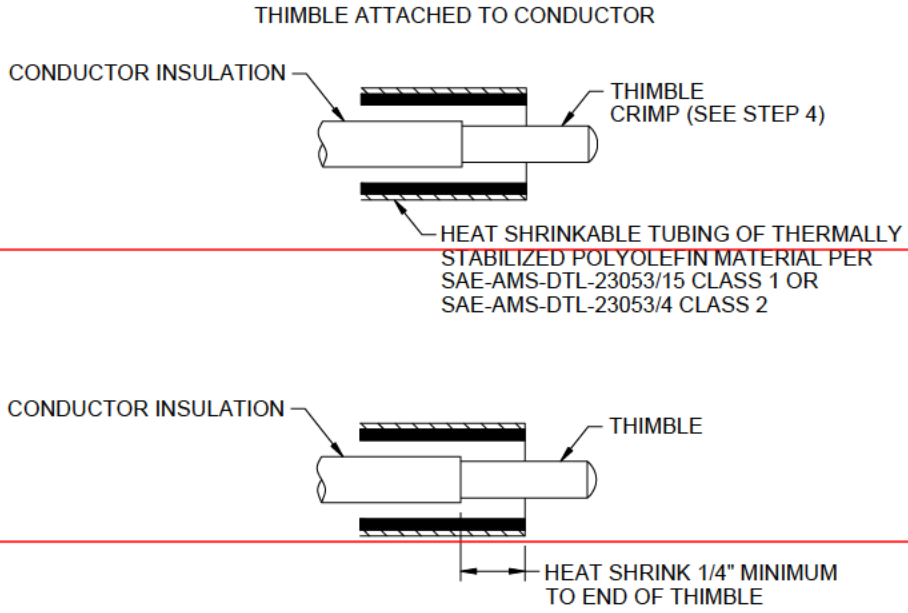


Illustration 4

FIGURE 1A22. Installation of thimbles for mechanical end connections for end sealing – Continued.

TABLE 1A22-I. List of thimbles and crimping tools.

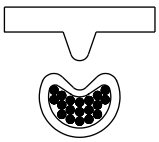
RD&T thimble part number 1/	National stock number	Size of cable (cir. mils)	Thimble inside diameter	Standard	Panduit crimping tool part number 1/	National stock number
CM003069	5940-00-194-7379	3,000	0.069	1	CT-1570	N/A
CM004084	5940-00-194-7380	4,000	0.084	1	CT-1570	N/A
CM009116	5940-00-194-7381	9,000	0.116	1	CT-1570	N/A
CM011124	N/A	10,380	0.124	1	CT-1003	N/A
CM013138	N/A	13,090	0.138	1.5	CT-1003	N/A
CM014144	5940-00-194-7382	14,000	0.144	1.5	CT-1003	N/A
CM021172	N/A	20,820	0.172	1.5	CT-1003	N/A
CM023179	5940-00-194-7383	23,000	0.179	1.5	CT-1004	N/A
CM030210	5940-00-194-7384	30,000	0.210	1.5	CT-1004	N/A
CM030229	N/A	33,090	0.229	1.5	CT-1004	N/A
CM040234	5940-00-194-7385	40,000	0.234	1.5	CT-1004	N/A
CM040247	N/A	41,740	0.247	1.5	CT-1005	N/A
CM050262	5940-00-194-7386	50,000	0.262	2	CT-1005	N/A
CM050268	N/A	52,620	0.268	2	CT-1005	N/A
CM060290	5940-00-194-7387	60,000	0.290	2	CT-1005	N/A
CM060308	N/A	66,360	0.308	2	CT-1005	N/A
CM075325	5940-00-194-7388	75,000	0.325	2	CT-1005	N/A
CM075340	N/A	83,690	0.340	2	CT-3001	F87
CM100371	5940-00-194-7395	100,000	0.371	2	CT-3001	F87
CM100381	N/A	105,600	0.381	2	CT-3001	F87
CM125415	5940-00-194-7396	125,000	0.415	2	CT-3001	F87
CM125427	N/A	133,100	0.427	2	CT-3001	F89
CM150465	5940-00-194-7397	150,000	0.465	2	CT-3001	F89
CM150478	N/A	167,800	0.478	2	CT-3001	F90
CM200522	5940-00-194-7398	200,000	0.522	2	CT-3001	F90
CM200536	N/A	211,600	0.536	2	CT-3001	F91
CM250585	5940-00-194-7399	250,000	0.585	2.5	CT-3001	F91
CM300636	5940-00-194-7400	300,000	0.636	2.5	CT-3001	F91
CM350693	5940-00-194-7389	350,000	0.693	2.5	CT-3001	F93
CM400750	5940-00-194-7390	400,000	0.750	2.5	CT-3001	F94
CM427800	N/A	427,000	0.800	2.5	CT-3001	F94

NOTE:
1/ Table information is for specific supplier thimbles and crimp tools. Equivalent parts and tools may be used as allowed by 4.2

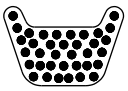
FIGURE 1A22. Installation of thimbles for mechanical end connections for end sealing – Continued.

NOTES:

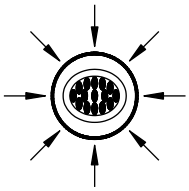
1. Table 1 crimp tools are defined by MIL-DTL-22520.
   - Type I - Indent Termination



   - Type II - Formed Termination



   - Type III - Compression Termination



2. CT 1570 is a Type I tool.
3. CT-1003 thru CT-1005 are Type II tools.
4. CT-3001 is a Type III tool.

FIGURE 1A22. Installation of thimbles for mechanical end connections for end sealing – Continued.

APPENDIX 1B – CABLE ENTRY TO EQUIPMENT

B.1 SCOPE

B.1.1 Scope. This appendix describes the procedures and methods for cable entry to equipment. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

B.2 APPLICABLE DOCUMENTS

B.2.1 General. The documents listed in this section are specified in this appendix. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in this appendix, whether or not they are listed.

B.2.2 Government documents.

B.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL SPECIFICATIONS

QQ-B-654	-	Brazing Alloys, Silver

COMMERCIAL ITEM DESCRIPTIONS

A-A-3097	-	Adhesives, Cyanoacrylate, Rapid Room Temperature-Curing, Solventless
A-A-50552	-	Fittings for Cable, Power, Electrical and Conduit, Metal, Flexible
A-A-59588	-	Rubber, Silicone
A-A-59770	-	Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-Y-1140	-	Yarn, Cord, Sleeving, Cloth, and Tape-Glass
MIL-I-3064	-	Insulation, Electrical, Plastic-Sealer
MIL-I-3158	-	Insulation Tape, Electrical Glass-Fiber (Resin-Filled): and Cord, Fibrous-Glass
MIL-T-16366	-	Terminals, Electrical Lug and Conductor Splices, Crimp-Style
MIL-I-24092	-	Insulating Varnishes and Solventless Resins for Application by the Dip Process
MIL-S-24235	-	Stuffing Tubes, Metal, and Packing Assemblies for Electric Cables, General Specification for
MIL-I-24391	-	Insulation Tape, Electrical, Plastic, Pressure-Sensitive
MIL-M-24519	-	Molding Plastics, Electrical, Thermoplastic
MIL-DTL-24640	-	Cables, Lightweight, Low Smoke, Electric, for Shipboard Use, General Specification for
MIL-DTL-24643	-	Cables, Electric, Low Smoke Halogen-Free, for Shipboard Use, General Specification for
MIL-DTL-24705	-	Penetrators, Multiple Cable, Electric Cable, General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-1310	-	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility, Electromagnetic Pulse (EMP) Mitigation, and Safety
MIL-STD-2003-2	-	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Equipment)
MIL-STD-2003-3	-	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Penetrations)
MIL-STD-2003-4	-	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Cableways)

(Copies of these documents are available online at https://quicksearch.dla.mil.)

B.2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

S9073-AF-SNC-010	-	Ship Noise Control

(Copies of this document are available online via Technical Data Management Information System (TDMIS) at https://mercury.tdmis navy mil/. Refer questions, inquiries, or problems to: DSN 296-0669, Commercial (805) 228-0669. These documents are available for ordering (hard copy) via the Naval Logistics Library at https://nll.navsup.navy.mil. For questions regarding the NLL, contact the NLL Customer Service at nllhelpdesk@navy mil, (866) 817-3130, or (215) 697-2626/DSN 442-2626.)

B.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM D2754	-	Standard Specification for High-Temperature Glass Cloth Pressure-Sensitive Electrical Insulating Tape
ASTM D4066	-	Standard Classification System for Nylon Injection and Extrusion Materials (PA)
ASTM D4388	-	Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes
ASTM D6779	-	Standard Classification System for and Basis of Specification for Polyamide Molding and Extrusion Materials (PA)
ASTM F1836M	-	Standard Specification for Stuffing Tubes, Nylon, and Packing Assemblies (Metric)

(Copies of these documents are available online at www.astm.org.)

SAE INTERNATIONAL

SAE-AS23053/4	-	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Dual-Wall, Outer Wall Crosslinked
SAE-AS23053/15	-	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked
SAE-AS23190	-	Wiring, Positioning, and Support Accessories

SAE-AS33671 - Strap, Tiedown, Electrical Components, Adjustable, Self-Clinching, Plastic, Type I, Class 1

SAE-AS33681 - Strap, Tiedown, Electrical Components, Identification, Adjustable, Self-Clinching, Plastic, Type II, Class 1

SAE-AS81765/1 - Insulating Components, Molded, Electrical, Heat Shrinkable Polyolefin, Crosslinked, Semi-Rigid and Flexible

SAE-AS90387 - Wiring Installation Tools for Plastic and Metal Tiedown Straps

(Copies of these documents are available online at www.sae.org.)

B.2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

B.3 REQUIRED EQUIPMENT AND MATERIALS

B.3.1 Required equipment and materials. The required equipment and materials shall be as specified in the individual methods.

B.4 NOTES AND PROCEDURES

B.4.1 Dimensions. For figures and tables in this appendix, all dimensions are in inches unless otherwise noted.

B.4.2 Figures. Table 1BI provides information for the figures in this appendix.

TABLE 1BI. Figures for cable entry into equipment enclosures.

Figure number	Cable entry into equipment enclosures	Page
1B1	Cable entrance to switchboards	82
1B2	Cable entrance to transformers	85
1B3	Cable entrance to non-watertight equipment	86
1B4	Cable entrance to watertight equipment	88
1B5	Strapping and supporting wire bundles in electrical equipment	90
1B6	Lacing and wrapping wire bundles in electrical and electronic equipment	92
1B7	Stuffing tubes installed on equipment exposed to high temperature	94
1B8	Installation of cables on sound isolated motors	95
1B9	Inboard stuffing tubes for submarines	97
1B10	Cable termination for motors and transformers (surface ships and submarines)	98
1B11	Insulating bus terminals and bus bars	104
1B12	Installation of thermocouple cable entering equipment	106
1B13	Heat-shrink cable entry applicable to watertight and non-watertight enclosures	108
1B14	Cable entrance to non-watertight enclosures – use of drip loop and plastic sealer	111
1B15	Equipment cable entrance using multi-cable transits	112

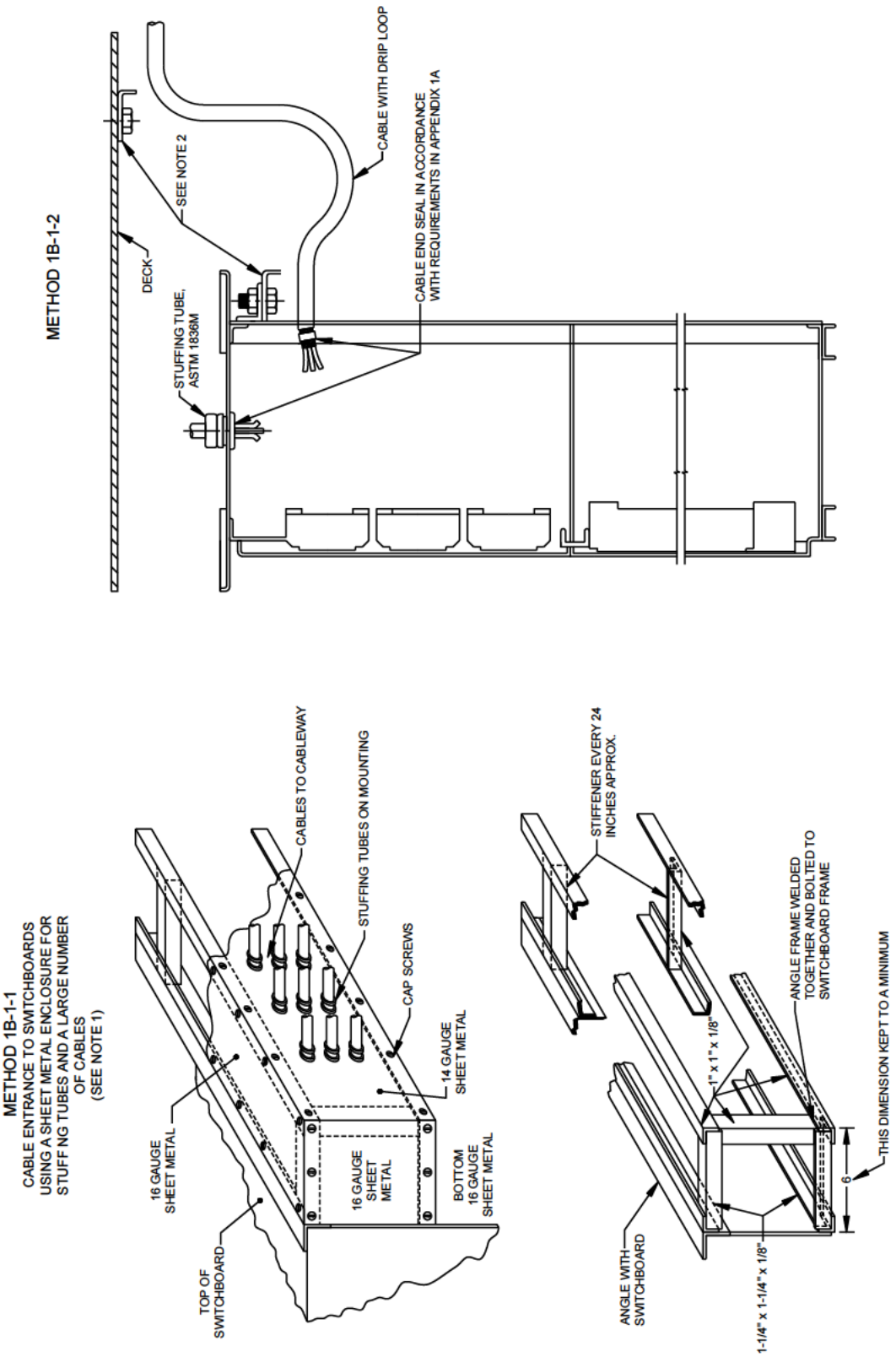
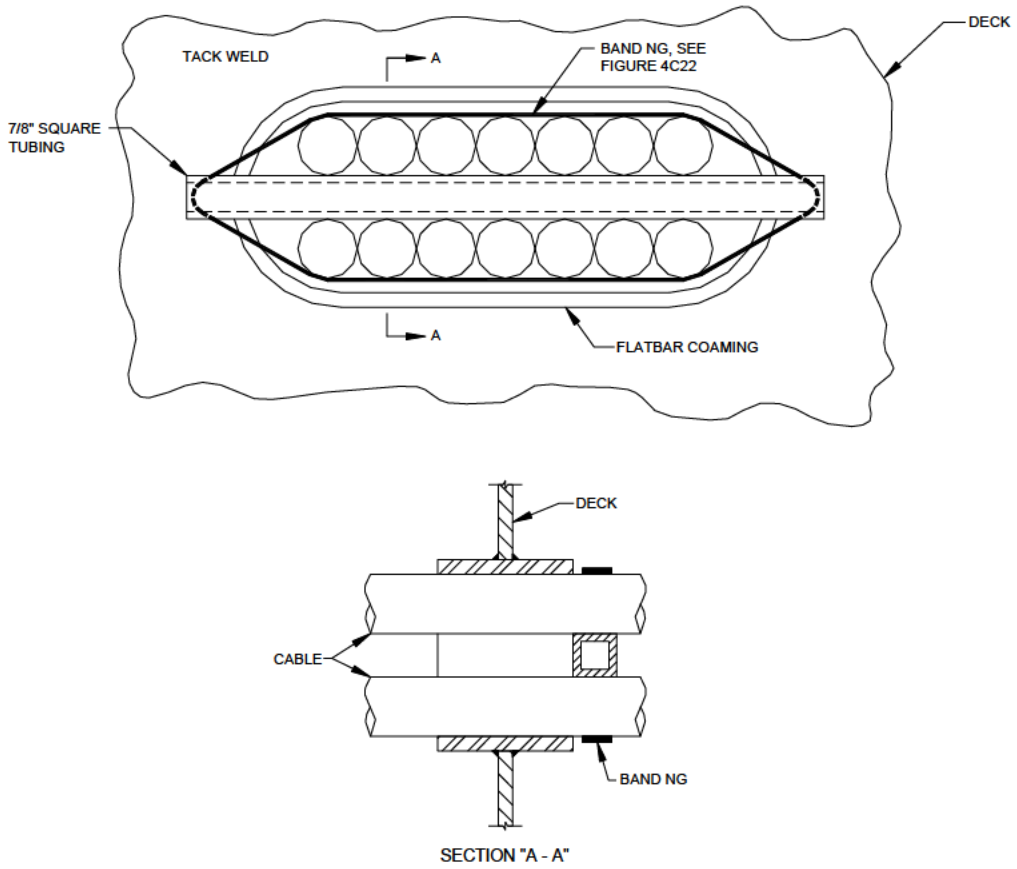


FIGURE 1B1. Cable entrance to switchboards.

METHOD 1B-1-3
BOTTOM ENTRY OF CABLES TO EQUIPMENT



SECTION "A - A"

Securing of power cables. Power cable groups entering switchboards shall adhere to the following requirements:

1. Cables shall be neatly formed into groups which shall be bundled or banded and supported or clamped in a manner that will prevent chafing of the insulation caused by vibration. Cables shall not be supported by bus bars. There shall be a minimum clearance of ¼ inch between cables and bus bars to prevent abrasion under conditions of vibration, except at the bus bar terminating end of the cable.
2. Cable straps or metal clamps may be used to support or secure cables, but any metal used shall be covered with a flame-retardant, heat-resistant material which will prevent chafing of the cable insulation. Commercial nylon cable straps shall not be used to support or secure power cables to the framework or structure of the switchboard unit.
3. There shall be no power cable splices within the switchgear enclosure. Power cables shall be bolted directly to the bus bars or terminal studs of the switchboard device.
4. Cable lug terminals installed on all cables entering or within the switchboard shall be crimp type CLC or CLCG in accordance with MIL-T-16366. Prior to assembly and crimping, a light coating of NO-OX-ID "A-SPECIAL" (NSN 8030-00-598-5915) corrosion-preventive paste, or equal (see 4.2), shall be applied to the conductor and the interior of the terminal lug barrel. CLC or CLCG lug terminals shall be used with vacuum circuit breakers or bus bar applications. For all cables of AWG-14 (4,000 circular mils) and larger, cable lug terminals shall be secured by means of locking devices in accordance with the fastener requirements in MIL-STD-2003-2.

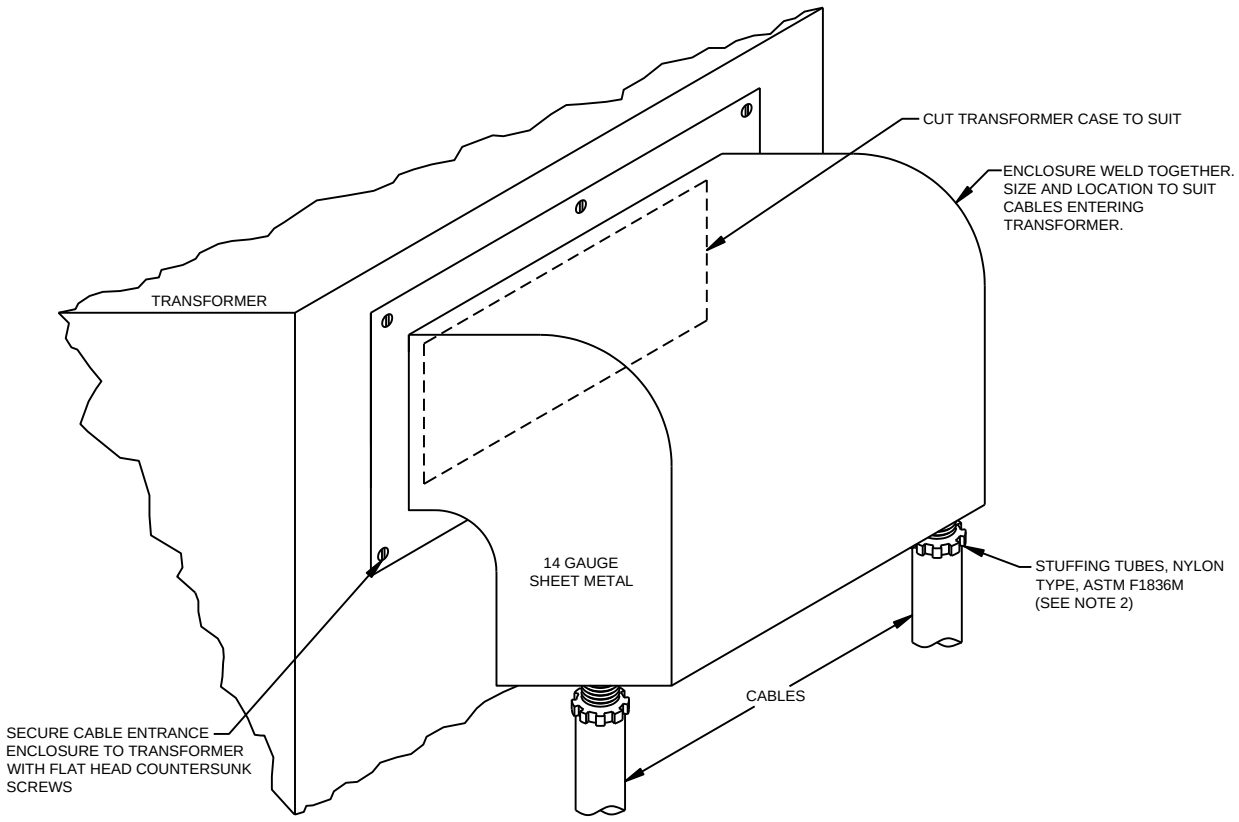
FIGURE 1B1. Cable entrance to switchboards – Continued.

NOTES:

1. This method of cable entrance to switchboards may be used where installation or wiring of straight or angle stuffing tubes attached directly to switchboard case is not feasible.
2. For suitable cable supports, see MIL-STD-2003-4.
3. Method 1B-1-3 may be used to support cables through open cuts under equipment on non-watertight decks.
4. See figure 1B15 for alternative to use multiple cable penetrations for cable entry into switchboards.
5. See MIL-STD-2003-2 for fastener and fastener material requirements.

FIGURE 1B1. Cable entrance to switchboards – Continued.

METHOD 1B-2-1
CABLE ENTRANCE TO TRANSFORMERS
USING A SHEET METAL ENCLOSURE WITH
STUFFING TUBES OR CABLE CLAMPS IN LIEU
OF ANGLE TUBES



NOTES:

1. This method of cable entrance to transformers may be used where installation or wiring of straight or angles type stuffing tubes attached directly to transformer case is not feasible.
2. Cable clamps may be used in lieu of stuffing tubes when enclosure is non-watertight except for cables entering through top of horizontal or sloping surfaces.
3. Remove all sharp edges in proximity of cut transformer case to prevent damage to conductor insulation.
4. See MIL-STD-2003-2 for fastener and fastener material requirements.

FIGURE 1B2. Cable entrance to transformers.

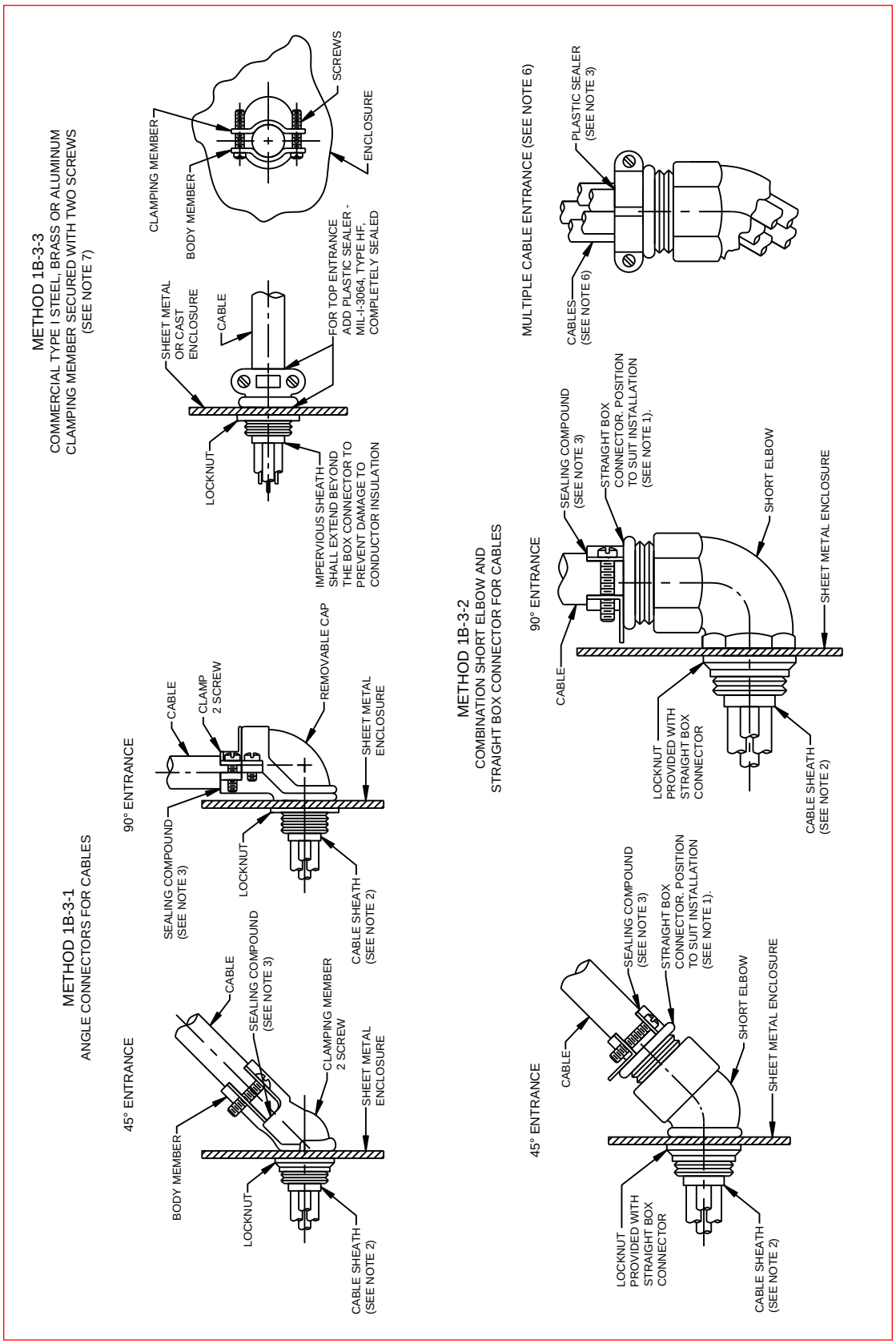


FIGURE 1B3. Cable entrance to non-watertight equipment.

TABLE 1B3-I. Connectors for small size cables. (see 4.2)

Cable O.D.	**5⁄16 to 17⁄32**	**½ to ¾**
45° angle connector	Appleton # 7245V T. & B. # 265, or equal	Method 1B-3-2 (see note 4)
90° angle connector	Appleton # 7380V, Gedney # 963, T. & B. # 266, or equal	Gedney # 964B, or equal

TABLE 1B3-II. Connectors for medium size cables. (see 4.2)

Cable O.D.	**¾ to ⅞**	**⅞ to 1 3⁄16**	**1 3⁄16 to 1 3⁄8**	**1 3⁄8 to 1 11⁄16**
45° short elbow	Gedney # 8-4100, or equal	Gedney # 8-4125, or equal	Gedney # 8-4150, or equal	Gedney # 8-4200, or equal
90° short elbow	T. & B. # 4252, or equal	T. & B. # 4253, or equal	T. & B. # 4254, or equal	T. & B. # 4255, or equal
Normal size straight connector	1	1¼	1½	2

NOTES:

1. Straight box connectors shall be equivalent to type I (2-screw clamp) of A-A-50552 for all sizes.
2. When retaining lips are absent on the connector, impervious sheath shall extend a minimum of ⅛ inch beyond the throat of the connector or short elbow. When retaining lips are present on the connector, the cable armor or sheath shall be installed over the retaining tab and butted up against the retaining lip.
3. Connectors shown hereon shall be sealed with plastic sealer (MIL-I-3064, type HF) applied both between the clamp and the cable and outside the clamp to prevent entry of water dripping from above. However, when entrance is made in the bottom or side of the enclosure and a drip loop can be provided, plastic sealer is not required.
4. For cable sizes ½ inch to ¾ inch, short elbow (Gedney # 8-475 or equal [see 4.2]) and ¾ normal size straight connector shall be used.
5. For community applications, multiple cable entrance may be used for all connector sizes shown hereon. Connector size (maximum diameter) shall be approximately the diameter of cable group for proper clamping.
6. In locations where 45° or 90° entrance is not required, straight connectors may be used for multiple cable entrance.
7. Box connectors shall be steel, except that on minesweepers they shall be of aluminum, brass, or steel to conform with the material of the enclosure in which installed. Steel box connectors may be used also with aluminum enclosures. “Straight duplex” box connectors may be used for cable entrance into NWT enclosures. However, cables shall be the type having nylon-covered conductors. Duplex connectors are not to be used for cables having silicone covered conductors.
8. If straight type clamping saddles are present, care shall be taken not to over-torque the connector screws to prevent damage to the conductors.
9. See MIL-STD-2003-2 for fastener and fastener material requirements.

FIGURE 1B3. Cable entrance to non-watertight equipment – Continued.

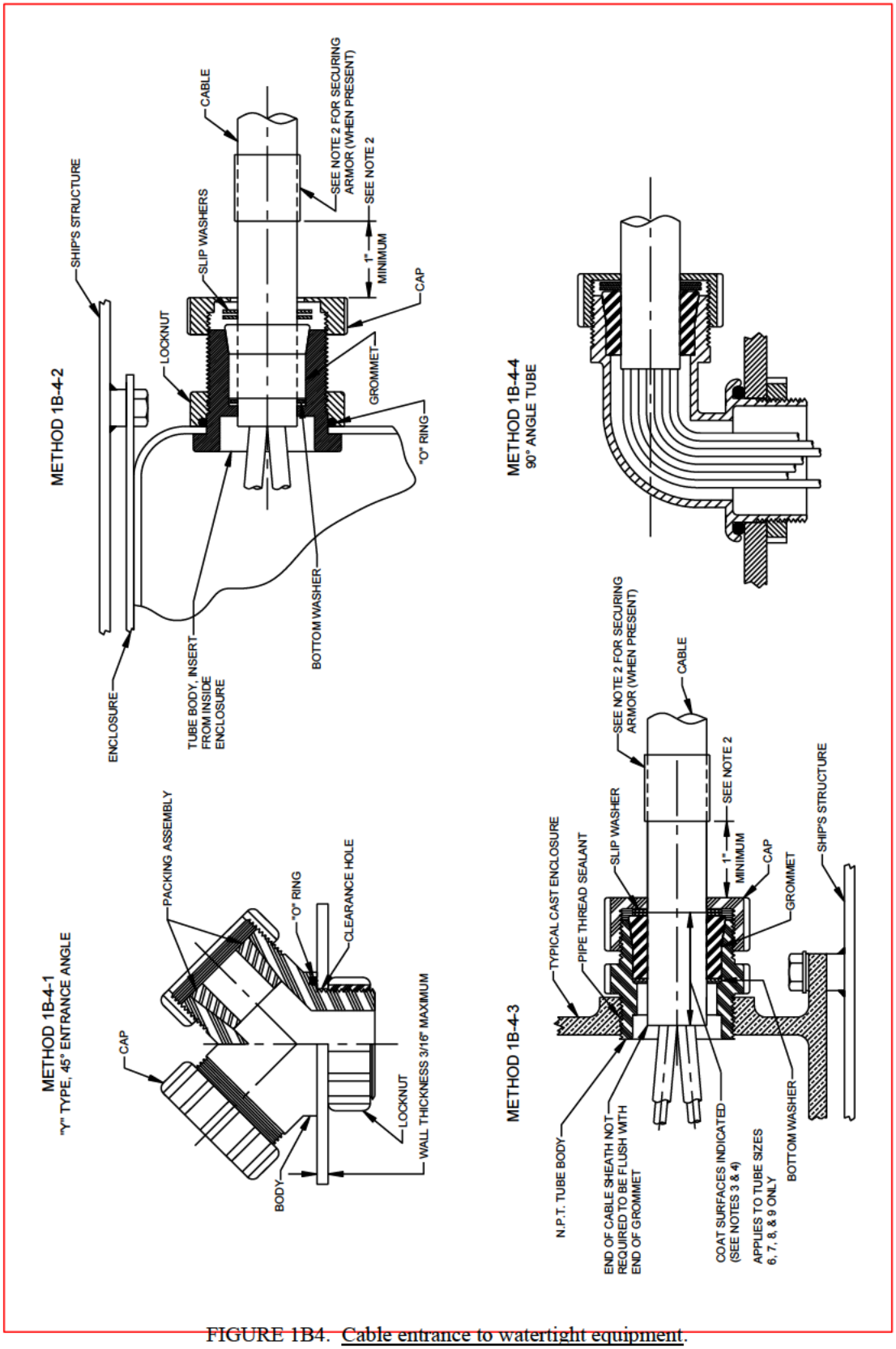


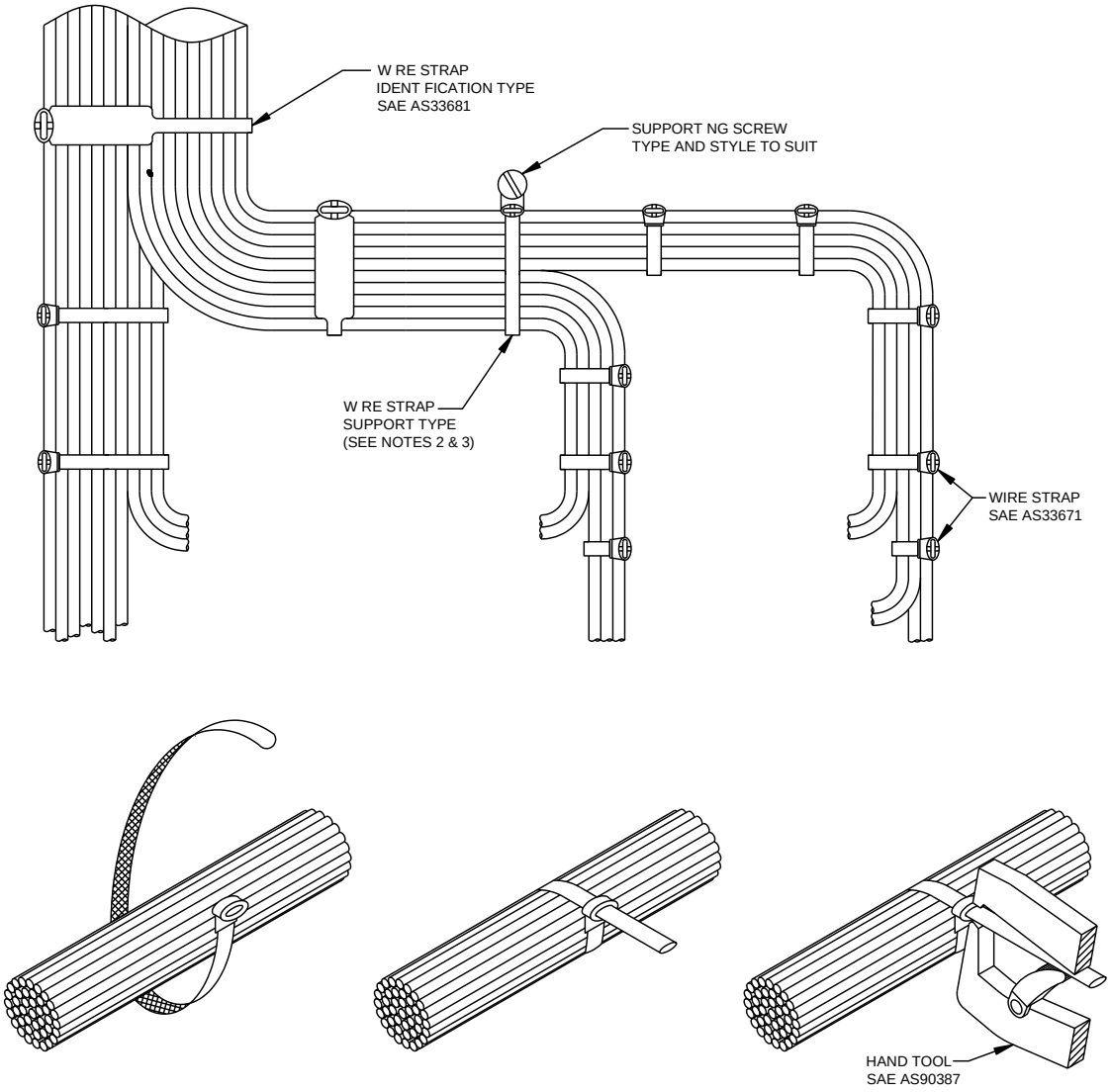
FIGURE 1B4. Cable entrance to watertight equipment.

NOTES:

1. See figure 3C1, “ASTM F1836M nylon stuffing tube typical installation”, figure 3C2, “ASTM F1836M nylon stuffing tube assembly”, and figure 3C3, “ASTM F1836M nylon stuffing tube data”, of MIL-STD-2003-3 for details on nylon stuffing tubes and installation requirements as well as tube cable assignment. Nylon stuffing tubes shall be in accordance with MIL-STD-2003-3.
2. Secure armor (when present) on cable a minimum of 1 inch from plastic tube face with a shrink fit plastic sleeve. Metal squeeze rings similar to Burndy-Hyring, or equal (see 4.2), may be used.
3. Apply one coat of bonding agent N-29 (accelerated with N-39) in accordance with NSN 8040-01-440-4328 to the sheathing of the cable beyond the flared armor (when present) for grounded installation and to the cable end including the tape in non-grounded installation. This note applies to tube sizes 6, 7, 8, and 9 only.
4. Coat the inner surface of the grommet with the N-29 (accelerated with N-39) bonding agent and immediately slide in place on the cable. This note applies to tube sizes 6, 7, 8, and 9 only. Notes 3 and 4 do not apply to top entrance in NWT boxes.

FIGURE 1B4. Cable entrance to watertight equipment – Continued.

METHOD 1B-5-1
STRAPPING PROCEDURE



Strapping procedure:

1. Slip strap around wire bundle as shown.
2. Thread tip through eye and draw up snug.
3. a. For straps not equipped with locking device:
   Apply tool, clinch tight, twist 120 degrees and squeeze to cut off excess.
   b. For self-clinching straps:
   Pull tight and cut off excess.

FIGURE 1B5. Strapping and supporting wire bundles in electrical equipment.

NOTES:

1. All plastic wire straps shall conform to SAE-AS23190.
2. Commercial support type wire straps may be used provided the locking device is as shown on SAE-AS33671.
3. Space between straps shall be as required to suit installation but not more than 2½ times the diameter of the bundle. Maximum distance between support type straps shall be 10 inches.
4. Self-clinching wire straps may be hand installed. However, for greater efficiency, use of tool, as referenced on cable and strap drawings, is recommended.
5. The following precautions shall be taken:
   a. Avoid use of straps in equipment having prolonged excessively high temperatures.
   b. Care in forming and securing wire bundles to prevent cutting of conductor insulation.
   c. See 4.7.
   d. Wire groups running from hinged panels shall be formed or clamped so that sharp bends do not occur with the panel in either the open or closed position. Also, wire grouping shall ensure that binding or chafing does not occur when opening or closing the hinged panel.
   e. Wire groups running from slide mounted equipment in racks shall be formed or clamped so that the wires, connectors, and clamps are not damaged or chafed when the equipment is slid in and out.
6. Plastic cable straps shall not be used in cableways to secure or support cables.
7. Conductors inside electrical equipment shall be formed up into groups and secured in place to prevent chafing of insulation due to vibration or maintenance. See 4.9 for additional guidance for securing cables inside equipment.
8. Bolted connections for conductors terminating in enclosures, such as bolts lugged together in motor terminal housings and in transformers, shall be installed in accordance with MIL-STD-2003-2 and figure 1B10.

FIGURE 1B5. Strapping and supporting wire bundles in electrical equipment – Continued.

METHOD 1B-6-1
LACING PROCEDURE

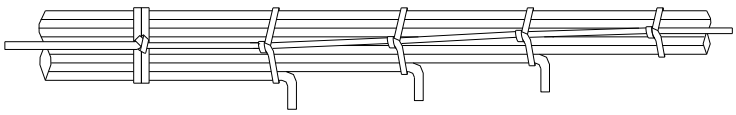
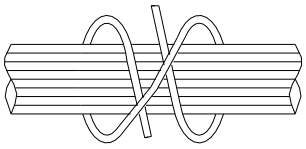


ILLUSTRATION 1



LLUSTRATION 2

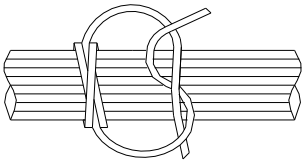


ILLUSTRATION 3

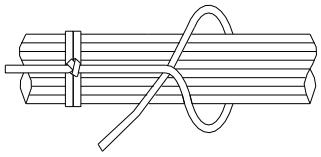


ILLUSTRATION 4

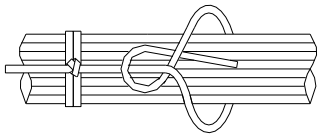


ILLUSTRATION 5

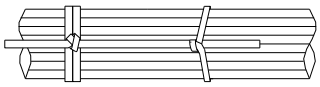


ILLUSTRATION 6

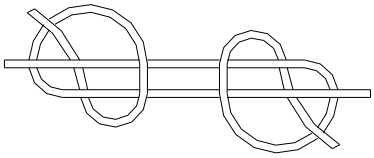
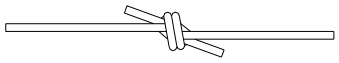
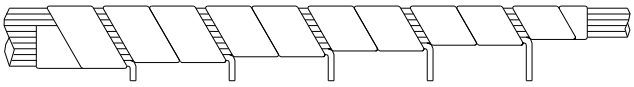


ILLUSTRATION 7



LLUSTRATION 8

METHOD 1B-6-2
WRAPP NG PROCEDURE
ALTERNATE TO METHOD 1B-6-1



Lacing procedure:

1. The lacing of the main wire bundle, auxiliary lines, and final breakouts shall be started with a clove hitch as shown on illustration 2. An overhand knot shall be tied over the clove hitch as indicated on illustration 3. A lockstitch shall then be tied as shown on illustrations 4, 5, and 8. The wire bundle shall be laced its entire length using the lockstitch as shown on illustration 1. The lacing shall be terminated with two lockstitches. The same procedure shall be used when using a double wrap of lacing twine.
2. Lockstitching on the main wire bundle and auxiliary lines shall be placed immediately adjacent to and on both sides of breakouts that are to be laced. The lacing of auxiliary lines and final breakouts shall be anchored to the main section by passing the lacing twine through the two lockstitches on the main section and then using the starting hitch and knot shown on illustrations 2 and 3.

FIGURE 1B6. Lacing and wrapping wire bundles in electrical and electronic equipment.

Lacing procedure (continued):

3. The spacing between lockstitches on wire bundle sections ⅝ inch or smaller in diameter shall be ½ inch to ¾ inch. On wire bundle sections larger than ⅝ inch in diameter, the spacing shall be ½ inch to 1 inch. In addition, on sections larger than ⅝ inch in diameter, a double wrap of lacing shall be used.
4. If it is necessary to splice two pieces of lacing together, a knot as shown on illustrations 7 and 8 shall be used.
5. A binder such as glyptol shall be applied to all starting, terminating, and splicing knots.

Wrapping procedure:

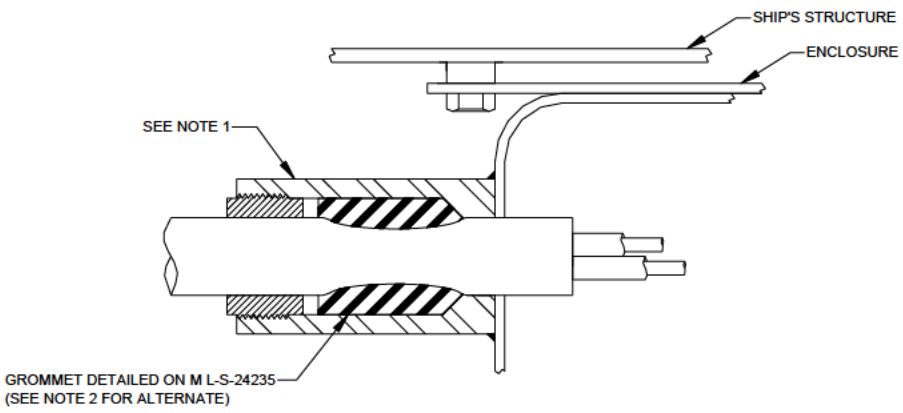
1. Cut a length of wrapping as needed. For greatest speed, use in a 2-foot length. Ends may be cut diagonally.
2. Hook the end of the wrapping into the bundle so that the tip curls around in an inner wire.
3. Straighten the first 2-4 inches of wrapping. Then wrap straightened portion around the bundle of conductors. Straighten another 2-4 inches and wrap. Continue the process until the entire strip of wrapping is attached.
4. Lock finishing end of wrapping into bundle. Twist ends of bundle in opposite direction with hands for tighter wrap if desired.
5. Repeat the process with next strip of wrapping.

NOTES:

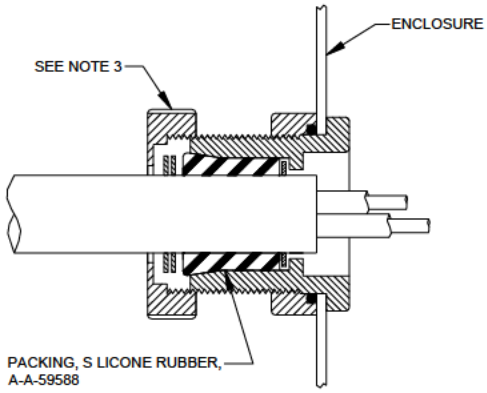
1. Special care shall be taken into forming and securing the bundle to prevent chafing of conductor insulation under vibration.
2. The wrapping material shall be of a fire-retardant plastic. The use of vinyl or polyethylene plastic material which may yield toxic combustion products is prohibited.
3. The lacing shall be of a non-nutrient material such as nylon.
4. Where temperature may exceed 250 °F (121.1 °C) or where flame resistance is specified, the lacing or tying materials shall conform to glass cord, MIL-Y-1140, treated with silicone resin. The cord (or tape) shall be treated to prevent unraveling by application of Neoprene cement (commercial) to the ends of the cord or tape.
5. See 4.7.

FIGURE 1B6. Lacing and wrapping wire bundles in electrical and electronic equipment – Continued.

METHOD 1B-7-1
METAL TUBE, MIL-S-24235



METHOD 1B-7-2
NYLON TUBE, ASTM F1836M



NOTES:

1. The metal stuffing tube used in method 1B-7-1 may consist of the following. References are from MIL-STD-2003-3.
   a. Half of the double gland stuffing tube, shown on figure 3A1, "MIL-S-24235/1 stuffing tubes for passing cables through pressureproof bulkheads (submarines)".
   b. Tube body, shown on figure 3A3, "Passing cable through tanks (pipe extension) (submarines)".
   c. Stuffing tube, shown on figure 3B7, "MIL-S-24235 stuffing tubes through shielded bulkheads (surface ships)".
2. Packing for metallic stuffing tubes used above 221 °F (105 °C) shall be silicone rubber type RTV or silicone rubber rope.
3. Nylon stuffing tubes in accordance with ASTM F1836M, except using silicone rubber grommet, may be used in temperatures up to 392 °F (200 °C).

FIGURE 1B7. Stuffing tubes installed on equipment exposed to high temperature.

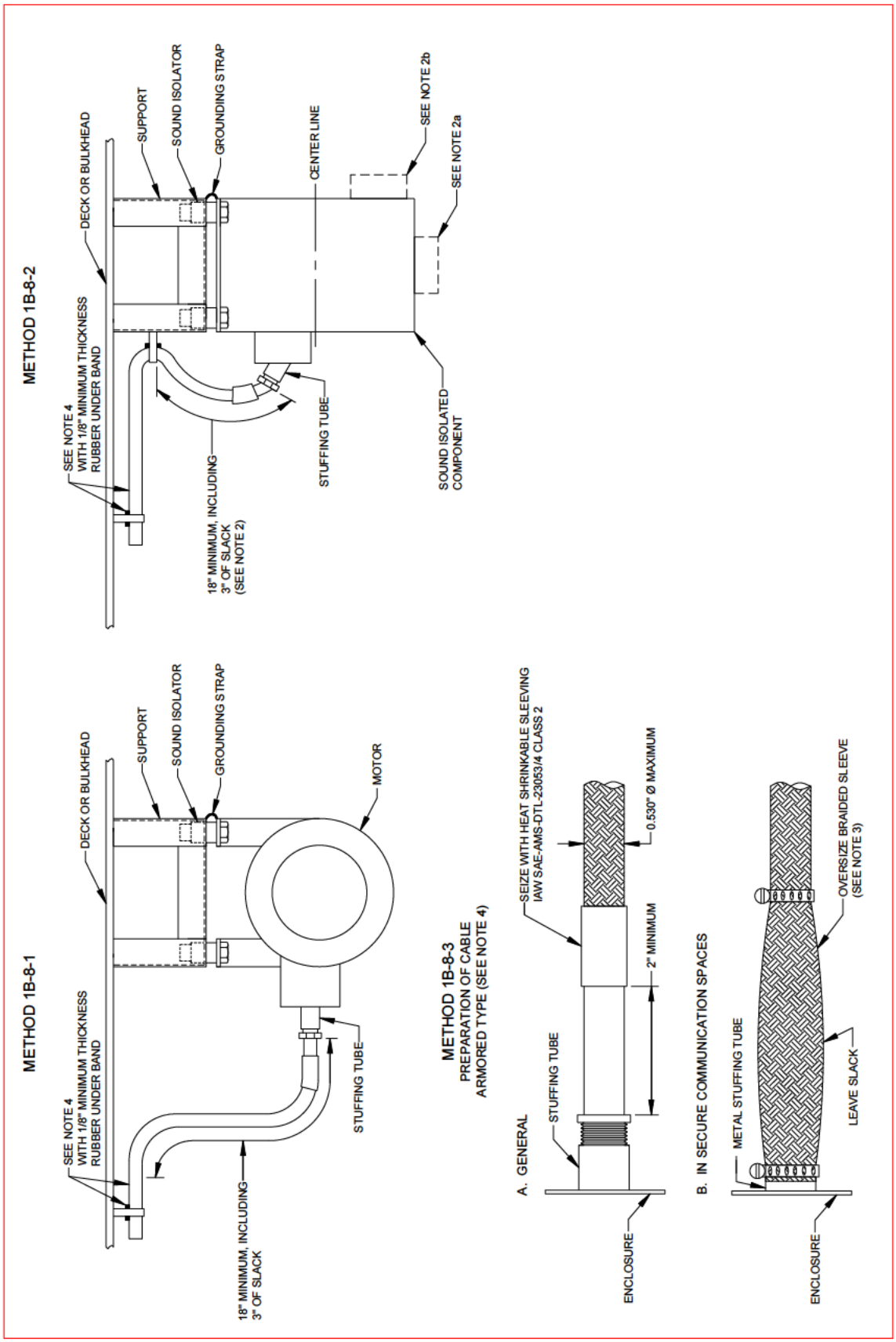


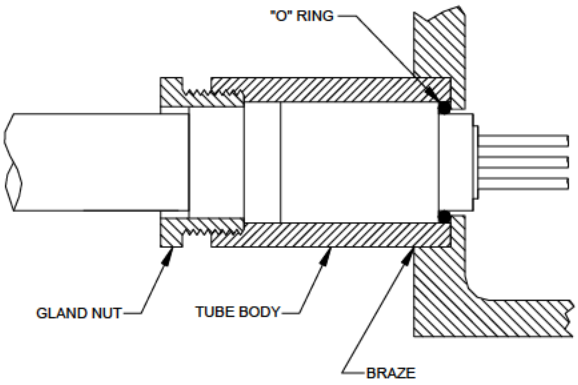
FIGURE 1B8. Installation of cables on sound isolated motors.

NOTES:

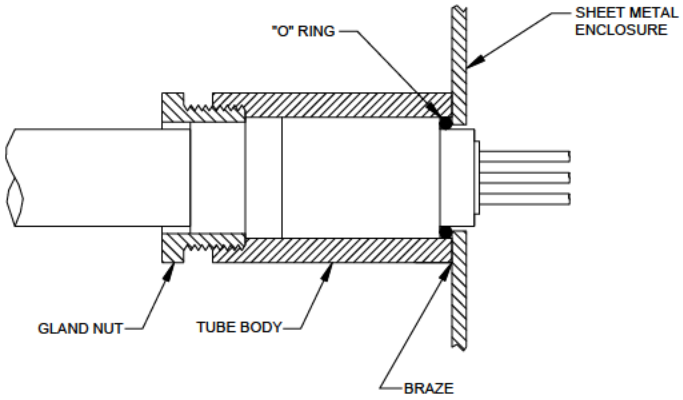
1. Position cable loop so that it will not touch structures or adjacent equipment.
2. Amount of slack (greater than 3 inches minimum) shall be determined by applicable equipment deflection diagram if the following exist:
   a. Cable entrance is opposite mounting feet.
   b. If side entrance is beyond center of tall equipment (i.e., height is greater than the smaller dimension of base).
3. Braided sleeve shall in general be of the same material as the cable armor. Clean contact surfaces to bright metal and secure sleeve to stuffing tube and cable armor with banding straps or clamps as shown. Do not stretch sleeve tight between stuffing tube and cable armor.
4. Based upon information contained in S9073-AF-SNC-010, stripping of armor is applicable only to cables of 0.530-inch diameter or less. Channel rubber shall be used under cable clamps on all cable size inclusive. Channel rubber shall be installed as indicated in MIL-STD-2003-4.
5. For suitable cable support, see MIL-STD-2003-4.

FIGURE 1B8. Installation of cables on sound isolated motors – Continued.

METHOD 1B-9-1



METHOD 1B-9-2

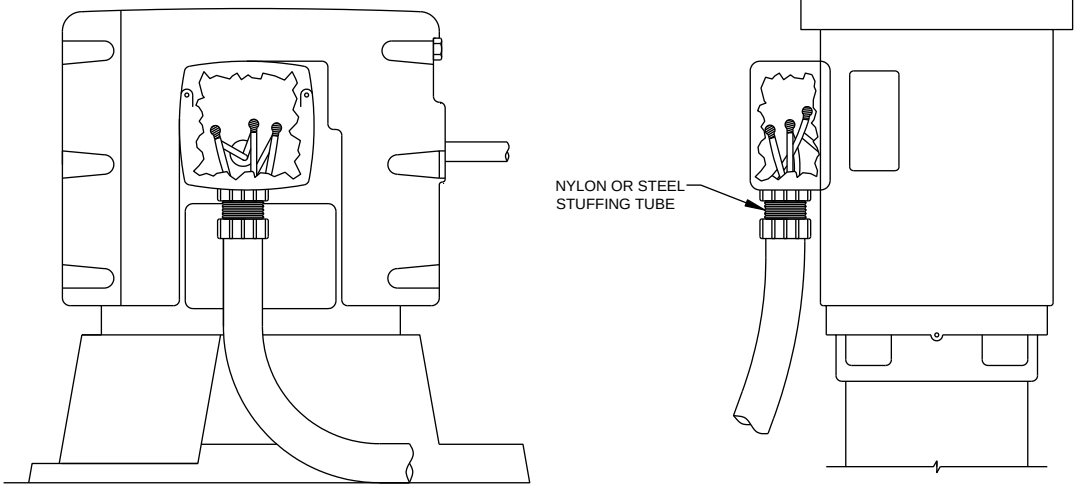


NOTES:

1. Stuffing tubes delineated hereon are for use on inboard fittings only.
2. Instructions for preparing cable ends and detail dimensions are shown in Appendix 1A.

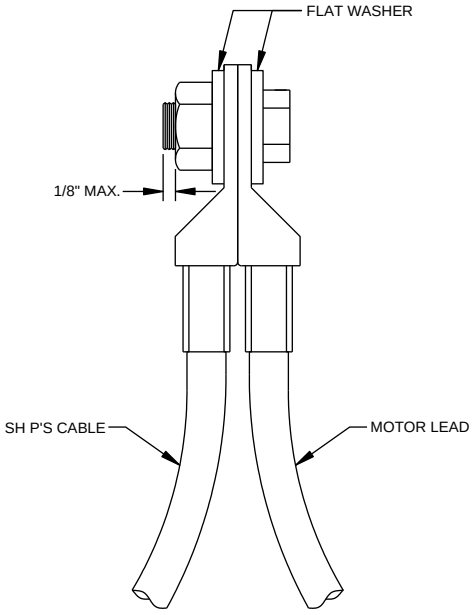
FIGURE 1B9. Inboard stuffing tubes for submarines.

METHOD 1B-10-1



TYPICAL HORIZONTAL MOUNTED MOTOR

TYPICAL VERTICAL MOUNTED MOTOR

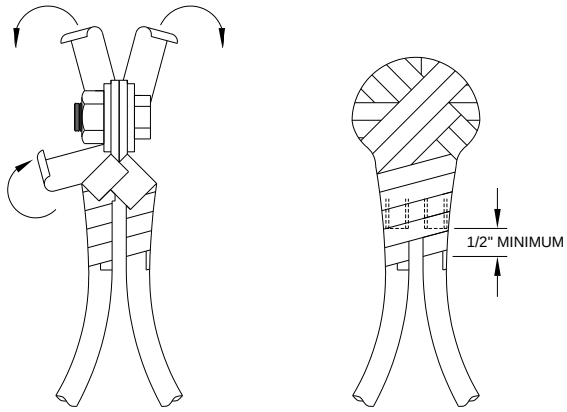


STEP 1

FIGURE 1B10. Cable termination for motors and transformers (surface ships and submarines).

Step 1:

Install solderless lugs on both shipboard cables. Lugs shall be connected as shown and properly tightened.



STEP 2

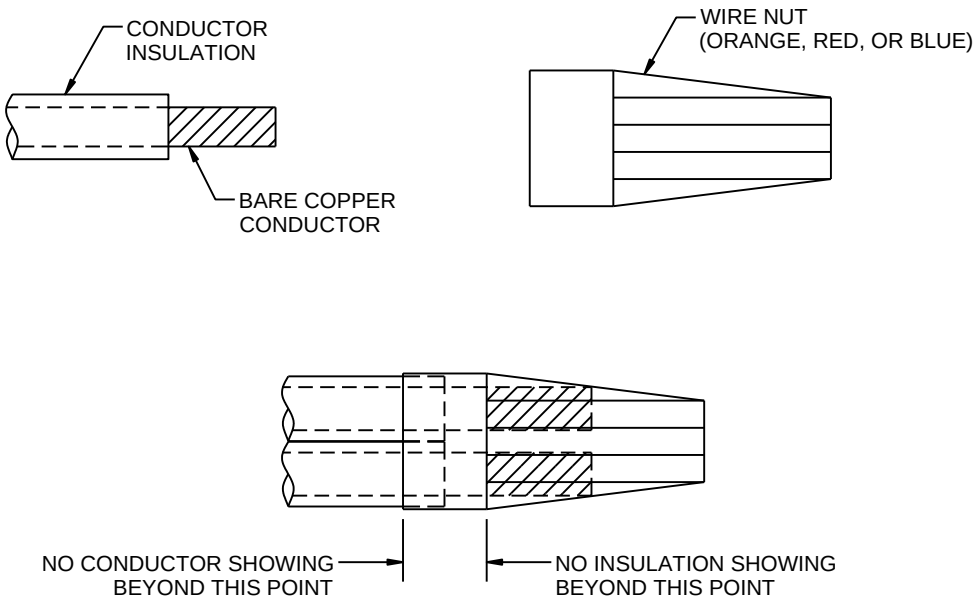
Step 2:

Apply tape or wire nuts as required in notes 1 and 2.

NOTES:

1. Perform the following steps to properly apply tape to a motor or transformer connection:
   a. Apply a minimum of two half-lap layers of pressure-sensitive glass-backed tape in accordance with A-A-59770, type IV-GFT, white, 0.007 inch thick.
   b. Apply a minimum of two half-lap layer of electrical filler tape in accordance with ASTM D4388.
   c. Apply a minimum of two half-lap layers of plastic electrical tape in accordance with MIL-I-24391.
2. For motors rated less than 1 horsepower and for wires 9,000 circular mils and smaller, insulated connectors (wire nuts) may be used instead of the tape method in step 1. See 4.1.7.3.4 for restrictions on the use of wire nuts. Apply the wire nuts as follows; see "Wire Nut Installation" illustration presented after the notes.
   a. Install the wire in accordance with illustration labeled "Wire Nut Installation". Do not twist conductors before placing in the wire nut.
   b. After the wire nut is installed, apply two half-lap layers of ¾ inch wide plastic pressure sensitive tape in accordance with MIL-I-24391. Start tape application ½ inch minimum beyond base of wire nut. Ensure to wrap and tighten tape in the same direction the wire nut tightens to avoid loosening the wire nut connection.
3. All hardware shall be CRES or zinc-plated steel.
4. In special circumstances such as fire recovery work and when approved by NAVSEA, this method may be used for splicing ships cables where appropriate. The specific applications would be the repair/replacement of portions of ships cables that have been damaged. In such cases, new and old cable conductors of slightly different diameters may need to be spliced and the proper butt splices may not be available. The lugs could be orientated "back to back" or "in line" as long as there is good contact on the flats of the lugs. These repair connections would be made in a suitable NEMA box. (Lessons learned from CVN 73 fire recovery cable splicing work.)
5. See figure 2A20, "Locking devices on electrical connections", of MIL-STD-2003-2 for requirements for locking devices for motor and transformer electrical connections.

FIGURE 1B10. Cable termination for motors and transformers (surface ships and submarines) – Continued.



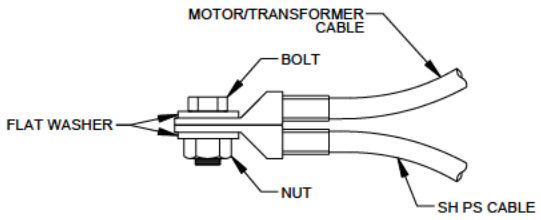
Wire Nut Installation

FIGURE 1B10. Cable termination for motors and transformers (surface ships and submarines) – Continued.

Method 1B-10-2
Alternate Method for Motor and Transformer Connections, TE Raychem MCK, or equal (see 4.2)

Step 1:

Install solderless lugs on both shipboard cables in accordance with this standard. Lugs shall be connected as shown and properly tightened.

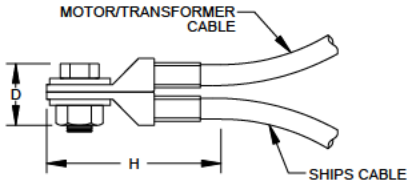


Step 2:

Select the correct TE Raychem MCK Series, or equal (see 4.2). The TE Raychem MCK kit dimensions are shown in table 1B10-I.

TABLE 1B10-I. Kit selection table for TE Raychem MCK.

TE Raychem MCK Kit Number	Motor Feeder Conductor Size (AWG)	Bolt Length Max (D)	Connection Length Max (H)
MCK-1V	#14 – #10 AWG	⅝" (15 mm)	2.0" (50 mm)
MCK-2V	#12 – #4 AWG	¾" (20 mm)	2.5" (65 mm)
MCK-3V	#2 – 4/0 AWG	1" (25 mm)	3.5" (89 mm)
MCK-4V	250-5 KCMIL	1½" (35 mm)	5.5" (140 mm)



Step 3:

Apply cloth tape provided with the kit to the bolted connection.

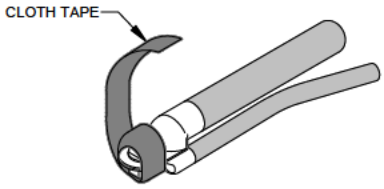
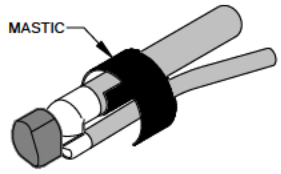


FIGURE 1B10. Cable termination for motors and transformers (surface ships and submarines) – Continued.

Step 4:

Apply mastic provided with kit in the crotch to form a seal.



Step 5:

Install MCK cap and apply heat with a heat gun or with a torch with a heat spreader.

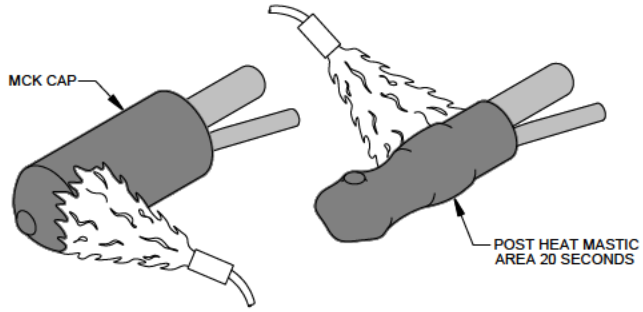


FIGURE 1B10. Cable termination for motors and transformers (surface ships and submarines) – Continued.

Method 1B-10-3
Alternate Method for Motor and Transformer Connections, 3M 5300, or equal (see 4.2)

1. Description. The main component of the 3M 5300 connection, the lug or splice cover, is made from ethylene propylene diene monomer (M-class) rubber (EPDM) either as a slip-on or as a cold shrink insulator. A mastic is used for the moisture seal on the pigtail kits. The 5 to 8 kilovolt kits, designed for shielded feeder cables, utilize a high dielectric constant stress control material or the feeder cable's electrical stress control. These kits are designed to be used with copper crimp connections, one- or two-hole lugs. After being crimped onto the cables, the lugs are bolted together in an inline or pigtail configuration, then insulated and sealed with the 3M motor lead splicing kits. Each kit contains all the necessary materials (except lugs) needed to make three splices. The lugs must be obtained separately.
2. Kit selection. The 3M 5300 series kit dimensions are shown in table 1B10-II.

TABLE 1B10-II. Kit selection table for 3M 5300.

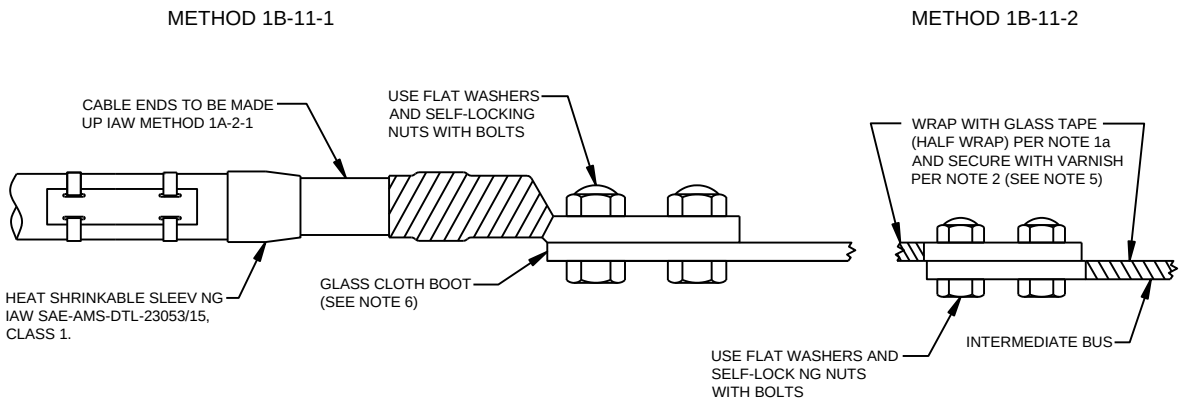
3M 5300 Kit Number	Motor Feeder Conductor Size (AWG or MCM)	Bolt Length Max (D)	Connection Length Max (H)
5300	14 - 10	⅜" (9 mm)	2.1" (53 mm)
5301	10 - 4	½" (12 mm)	3.4" (86 mm)
5302	2 - 1/0	¾" (18 mm)	4.2" (107 mm)
5303	1/0 - 250	1¼" (31 mm)	5.3" (135 mm)
5304	250 - 500	1½" (35 mm)	6.7" (170 mm)

3. Installation instructions. The 3M 5300 splice kits shall be installed in accordance with manufacturer's instructions.

NOTES:

1. The terminal connection hardware shall be CRES or zinc plated to prevent corrosion and shall be properly sized to fit in holes in lugs and to fit cable (use a single barrel lug, if possible).
2. See figure 2A20, "Locking devices on electrical connections", of MIL-STD-2003-2 for requirements for locking devices for motor and transformer electrical connections.

FIGURE 1B10. Cable termination for motors and transformers (surface ships and submarines) – Continued.



Motor and generator connections:

1. Bus bars to be bare. Apply three coats of varnish (see note 2). Provide drip-proof box over terminals. Glass cloth boot shall not be installed.

Forward and aft battery terminals (see note 4):

1. All bus bars in battery tanks, except inter-cell connectors, shall be taped with at least two layers of half-lapped glass tape in all cases where buses of opposite polarities pass within 3 inches of each other or within 3 inches of ground.
2. (Except inter-cell connectors) Two layers of half-lapped mica tape shall be applied under the glass tape. Such mica tape should extend approximately 6 inches beyond where the buses are in proximity to each other or to ground. The glass and mica tapes in accordance with notes 1a and 1b shall each be not less than seven mils thick, and each layer should be well coated with insulating varnish in accordance with note 2. Taping of bus bars shall be accomplished as follows:
   a. Where mica and glass tape are required, coat the bus bar with insulating varnish in accordance with note 2 and while still tacky, apply a layer of half-lapped mica tape. Apply a second coat of varnish and while still tacky, wrap a second layer of half-lapped mica tape. Repeat the application of varnish as before and wrap on a layer of glass tape half-lapped. Repeat the application of varnish as before and wrap on a second layer of glass tape half-lapped. Coat the finished taping completely with insulating varnish (see note 5).
   b. Where mica tape is not required, apply two layers of glass tape in sequence interposing a coating of insulating varnish before each layer is wrapped on and half-lapping each layer of tape. Apply a coating of varnish on completion of taping (see notes 5 and 6).

Propulsion control cubicle:

1. Wrap all bus bars in main control cubicle with untreated glass tape in accordance with note 1a. Apply two layers of tape half-lapped. Apply one or more coats of varnish in accordance with note 4 before each layer of tape is wrapped and after the final layer of tape is applied, sufficient to hold the glass tape in place, bake the taped bus 3 to 4 hours at 350 °F (176.6 °C).
2. Because of non-accessibility to the inside of the cubicle when energized, glass boots are not generally required but should be installed on bolted joints where necessary for personnel protection.
3. Bolted disconnects of opposite polarities within 3 inches of each other, or disconnects closer than 3 inches to ground, shall have sheets of approved insulating material installed as baffles, or covering an area of the ground surface, so that the distance in air between opposite polarities, or to ground, shall exceed 3 inches.

FIGURE 1B11. Insulating bus terminals and bus bars.

Alternate bus bar insulation (not to be used on propulsion control cubicle):

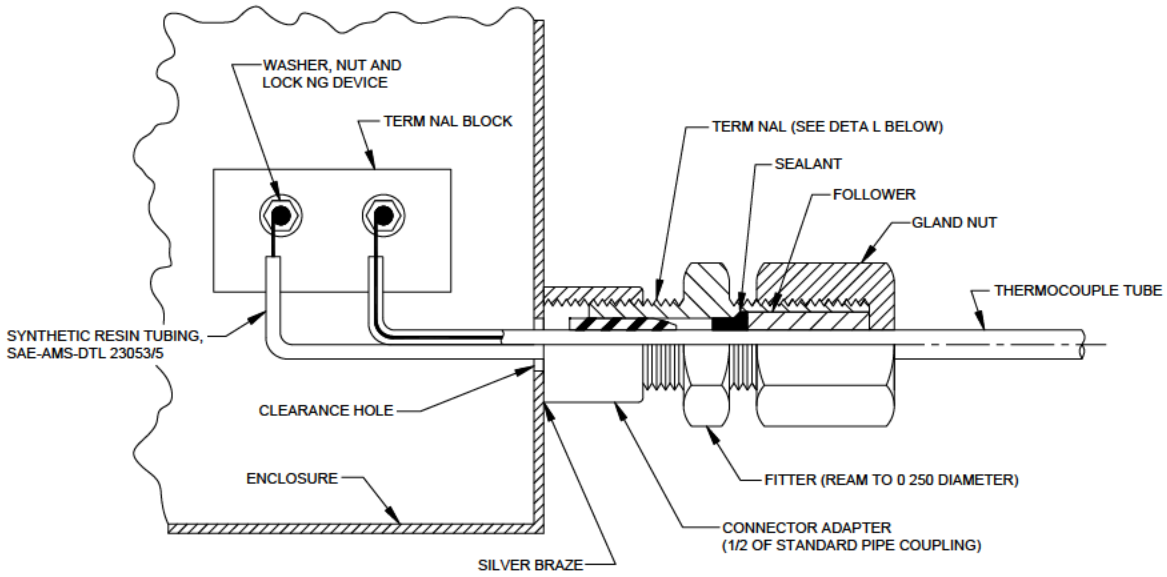
1. In lieu of taping methods shown hereon, the use of non-rigid, thin wall, heat-reactive tubing, SAE-AS23053/15, class 1, for insulation of exposed bus bars is approved, except heat-reactive tubing shall not be used on propulsion control cubicle.
2. Tubing shall be slipped over bus bar sections and, by application of heat (300 °F [148.8 °C] for ten minutes), will contract to form a uniform wall thickness of insulation over bus bar.
3. Tubing may be heated by use of a heat lamp or commercial blowers. Heating to less than 250 °F (121.1 °C) will not provide a satisfactory shrink.
4. Heat-reactive tubing shall not be used where temperature rise of equipment plus ambient is over 221 °F (105 °C).
5. Extreme care should be exercised in cutting and trimming the tubing to the desired length for the bus bar. Utilize a sharp knife or blade and cut the tubing in smooth continuous strokes. Avoid irregular cuts or nicks when trimming the edges and face of the bus bars. Position tubing so that bolting, clamping, or other forces do not pinch, cut, or similarly stress the tubing. When trimming tubing applied to laminated bus bars, exercise extreme care so as to avoid cuts in the laminated bus.

NOTES:

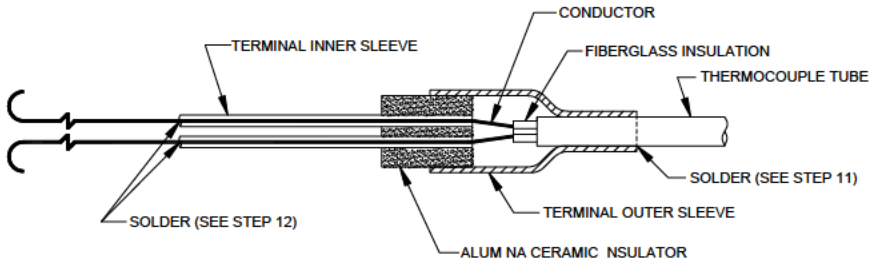
1. Tapes used shall be the following:
   a. Glass tape - MIL-Y-1140, class C, 1½ inches wide, 0.007 inch to 0.010 inch thick.
   b. Mica tape - reinforced mica tape seven mils thick, 1 inch wide.
2. Insulating varnish in accordance with MIL-I-24092.
3. In lieu of taping, a coating of approved plastisol insulation applied to a thickness of 0.125 inch may be used as an alternate, or tubing in accordance with method 1B-11-2.
4. Varnish or paint insulation shall not be applied to bolted bus bar connections for personnel protection, except at cell terminals and except quick opening disconnects. Bolted joints shall be covered with a varnish impregnated glass cloth removable boot securely tied in place. Glass cloth tape shall comply with ASTM D2754, type 1, grade B, 0.010 inch thick.
5. The edges of all bus bars to be taped shall be rounded with a radius equal to ½ their thickness.
6. See figure 2A20, “Locking devices on electrical connections”, of MIL-STD-2003-2 for requirements for locking devices for busbar electrical connections.

FIGURE 1B11. Insulating bus terminals and bus bars – Continued.

METHOD 1B-12-1
THERMOCOUPLE TUBE ENTERING
FIXTURE OR FITTING



TERMINAL - ELECTRIC (HERMETIC SEAL) ASSEMBLY



Thermocouple installation steps:

1. Determine length of bare conductors required to permit proper installation of the terminal and thermocouple tube, and mark the length on the tube. Remove tube to this mark by notching approximately 2-inch sections with a file and flexing slightly to break. Exercise care in flexing the tube not to excessively bend conductors.
2. Trim exposed fiberglass insulation on individual conductors retaining approximately ¼ inch from end of tube.
3. Clean the tube back a maximum of 1 inch from cut and individual conductors in way of solder joint to terminal inner sleeve using a fine grade sandpaper.
4. Conduct an insulation test as outlined in step 18, only if the thermocouple junction has been opened.
5. Test the insulation between the tube and the conductors by use of an ohmmeter. The readings, to be satisfactory, shall be over 0.2 megohms.
6. Place the gland nut, follower, and sealant on the tube.
7. Slide the terminal onto the tube. The tube shall be inserted approximately one half the distance to the ceramic portion of the terminal.
8. Place assembly in a position which will permit soldering. Soldering to top of terminal when in a vertical position is not recommended.

FIGURE 1B12. Installation of thermocouple cable entering equipment.

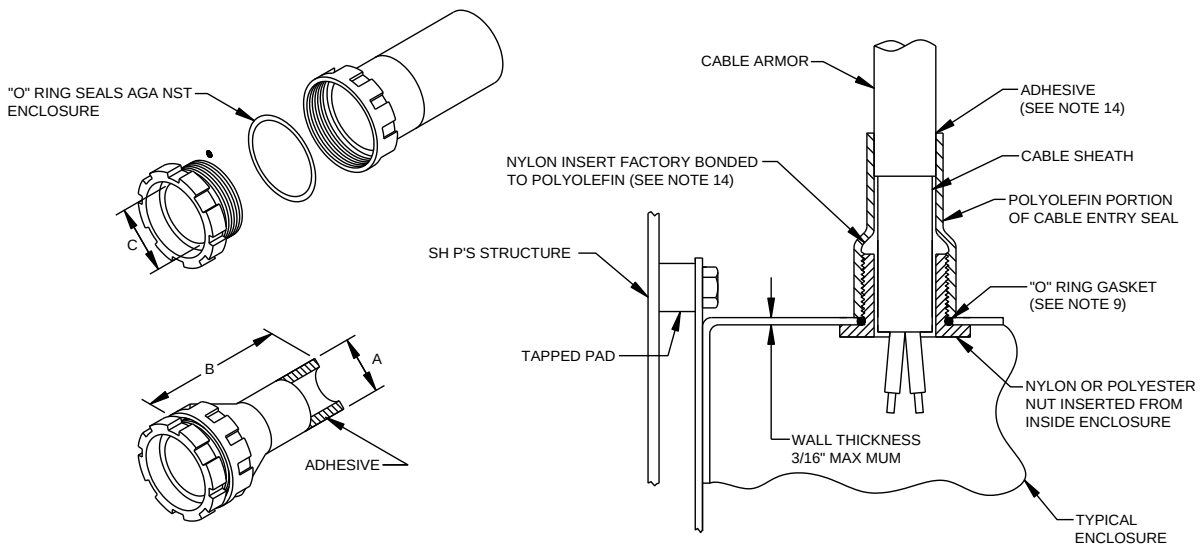
Thermocouple installation steps (continued):

9. Apply to junction of the outer sleeve of terminal and tube an absolute minimum of low temperature, non-acid soldering flux.
10. Using oxy-acetylene or hydrogen torch flame, preheat the tube and terminal. The flame should be directed to the outer sleeve of the terminal using care not to direct the flame at the ceramic portion.
11. Solder outer sleeve of terminal to the tube using a soft solder and a minimum amount of heat.
12. Solder the inner sleeves of the terminal to conductors as outlined in steps 9, 10, and 11.
13. Inspect all soldered joints visually for pin holes.
14. Repeat the test outlined in step 5.
15. Drill connection box, clean surface immediately around hole, and braze connector adapter in place. Insert fitter into connector adapter and tighten.
16. Insert soldered terminal through installed fitter, and tighten gland nut against follower and sealant.
17. In making the electrical connection in the connection box, the thermocouple conductor shall be wrapped around its specified terminal post and secured by means of a flat washer nut and locking device. The entire exposed portion of the conductor between the terminal post and the ceramic shall be covered with synthetic resin tubing, SAE-AS23053/5, class 1, when shipboard cable in accordance with MIL-DTL-24640 and MIL-DTL-24643 is used to connect the thermocouple conductors at the terminal post. Lugs shall be attached to the shipboard cable conductors and secured in direct contact with the thermocouple conductors.
18. Should the thermocouple junction be opened, the insulation between conductors and between each conductor and the tube shall be tested by an ohmmeter. Each reading, to be satisfactory, shall be over 0.2 megohms. The end hole shall be made watertight by filling with a silver base brazing alloy QQ-B-654, grade IV. The outside diameter of the tube shall not be increased at the tip due to this closure. Conduct an insulation test on this remade thermocouple in accordance with step 5.
19. Identification between chromel and alumel conductors can be made by use of a permanent magnet. The alumel conductor is the more magnetic.

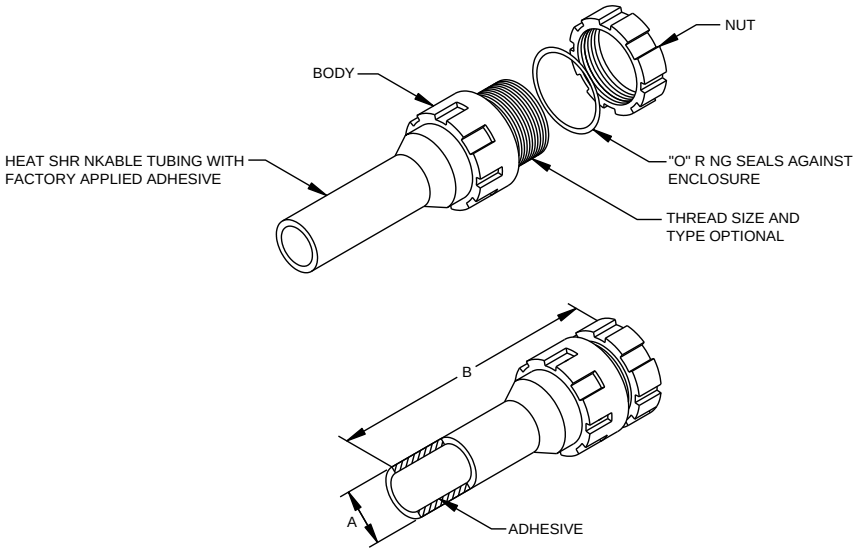
FIGURE 1B12. Installation of thermocouple cable entering equipment – Continued.

METHOD 1B-13-1

TYPE I



TYPE II



SEE TABLE 1B13-I FOR CABLE ENTRY SEAL D MENSIONS

FIGURE 1B13. Heat-shrink cable entry applicable to watertight and non-watertight enclosures.

TABLE 1B13-I. Cable entry seal dimensions (inches).

Part number	A		B Nom.	C Min.	Drill size
	Exp.	Rec.			
1B13-01	0.750	0.250	2.750	0.750	1.00
1B13-02	1.200	0.500	3.750	1.100	1.38
1B13-03	1.700	0.750	4.500	1.600	2.00
1B13-04	0.390	0.160	1.780	0.470	0.94
1B13-05	0.710	0.280	2.020	0.790	1.34
1B13-06	1.100	0.470	2.610	1.220	1.85
1B13-07	1.65	0.710	3.200	1.770	2.38
1B13-08	2.520	1.180	3.990	2.680	2.35
(Also available in multiple conductor sizes from approved manufacturers.)					

Installation notes:

1. Inspect the clearance hole which has been drilled or punched in the enclosure for the tube as indicated in table 1B13-I, and remove any burrs or irregularities. The surface shall meet the specification for a normal "O" ring seal.
2. Type I: Place rigid, externally-threaded nut through hole so that the flanged end is on the inside of the can or cabinet.
   Type II: Place the end nut inside the cabinet and insert the externally threaded cable entry seal into the nut.
3. Place "O" ring over threaded end and position against outside of can or cabinet.
4. Screw shrinkable, internally-threaded component (shrink portion) on rigid nut. Tighten the male and female parts with appropriate spanner wrenches.
5. To prepare the cable for entering the electrical enclosure, proceed in the normal manner by removing enough armor (when present) to allow for the conductors to reach the remotest location on the connection block with reasonable amount of slack. When removing the sheath from the conductors, be sure to leave enough sheath extending through the armor (when present) to obtain a maximum seal between the shrinkable nose and the sheath. Normally ¼ inch to ⅜ inch of the armor (when present) shall be inside the cable entry seal, then the sheath should extend through the nose (shrink section). See method 1B-13-1 for proper installation. (Note: The waterseal is accomplished by the factory-applied sealant forming a mechanical bond between the nose of the cable entry seal and the cable sheath, when the nose is shrunk to the cable.) Avoid unnecessary cutting of the sheath and conductor insulation during the process of preparation. If it is not possible or desirable to secure the armor (when present) under the shrinkable nose, then use tape or shrink tubing to keep the armor from unraveling as described in MIL-STD-2003-3, figure 3C2, "ASTM F1836M nylon stuffing tube assembly", method 3C-2-1.
6. Prepare the conductors for making the electrical connections.
7. Insert the cable through the previously assembled unit and into the enclosure so as to "trap" the armor (when present) inside the nose and extend the cable sheath through the shrink portion of the entry seal. The conductors may be connected at this point, before shrinking, if necessary, to electrically check out. It may be desirable to wait until all cables are installed and checked out before shrinking any of the cable entry seals.
8. Shrink expanded opening in the cable entry seal by applying heat (250 to 275 °F [121.1 to 135 °C]) using hot air blower (heat gun with circular deflector) or other heat source. When part has been fully shrunk and assumes the configuration of the cable, discontinue heating. Additional heating will not make the component shrink tighter.
9. "O" rings shall be furnished by the manufacturer as part of the complete cable entry seal.
10. The cable entry seal shown on this sheet is suitable for all thin wall enclosures up to and including 3⁄16 inch thick.

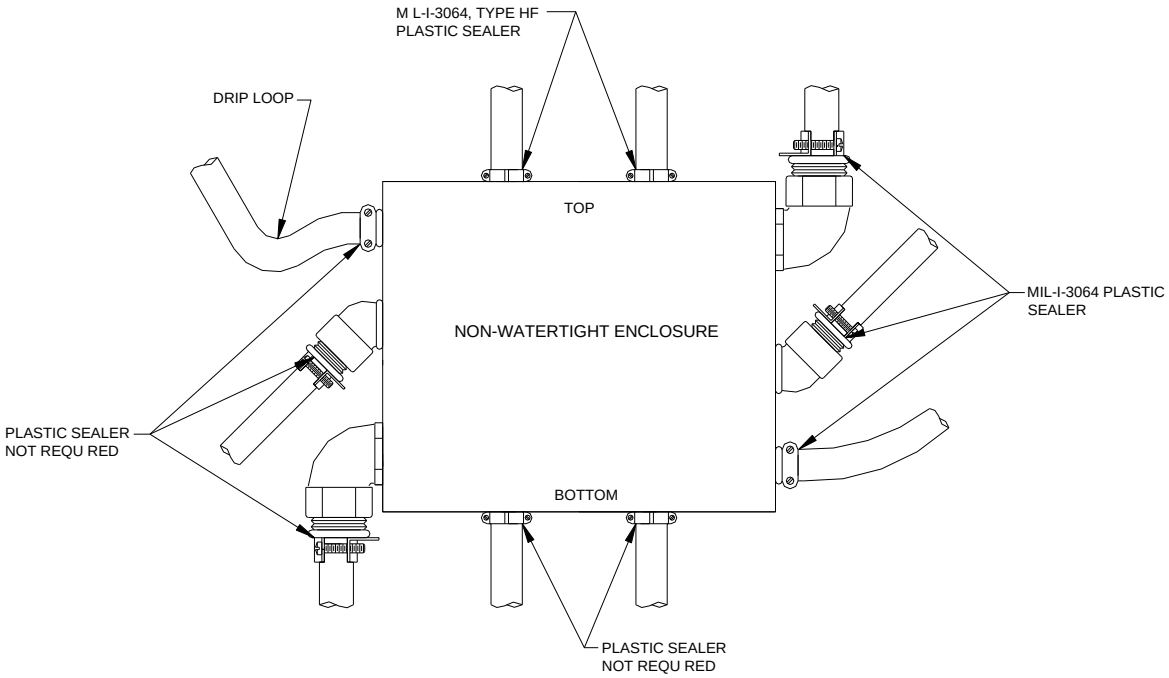
FIGURE 1B13. Heatshrink cable entry applicable to watertight and non-watertight enclosures – Continued.

Installation notes (continued):

11. Grounding, if required, shall be accomplished according to the applicable requirements of MIL-STD-1310.
12. The rigid plastic parts shall be made from polyamide material in accordance with type II of ASTM D4066 or ASTM D6779 or polyester in accordance with MIL-M-24519.
13. Material shall conform to the requirements of SAE-AS81765/1, type 1.
14. The adhesive used to bond the polyolefin to the nylon (polyamide) inset shall be in accordance with A-A-3097.
15. Seals shall not be installed in any cabinet or device in which normalized temperature (ambient plus temperature rise) will exceed 185 °F (85 °C). Application is limited to 20 psi water pressure maximum. These seals are not to be used with any cable in which the normalized temperature will exceed 185 °F (85 °C).
16. These seals are considered as an alternate to nylon stuffing tubes when meeting the performance requirements of ASTM F1836M.
17. These seals shall not be installed in areas exposed to the weather.

FIGURE 1B13. Heatshrink cable entry applicable to watertight and non-watertight enclosures – Continued.

METHOD 1B-14-1



NOTES:

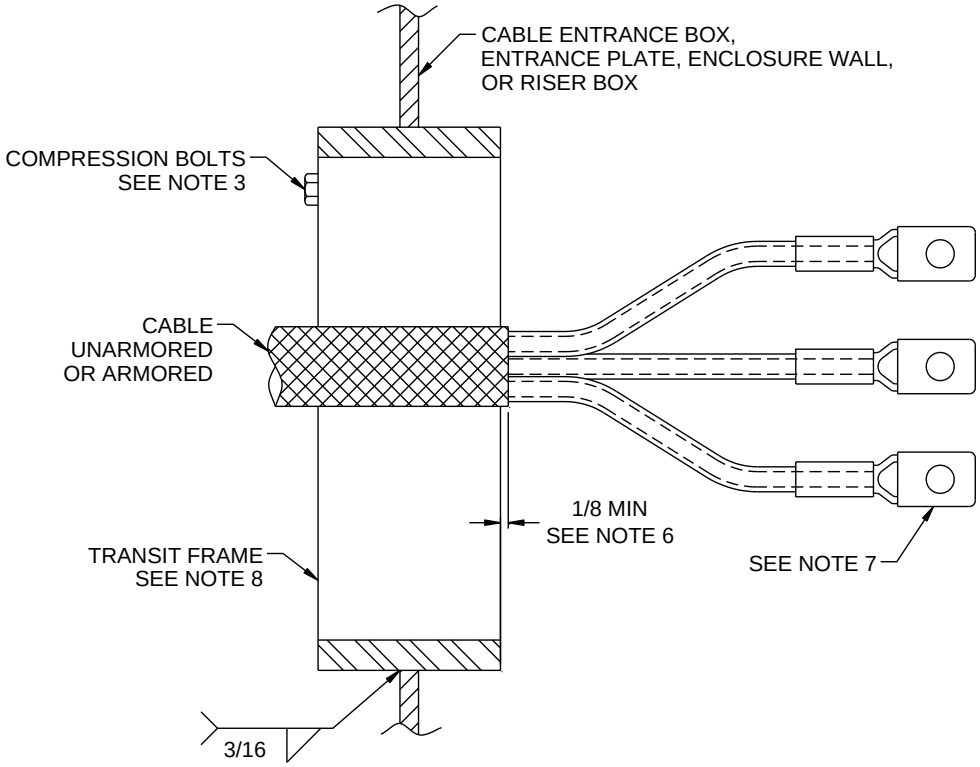
1. See figure 1B3 for box connector and plastic sealer requirements.
2. See 4.1.8 for equipment cable entry requirements.
3. When cables are installed in the top or side of enclosures, the cable shall have a drip loop or MIL-I-3064 plastic sealer installed both between the clamp and the cable and outside the clamp to prevent entry of water from above.
4. Unused box connectors shall be removed and the hole properly blanked.

FIGURE 1B14. Cable entrance to non-watertight enclosures – use of drip loop and plastic sealer.

Method 1B-15-1
Equipment cable entrance using multi-cable transits (MCT)

NOTES:

1. This method is applicable for cable entrance into equipment and riser boxes using multi-cable transits.
2. The multi-cable transits shall be qualified to MIL-DTL-24705. The multi-cable transit installation methods in MIL-STD-2003-3 shall be used for equipment entry installation.
3. Position MCT frames so that the heads of the compression bolts are on the outside of the cable entrance box or enclosure.
4. When the equipment cable entrance uses structural beams, and the MCT is installed in the beam, structural compensation shall be provided, if required.
5. See MIL-STD-2003-3 for cable packing details.
6. Cable jacket or jacket and armor shall extend a minimum of ⅛ inch beyond the transit blocks to prevent damage to the conductor insulation.
7. Cable end preparation shall be in accordance with this standard.
8. MCT frames may be square or square radius corner type as shown in MIL-STD-2003-3. The material of the frame, either steel or aluminum, shall match the material type of the cable entrance box, entrance plate, or enclosure wall.



TYPICAL MCT INSTALLATION DETAIL

FIGURE 1B15. Equipment cable entrance using multi-cable transits.

APPENDIX 1C – PROTECTION OF TOPSIDE CONNECTORS

C.1 SCOPE

C.1.1 Scope. This appendix describes the procedures for protection of topside connectors. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

C.2 APPLICABLE DOCUMENTS

C.2.1 General. The documents listed in this section are specified in this appendix. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in this appendix, whether or not they are listed.

C.2.2 Government documents.

C.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

COMMERCIAL ITEM DESCRIPTIONS

A-A-50493 - Oil, Penetrating (for Loosening Frozen Metallic Parts)

A-A-59382 - Reusable Environmental Protection Sleeves

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-I-24391 - Insulation Tape, Electrical, Plastic Pressure-Sensitive

(Copies of these documents are available online at https://quicksearch.dla.mil/.)

C.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

SAE INTERNATIONAL

SAE-AS23053/5 - Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked

(Copies of this document are available online at www.sae.org.)

C.2.4 Order of precedence . Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

C.3 REQUIRED EQUIPMENT AND MATERIALS

C.3.1 Required equipment and materials. The required equipment and materials shall be as specified in the individual methods.

C.4 NOTES AND PROCEDURES

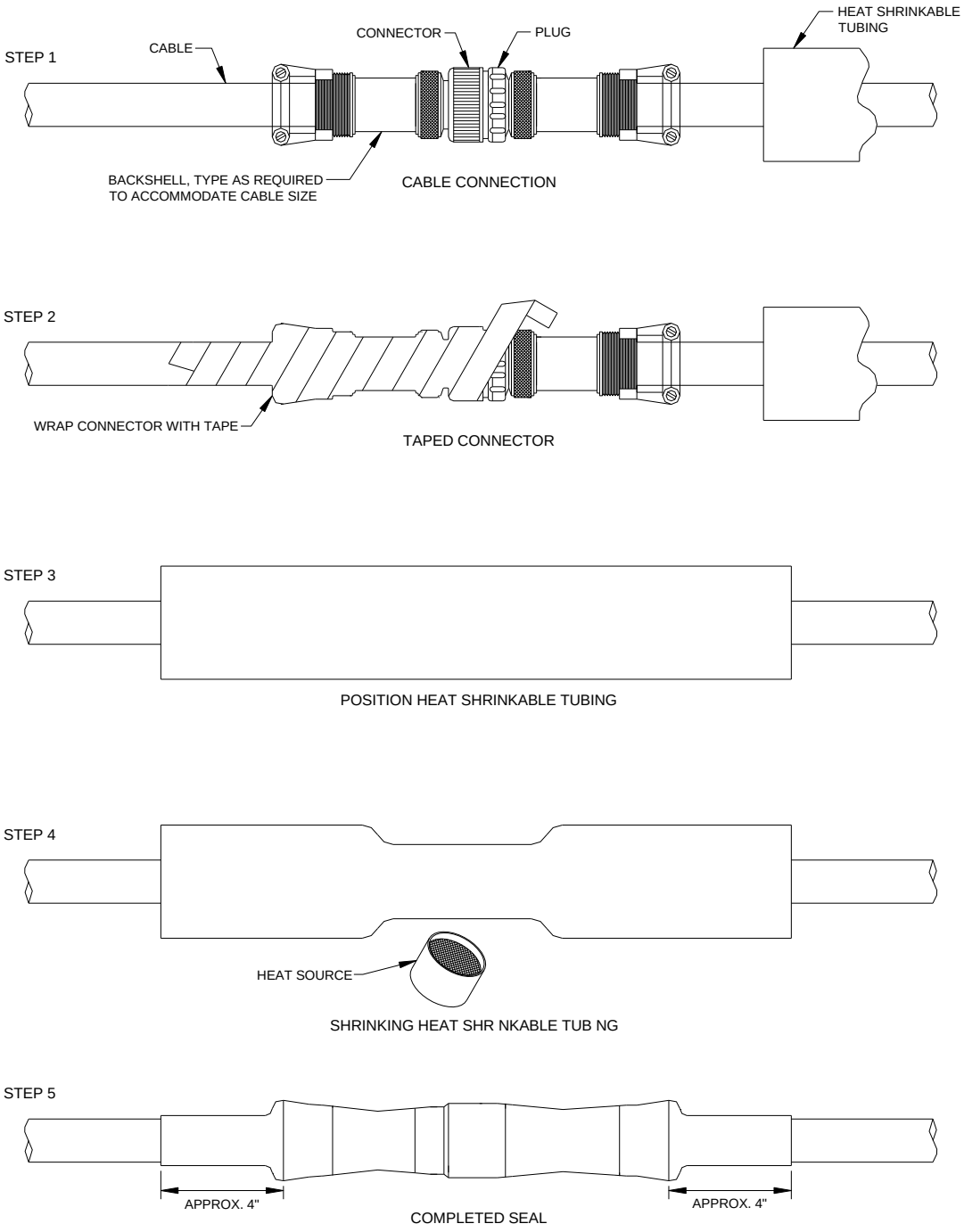
C.4.1 Dimensions. For figures and tables in this appendix, all dimensions are in inches unless otherwise noted.

C.4.2 Figures. Table 1CI provides information for the figures in this appendix.

TABLE 1CI. Figures for the protection of topside connectors.

Figure number	Protection of topside connectors	Page
1C1	Protection of connectors topside	115
1C2	Gel in the middle connector protection	117

METHOD 1C-1-1



NOTES:

1. The procedure outlined on this figure is suitable for covering in-line connectors located topside, with heat-shrinkable tubing to protect against corrosion by making the connectors watertight.

FIGURE 1C1. Protection of connectors topside.

NOTES (continued):

2. Install the heat-shrinkable tubing in accordance with the following steps:
   - Step 1: Install heat-shrinkable tubing of proper diameter and length (approximately 8 inches longer than mated connectors) on one of the cables. Connect the connectors together. Abrade the cable jacket circumferentially and clean with appropriate solvent such as Methyl Ethyl Ketone (MEK).
   - Step 2: Wrap connector in tape MIL-I-24391.
   - Step 3: Position heat-shrinkable tubing. Place heat-shrinkable tubing centered over connectors.
   - Step 4: Using a hot air blower or other heat source, heat the center of tubing until it shrinks over connectors. Start working towards one end applying the heat uniformly and smooth. When one half of the tubing is shrunk, repeat the same procedure on the unshrunk half.
   - Step 5: Remove heat and allow tubing to cool. Do not try to move.
3. Heat-shrinkable tubing shall be in accordance with SAE-AS23053/5, class 1 or class 3 (without sealant).

FIGURE 1C1. Protection of connectors topside – Continued.

Method 1C-2-1
Weatherproof Electrical Connector with Gel in Middle Connector Protector (GIMCP)

Criteria for using GIMCP connector weatherproofing:

1. GIMCP (A-A-59382 - reusable environmental protection sleeves). Approved for use in a topside environment to provide corrosion and environmental protection where access to the connector is routinely required. Provides the ability to quickly remove and re-install connectors without having to repeat entire weatherproofing process.
2. All components of the GIMCP shall meet requirements of A-A-59382.
3. Sufficient clearance around circumference of the connector (minimum 1 inch).
4. Connector to cable size (diameter) ratio is no greater than 2 to 1.
5. GIMCP sleeves shall not be utilized in areas of extended or continuous exposure to hydrocarbon-based fuels or fluids.

General procedure:

Note: the following procedure covers a particular GIMCP that meets the requirements of A-A-59382. Other GIMCP systems that meet the requirements of A-A-59382 may require different steps.

1. Remove all contaminants (dirt, grease, etc.), weatherproofing materials, and adhesives/sealants from the cable connector, the back-shell, the gap between connector and the back-shell, and mating receptacle external surfaces.
   a. For existing connector installations, use detergent (General Purpose, Spray-on/Wipe off, P-D-1747, NSN 7930-00-068-1669) for removal of all contaminants.
   b. Remove existing weatherproofing material with care. To avoid damaging cable, use diagonal cutting pliers rather than a craftsman's knife to cut existing weatherproofing materials whenever possible.
2. Inspect existing connector for corrosion. Remove any corrosion products by using the milder of either a fiber bristle brush or a metal bristle brush. Do not use abrasive material or a wire brush on new aluminum connectors to prevent damage to anodizing treatment. Use only enough force to clean away corrosion on existing connectors.
3. Disconnect the existing connector that is to be corrosion protected. If connector is difficult to disconnect, liberally apply penetrating oil (A-A-50493 [class A, type 1]; NSN 9150-01-591-4213) to the connector at the receptacle interface and wrap a rag soaked with penetrating oil around the area. Allow to soak for 30 minutes. Take care not to damage tool gripping surfaces while attempting to loosen connector.
4. If disconnecting the connector per step 3 is unsuccessful, reapply penetrating oil (A-A-50493 [class A, type 1]; NSN 9150-01-591-4213) and allow to soak for 4 hours.
5. Repair defective paint and corrosion on the receptacle mounting surface within a 2-inch wide perimeter surrounding the receptacle.
6. Do not heat the GIMCP during installation.
7. Generally GIMCP sleeves can be used over diameters up to twice the diameter of the shipping tube. However, this high ratio becomes physically difficult over larger diameters.
8. Never cut GIMCP sleeves.
9. The GIMCP is supplied as a kit. See table 1C2-I for available kit sizes and NSNs. The GIMCP kit contains the following (see illustration 1):
   a. Instructions for sealing conduit and cable splices and connector terminations
   b. GIM sealing sleeve
   c. Gel sealing strip, foamed backed GTS 1030
   d. Removable cable tie, UV resistant, (3)
   e. Paper tube core (delivery tube)
   f. Paper tube core (extra tube)
   g. Transition tube (short tube included in kit sizes 13 and 14 only)
   h. Flange cover (type N kits only)

FIGURE 1C2. Gel in the middle connector protection.

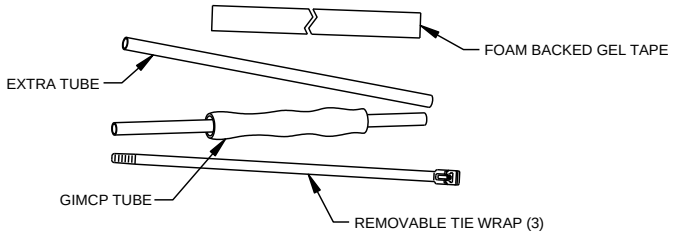


Illustration 1 – Typical GIMCP kit

TABLE 1C2-I. List of GIMCP kit sizes.

Base part no.	Available kits	Dimensions diameter in. (mm)	Reference lengths in. (mm)	Recommended use range in. (mm)	Connection length in. (mm)	NSN
LNCL-11-125-GK-125	GK	0.51 (13)	4.92 (125)	0.22-0.68 (6-17)	3.00 (75)	5970-01-516-4418
LNCL-11-205-GK	GK	0.51 (13)	8.07 (205)	0.22-0.68 (6-17)	6.00 (150)	5970-01-516-4422
LNCL-12-140-GK	GK	0.56 (14.2)	5.51 (140)	0.48-0.90 (12-23)	4.00 (100)	5970-01-516-4424
LNCL-12-140-CK-N	CK-N			GIM Type N Kit		5970-01-516-4430
LNCL-12-240-GK	GK	0.56 (14.2)	9.45 (240)	0.48-0.90 (12-23)	7.00 (175)	5970-01-516-4425
LNCL-13-155-GK	GK, TK-8	0.75 (19.0)	6.10 (155)	0.69-1.20 (18-30)	4.00 (100)	5970-01-516-4428
LNCL-13-305-GK	GK	0.75 (19.0)	12.00 (305)	0.69-1.20 (18-30)	9.00 (225)	5970-01-516-4431
LNCL-14-185-GK	GK, TK-7	1.02 (25.9)	7.28 (185)	0.96-1.50 (25-38)	5.00 (125)	5970-01-516-4432
LNCL-14-355-GK	GK	1.02 (25.9)	14.00 (355)	0.96-1.50 (25-38)	10.00 (250)	5970-01-516-4973
LNCL-15-355-GK	GIC TK-1, TK-5, TK-6	1.45 (36.8)	7.28 (185)	1.40-2.00 (36-46)	5.00 (125)	5970-01-516-5007
LNCL-15-260-GK	GK	1.45 (36.8)	10.2 (260)	1.40-2.00 (36-46)	7.50 (190)	5970-01-516-5014
LNCL-15-260-SS	SS			GIM shore power sleeve kit		5970-01-516-5018
LNCL-15-450-GK	GK	1.45 (36.8)	17.72 (450)	1.40-2.00 (36-46)	12.00 (300)	5970-01-516-5015
LNCL-GTS-130-1X25FT				Tape, foam backed blue sealant		5970-01-516-5022

FIGURE 1C2. Gel in the middle connector protection – Continued.

Method 1C-2-2
Installation Instructions for Splice Sealing Applications

1. Select proper GIMCP sleeve diameter from table 1C2-I. Use smallest diameter sleeve that will clear connector plus an additional ⅛ inch.
2. Clean the connector and the insulation on the conduit or cable 1.5 times the length of the roll-on sleeve of the GIMCP on both sides of the splice/connectors of area to be protected. This is to prevent foreign matter from becoming trapped underneath the GIMCP sleeve.
3. Twist the GIMCP sleeve back and forth over the entire length of the sleeve to distribute lubricant inside the sleeve. Butt the delivery tube with GIMCP against cable end or connector. See illustration 1.

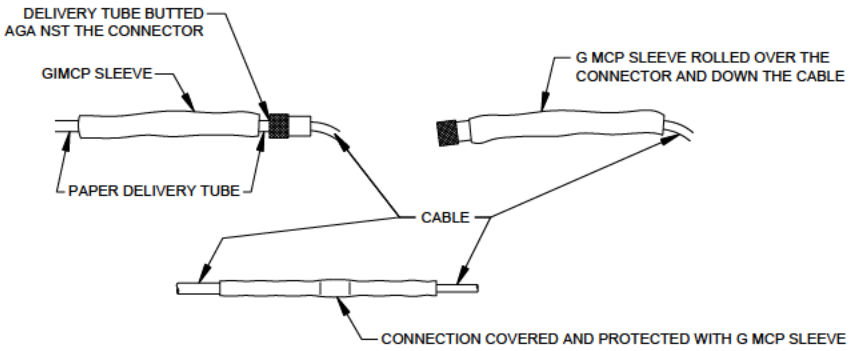


Illustration 1

1. Roll the GIMCP onto cable as shown on illustration 1. Use the short transition paper core tube included in kits # 13 and # 14, if needed to ease the rolling operation due to a large diameter difference between the core and cable or connector. Complete the connections in accordance with the manufacturer's instructions for the connector/splice. Ensure the splice connection does not exceed the maximum length of the GIMCP sleeve.
2. Roll on the GIMCP sleeve evenly back over the connection covering the connector.
3. Properly discard any unused portion of the kit.
4. The splice sealing is complete. The removable tie wraps are not necessary for an in-line connection but should be retained for re-entry for other applications. To re-enter the connection, simply roll the GIMCP off the splice to one side or the other.

FIGURE 1C2. Gel in the middle connector protection – Continued.

Method 1C-2-3
Installation instructions for Straight Connector Sealing Applications

1. Verify the proper GIMCP size using the selection guide from table 1C2-1.
2. Clean the connector and the insulation on the conduit or cable 1.5 times the length of the GIMCP sleeve. This is to prevent foreign matter from becoming trapped underneath the GIMCP sleeve.
3. Twist the GIMCP back and forth over its entire length to distribute lubricant inside the sleeve. Butt the delivery tube with the GIMCP against the connector on the end of the cable and push the GIMCP sleeve onto the connector and cable. Use the short transition paper core tube included in the kit only when using kits #13 and #14, if needed, to ease the rolling operation due to a large diameter difference between the core and the cable or connector. Roll the GIMCP over the connector and onto the cable until clear of the connector back-shell.
4. Add multiple layers of Scotch 130C, or equal (see 4.2), tape to the back half of the connector and cable to build up the diameter to the appropriate dimension for the GIMCP sleeve. Use the paper core as an estimator to provide a smooth transition for the GIMCP sleeve to roll easily onto the connector. See illustration 1.

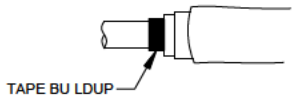


Illustration 1

5. With type N connectors, it is necessary to build up a bulge over the end of the connector to provide a seat for the tie wrap.
6. Reconnect and torque the connector to proper tightness. Use the gel sealing strip (included in the kit) as an interfacial seal around the connector face. Wrap the sealing strip around the front of the connector, being sure to cover the interface between the connector and the panel.
7. The rear of the assembly shall be taped at the connector and cable transition. A buildup shall be on the rear of the connector for type N and other coaxial connectors to reduce stress in the force ring holding the shield. Taped sections over all cables are required to provide an interference seal. Taped sections shall be large enough to provide a "bump" on the cable sufficient to provide an interference fit and hence, a seal. Roll the GIMCP down the cable and over the connector and the gel sealing strip. For added protection against vibration, double the GIMCP sleeve onto itself for a short distance by pushing the sleeve towards the connector. A small extrusion of the gel material is acceptable. Place a removable tie wrap snugly forward of the tape bump, but do not over tighten. See illustration 2.

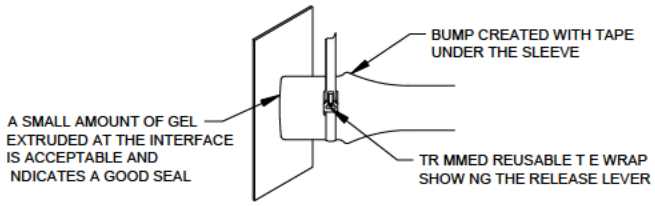


Illustration 2

8. To re-enter the connection, carefully remove the cable tie and roll the GIMCP onto the cable. If there is sufficient length of cable tie end protruding, reuse the same tie. If the tie is trimmed flush, the tie shall be replaced to properly finish the seal.

FIGURE 1C2. Gel in the middle connector protection – Continued.

Method 1C-2-4

Installation Instructions for Angled Connector Sealing Applications

1. Verify the proper GIMCP size using the selection guide from table 1C2-1.
2. Clean the connector and the insulation on the conduit or cable 1.5 times the length of the GIMCP sleeve. This is to prevent foreign matter from becoming trapped underneath the GIMCP sleeve.
3. Cable clamp style backshells shall have the bolts trimmed and filed smooth before rolling on the sleeve. A wrap of electrical tape around the bolts is a good secondary precaution.
4. To assist in the installation around right-angle connector backshells, use a cable tie included in the kit as a leverage device (especially helpful where the cable is very flexible). Start by locating a convenient spot for the cable tie to be temporarily fixed at the cable end of the connector. See illustration 1.

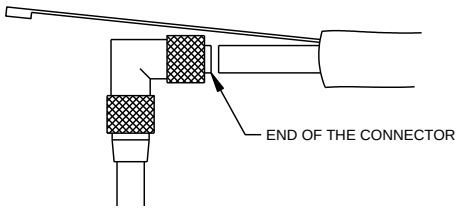


Illustration 1

5. Note the distance to this spot. Use an extra paper tube supplied in the kit to roll on the sleeve over the extra tube and the tie wrap so the proper length of tie wrap sticks out of the assembly, trapping the tie in the process. The resulting assembly shall be butted up to the connector (or backshell) and the tie wrap will latch into place as shown on illustration 2. Electrical tape may be used as a temporary fixtures aid to stabilize the tie.

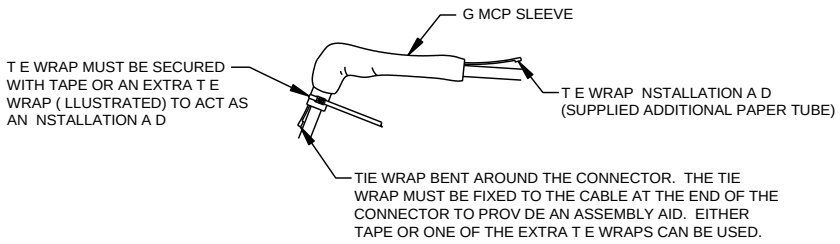


Illustration 2

6. Use the cable tie installation aid. See illustration 2 as a guide for obtaining leverage on the cable assembly as the GIMCP is rolled on over the top and around the angled corner to the tape or the cable tie. Remove the temporary electrical tape and cable tie wrap from the connector or backshell. Then, continue to roll the sleeve over and down the cable. Cable clamp style backshells are to have the bolts trimmed and filed smooth before rolling on the GIMCP sleeve. See illustration 3. A wrap of tape around the bolts is a good secondary precaution.

FIGURE 1C2. Gel in the middle connector protection – Continued.

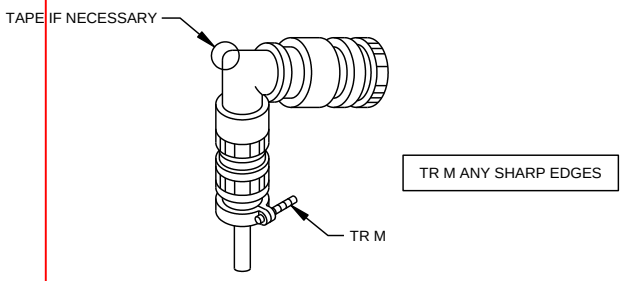


Illustration 3

7. The sleeve is rolled over the connector; see illustration 4. The sleeve is rolled back on the cable; see illustration 5. The sleeve can now be rolled back over the connector after the connector is mated with relative ease.

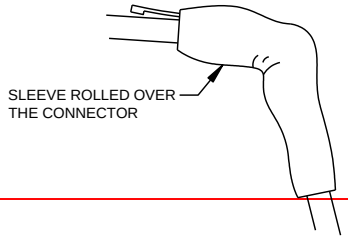


Illustration 4

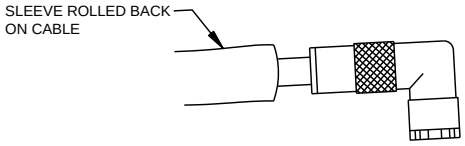


Illustration 5

8. To re-enter the connection, carefully remove the cable tie, if installed, and roll the GIMCP onto the cable. If there is sufficient length of cable tie end protruding, reuse the same cable tie. If the tie is trimmed flush, the tie shall be replaced to properly finish the seal.

FIGURE 1C2. Gel in the middle connector protection – Continued.

APPENDIX 1D – REPAIR OF DAMAGED CABLE

D.1 SCOPE

D.1.1 Scope. This appendix describes the procedures for the repair of damaged cables. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

D.2 APPLICABLE DOCUMENTS

D.2.1 General. The documents listed in this section are specified in this appendix. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in this appendix, whether or not they are listed.

D.2.2 Government documents.

D.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

COMMERCIAL ITEM DESCRIPTIONS

A-A-59296 - Insulating Compound, Electrical (for Field Splicing Applications)

A-A-59770 - Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-17695 - Insulation Tape, Electrical, Filler Type, Flameproof, Synthetic

MIL-I-22444 - Insulation Tape, Electrical, Self Bonding, Silicone Rubber Treated Bias Weave or Sinusoidal Weave Glass, Cable Splicing, Naval Shipboard (see 4.5)

MIL-I-24391 - Insulation Tape, Electrical, Plastic, Pressure-Sensitive

(Copies of these documents are available online at https://quicksearch.dla.mil.)

D.2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) DRAWINGS

803-5725675 - Surface Ship Electronics/Electrical Installation Methods (NOFORN)

(Copies of this document are available from the applicable repositories listed in S0005-AE-PRO-010/EDM, which can be obtained online at https://nll navsup navy mil, may be requested by phone at 215-697-2626, or may be requested by email at nllhelpdesk@navy.mil. Copies of this document may also be obtained from the Naval Ships Engineering Drawing Repository (NSEDR) online at https://199.208.213.105/webjedmics/index.jsp. To request an NSEDR account for drawing access, send an email to NNSY_JEDMICS_NSEDR_HELP_DESK@navy mil.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

S9086-KC-STM-010/300 - Naval Ships' Technical Manual Chapter 300, Electric Plant-General

(Copies of this document are available online via Technical Data Management Information System (TDMIS) at https://mercury.tdmis navy mil/. Refer questions, inquiries, or problems to: DSN 296-0669, Commercial (805) 228-0669. These documents are available for ordering (hard copy) via the Naval Logistics Library at https://nll.navsup.navy.mil. For questions regarding the NLL, contact the NLL Customer Service at nllhelpdesk@navy mil, (866) 817-3130, or (215) 697-2626/DSN 442-2626.)

D.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

SAE INTERNATIONAL

SAE-AS23053/5 - Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked

SAE-AS23053/15 - Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked

(Copies of these documents are available online at www.sae.org.)

D.2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

D.3 REQUIRED EQUIPMENT AND MATERIALS

D.3.1 Required equipment and materials. The required equipment and materials shall be as specified in the individual methods.

D.4 NOTES AND PROCEDURES

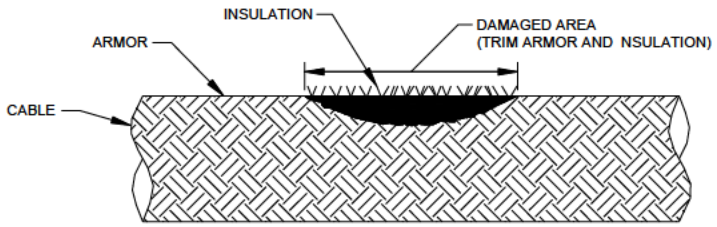
D.4.1 Dimensions. For figures and tables in this appendix, all dimensions are in inches unless otherwise noted.

D.4.2 Figures. Table 1DI provides information for the figures in this appendix.

TABLE 1DI. Figures for the repair of damaged cables.

Figure number	Repair of damaged cables	Page
1D1	Repair of damaged cables, insulation, and armor	125
1D2	Repair of jet aircraft servicing and starting cables	127
1D3	Repair of cables, power, control, telephone, and electronic	129
1D4	Cable jacket repair sleeve, installation	131
1D5	Cable jacket repair sleeve, installation	133
1D6	Cable jacket repair sleeve, installation	135
1D7	Cable conductor insulation repair when approved by NAVSEA	138
1D8	Low smoke cable conductor insulation and protective cover repair within an enclosure	139
1D9	5-kilovolt rated cable conductor insulation repair within an enclosure	141

METHOD 1D-1-1



LLUSTRATION 1

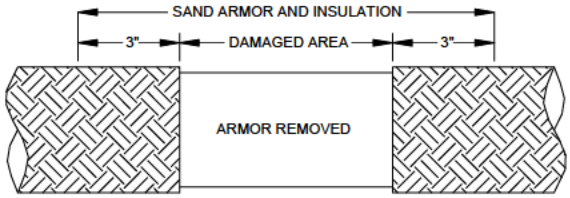


ILLUSTRATION 2
REMOVE ARMOR FROM AREA TO BE REPAIRED

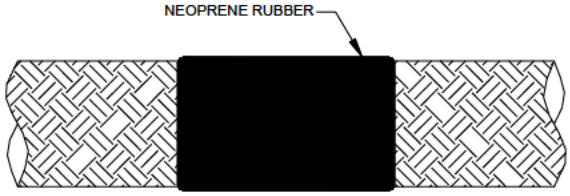


ILLUSTRATION 3

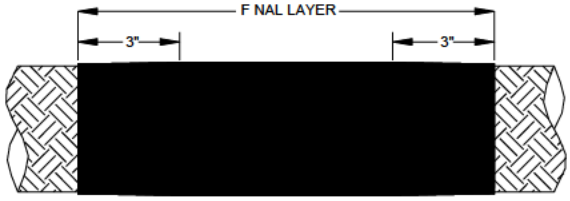


ILLUSTRATION 4

The procedure outlined is suitable for repairing cables with armor or sheath damage only, with conductors and water-sealing compounds being intact. See figure 1D7.

Step 1:

Trim damaged insulation and armor to remove frayed areas. See illustration 1.

Step 2:

Sand insulation and armor to be prepared providing a rough surface that extends 3 inches each side of the damaged area. See illustration 2.

Step 3:

Clean area with Xylol, or similar solvent.

Step 4:

Apply successive layers of type N29 adhesive in accordance with NSN 8040-01-440-4328 and 1/16-inch thick Neoprene rubber4.2 to obtain a resultant thickness greater than that of the damaged material. See illustration 3.

FIGURE 1D1. Repair of damaged cables, insulation, and armor.

Step 5:

The final layer of Neoprene rubber should extend 3 inches each side of the damaged area. See illustration 4.

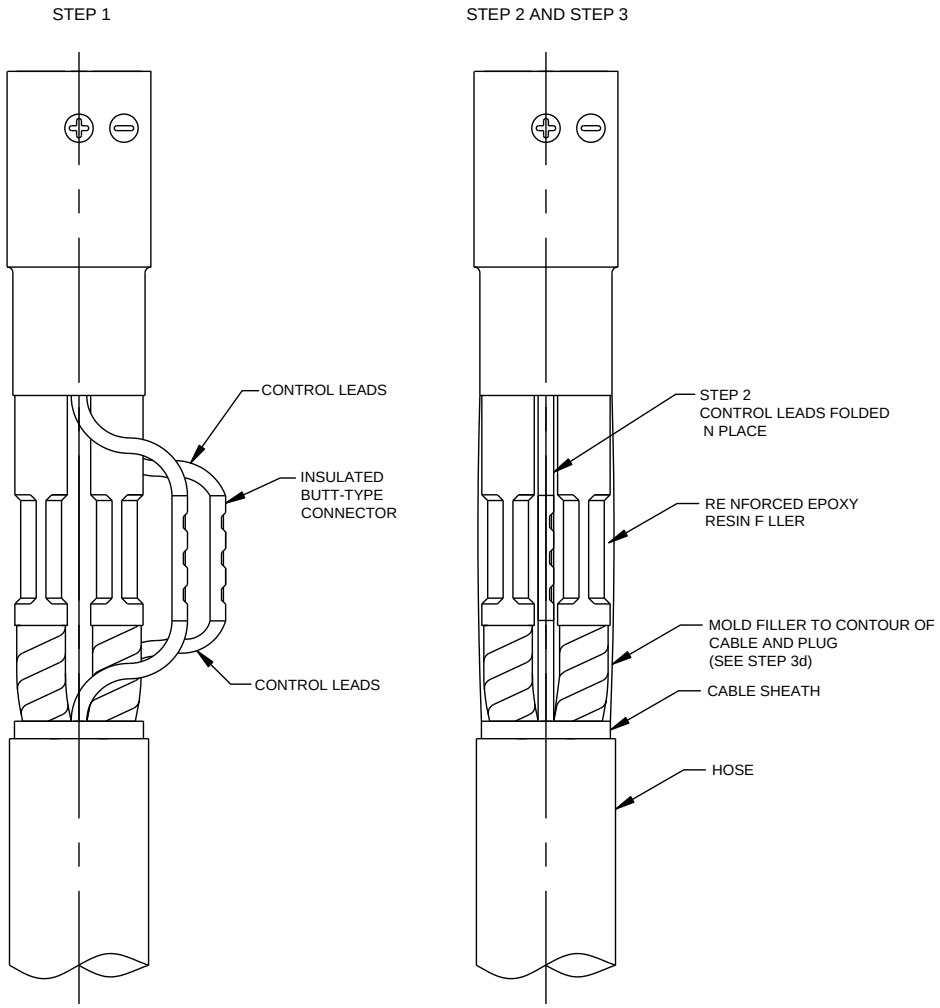
Step 6:

Apply a sufficient amount of type N29 adhesive coating, in accordance with NSN 8040-01-440-4328 to cover the repair and saturate the adjacent exposed armor.

NOTE: An alternate method for repairing damaged armor utilizing self-adhesive aluminum tape in accordance with Surface & Submarine Electronic/Electrical Installation Methods, 803-5725675, is acceptable.

FIGURE 1D1. Repair of damaged cables, insulation, and armor – Continued.

METHOD 1D-2-1



Step 1:

Insert the prepared ends of the control leads from the plug tip assembly and the cable in the insulated butt connector. Crimp in place with the hand crimping tool.

Step 2:

Fold the control leads in place as shown in detail.

Step 3:

Prepare reinforced epoxy resin filler as follows:

a. Obtain and have ready an expendable container and spatula or putty knife for mixing the epoxy resin and milled fiber.
b. Mix together the resin and hardener contained in one 2¾-ounce size package of epoxy resin A-A-59296, type I, in accordance with manufacturer's instructions.
NOTE: Resin will set up hard in 10 to 15 minutes.
c. Pour the epoxy resin mixture (b above) onto about ⅔ cup of milled fiber and mix to the consistency of soft putty.

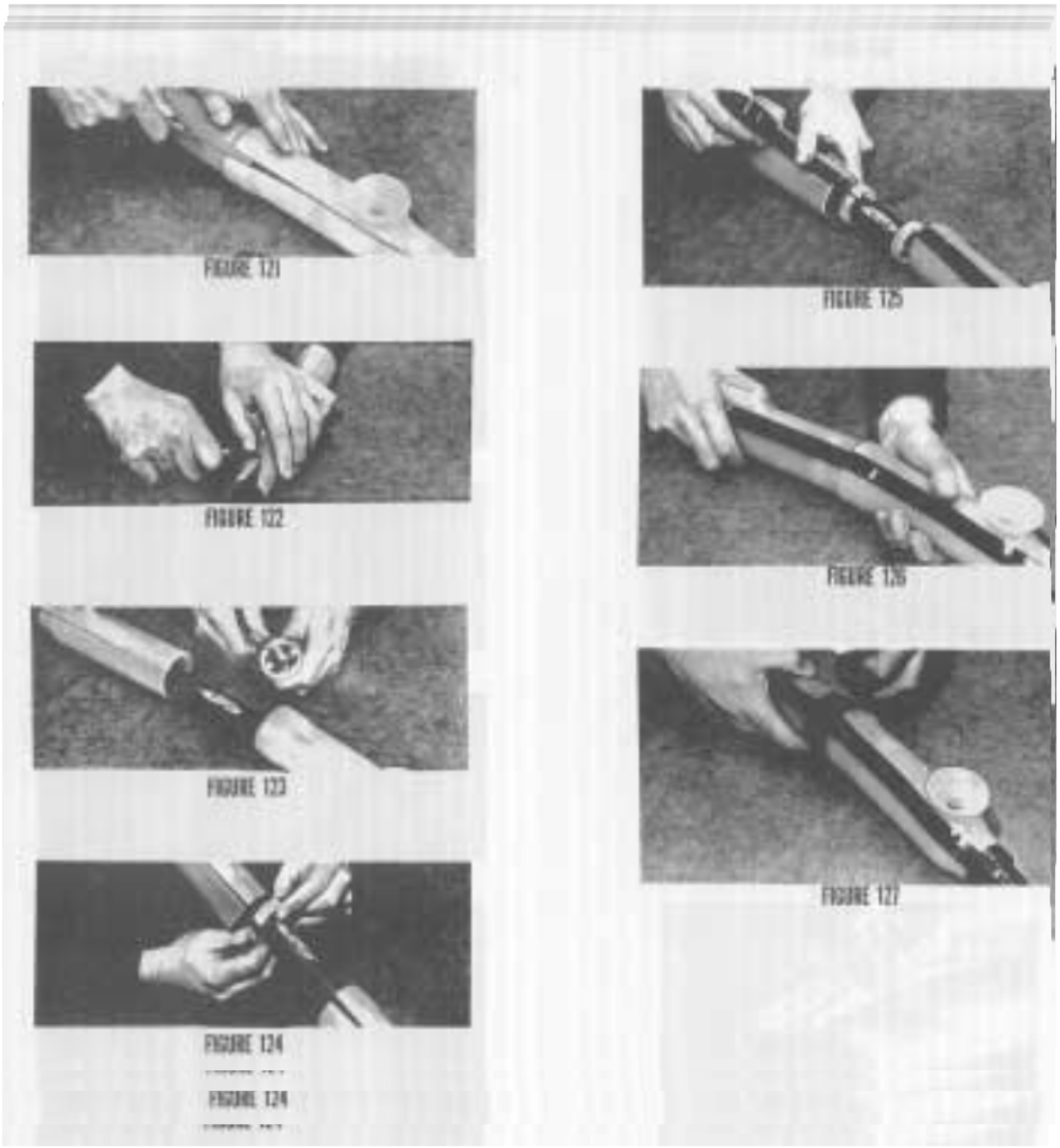
FIGURE 1D2. Repair of jet aircraft servicing and starting cables.

Step 3 (continued):

d. Mold the putty to desired shape, filling voids between plug tip and cable sheath. Slide hose in place and secure with banding as shown in step 1 detail.

NOTE: The milled fiber shall consist of ⅛-inch strands of cationic binder. Possible sources are manufacturers and processors of fiber glass.

FIGURE 1D2. Repair of jet aircraft servicing and starting cables – Continued.



NOTES:

1. The procedure outlined is suitable for repairing cables having polyethylene cable jacket or insulation by using casting molds with epoxy or polyurethane as a casting resin in conjunction with the proper cable primer which acts as a sealer between the cable jacket and casting resin. See figures 1E1 and 1E3 for material specifications.
2. Roughen outer jacket of cable with emery cloth. Be sure to roughen complete area that will be covered with mold. Prime roughened area with cable primer for superior adhesion and best moisture protection. Brush on liberal quantity and let dry.
3. Put case together and cut lengthwise, ½ inch to right of filler neck and air vent. Remove closed ends of both halves by cutting off tapered sections at smallest possible diameter. See illustration 1.
4. To determine cable end size, squeeze split case around cable until split in case touches together. Cut off excess tapered end where split in case separates. See illustration 2.
5. Clip spokes of centering wafer to equal lengths to fit cable diameter, then cut outer ring of wafer as shown. See illustration 3.

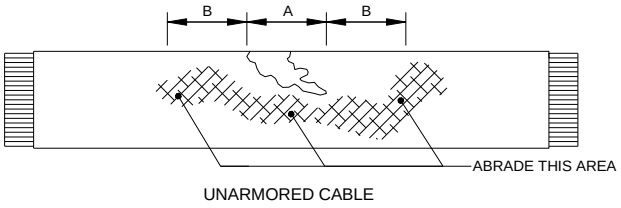
FIGURE 1D3. Repair of cables, power, control, telephone, and electronic.

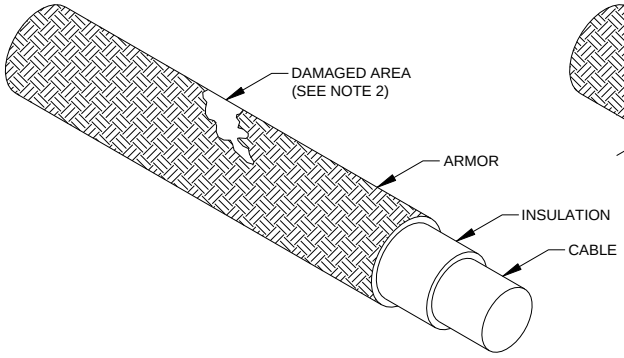
NOTES (continued):

6. Slip wafer over cable. See illustration 4.
7. Place each half of case around cable and tape seam. See illustration 5.
8. Slide the two halves together. See illustration 6.
9. Seal both ends and center seams with tape. See illustration 7. Complete encapsulation as shown on figures 1E1 and 1E3, making sure cable is in level position before pouring encapsulating resin.

FIGURE 1D3. Repair of cables, power, control, telephone, and electronic – Continued.

METHOD 1D-4-1





LLUSTRATION 1
DAMAGED CABLE

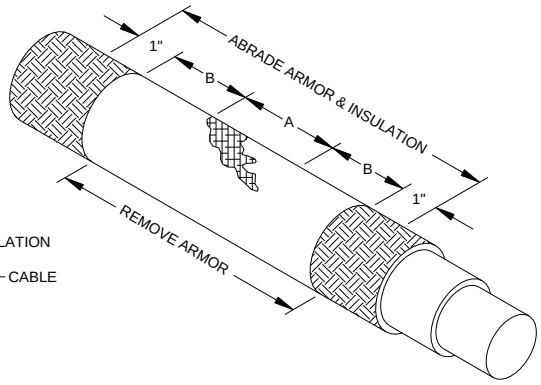


ILLUSTRATION 2
CABLE PREPARATION

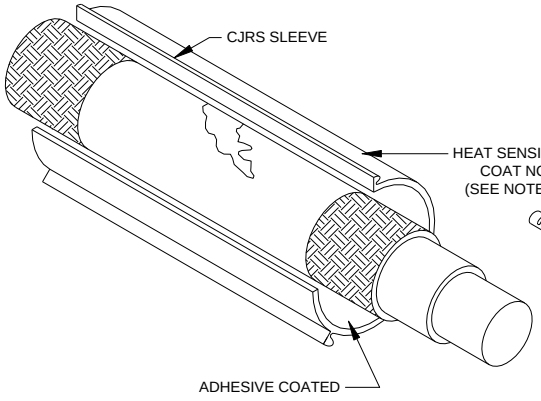


ILLUSTRATION 3
INSTALL NG SLEEVE

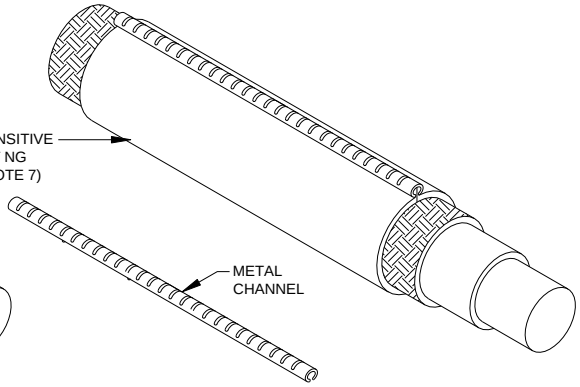


ILLUSTRATION 4
FINISHED REPA R

Notes and installation instructions:

1. The procedure outlined is suitable for repairing armor or sheath damage only, with conductors and water-sealing compounds being intact as an alternate to method 1D-1-1. See figure 1D7.
2. Trim damaged insulation or armor to remove frayed areas. See illustration 1.
3. Abrade insulation or armor to be repaired, providing a rough surface as shown on illustration 2. Painted surfaces shall be abraded to remove loose, peeling, or chipped particles.
4. Clean area with appropriate solvent such as Methyl Ethyl Ketone (MEK).

FIGURE 1D4. Cable jacket repair sleeve, installation.

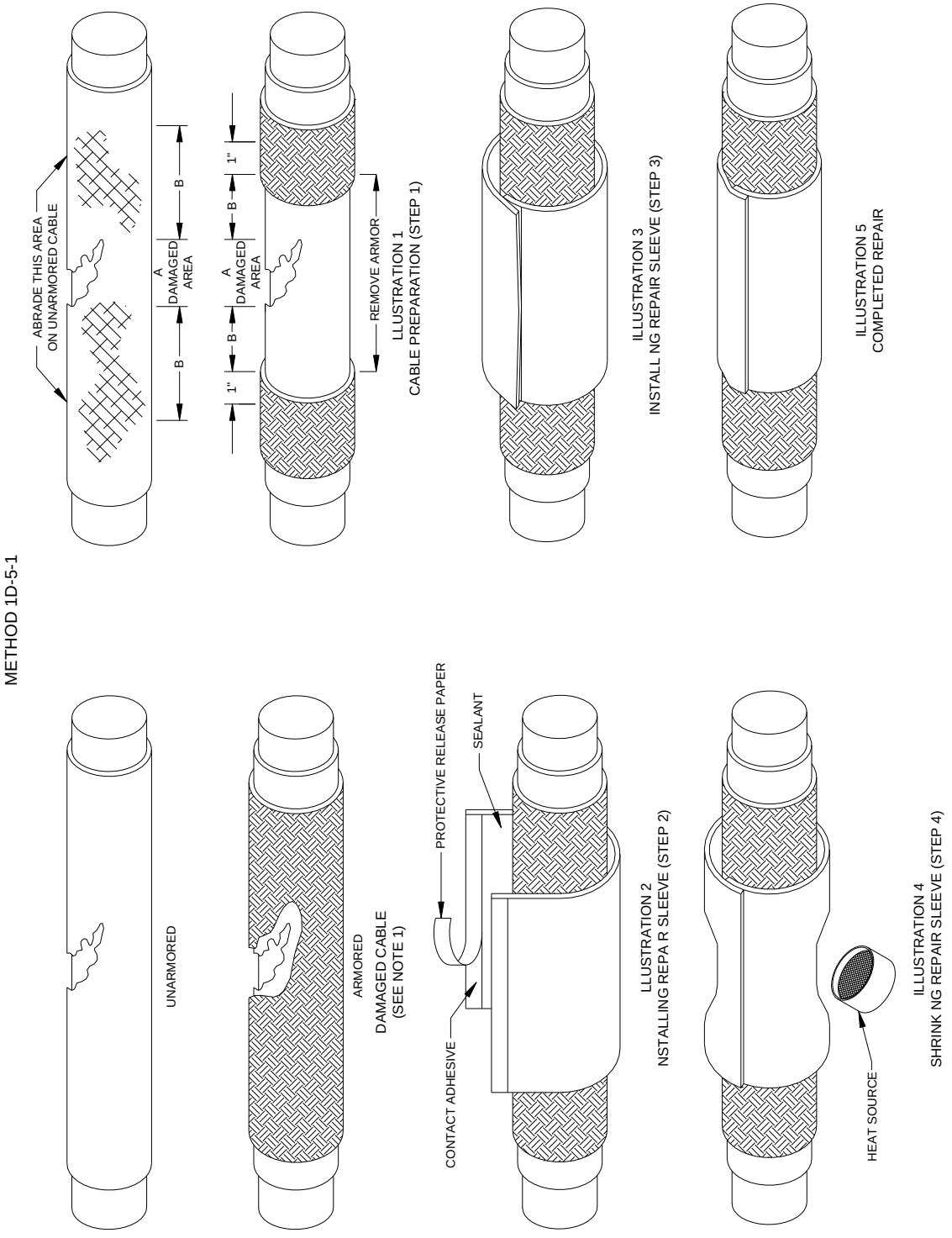
Notes and installation instructions (continued):

5. Use a hot air blower or other heat source. Apply heat to all parts of the cable jacket to which the repair sleeve is to be applied. Do not overheat. The jacket should be heated uniformly until warm to the touch.
6. Assemble cable jacket repair sleeve (CJRS) as shown on illustrations 3 and 4. Place the rail section of the CJRS on top of the cable. Slide the metal channel over the rails. Leave ½ inch overhang of the channel on either end of the repair sleeve.
7. Center the assembled sleeve over the damaged area. Apply heat source to outer surface of sleeve to shrink sleeve and melt adhesive. When the sleeve is in intimate contact with cable jacket and the adhesive has melted and flowed, the installation is complete. The colored paint coating on the outside of the repair sleeve is heat sensitive and will change color to indicate sufficient heat has been applied for a correct installation.
8. Configuration and use of cable jacket repair sleeves shall conform to table 1D4-I. Material, conforming to the performance requirements of SAE-AS23053/15, shall be fabricated into a wrap-around sleeve with a rail channel closure system as shown on illustrations 3 and 4. Inside surface of sleeve shall be coated with adhesive.
9. Sleeves may be cut from stock lengths.
10. This repair to be accomplished only on installed cables.

TABLE 1D4-I. Dimensions in inches.

B	Use on cable diameter range	Sleeve length minimum for		Rail-to-rail		Wall thickness after shrinking
		Unarmored cable	Armored cable	As supplied	After shrinking	
3	0.30 to 0.60	A+2B	A+2B+2	1.8	0.94	0.080±0.010
3	0.61 to 1.00	A+2B	A+2B+2	3.14	1.91	0.080±0.010
3	1.01 to 1.60	A+2B	A+2B+2	5.03	3.17	0.080±0.010
4	1.61 to 2.30	A+2B	A+2B+2	7.22	5.06	0.080±0.010
5	2.31 to 3.62	A+2B	A+2B+2	11.37	7.26	0.080±0.010

FIGURE 1D4. Cable jacket repair sleeve, installation – Continued.



NOTES:

1. The procedure outlined on this sheet is suitable for repairing armor or sheath damage only, with conductors and water-sealing compounds being intact. This method is an alternate to method 1D-1-1. See figure 1D7.

FIGURE 1D5. Cable jacket repair sleeve, installation.

NOTES (continued):

2. Install the repair sleeve in accordance with the following steps:

   Step 1:

   Trim damaged insulation or armor to remove frayed areas. Remove armor on armored cables as shown on illustration 1. Abrade the cable jacket circumferentially and clean area with appropriate solvent such as MEK.

   Step 2:

   Select proper repair sleeve and cut to proper length as shown in table 1D5-I. Roll the sleeve tightly to give it a circular shape. Remove the protective release paper from both flaps. This will expose the surface of the contact adhesive.

   Step 3:

   Place the repair sleeve around cable so that the sealant side of the sleeve is next to the cable. Align the center of the top flap over the center of the lower flap, as well as aligning the edge of the top flap with the white line ridge of the lower flap. Press down firmly on the center of the flaps to mate the contact adhesive surfaces. Working from the center to one end, align flaps and press them together using firm pressure. Then continue with the other end by starting at the center. Do not try to take the flaps apart once the surfaces have made contact to each other.

   Step 4:

   Center the repair sleeve over the damaged area, placing the flap on the top of the cable. Using a hot air blower or other heat source, heat the flap lightly along its full length. Then heat the center until it shrinks over cable. Start working towards one end applying the heat uniformly and smoothly. Apply more heat to the flap area so that the letters of the manufacturer's name become shallow and flatten out. Make sure the sealant is flowing around the end. When one half of the repair sleeve is shrunk, repeat the same procedure on the unshrunk half. Check entire flap length to ensure that the letters have flattened out.

   Step 5:

   Remove heat and allow repair sleeve to cool. Do not try to remove repair sleeve while still hot.

3. Configuration of cable jacket repair sleeve shall conform to table 1D5-I. Material shall conform to the performance requirements of SAE-AS23053/15 and be fabricated into a wrap-around sleeve with edges having a contact adhesive to form a circular tube. The manufacturer's name shall be stamped or molded in recessed letters on the top of the top flap. These letters are used as a gauge to verify that proper heat was applied. Normal ordering lengths shall be 36 inches.
4. This repair to be accomplished only on installed cables.

TABLE 1D5-I. Dimensions in inches.

B	Use on cable diameter range	Sleeve length minimum for		I.D.		Wall thickness after shrinking
		Unarmored cable	Armored cable	Minimum expanded	Maximum recovered	
3	0.50 to 1.10	A+2B	A+2B+2	1.25	0.50	0.080±0.010
3	0.80 to 1.80	A+2B	A+2B+2	2.00	0.75	0.080±0.010
4	1.20 to 3.30	A+2B	A+2B+2	3.60	1.10	0.080±0.010
5	1.60 to 4.00	A+2B	A+2B+2	4.50	1.50	0.080±0.010

FIGURE 1D5. Cable jacket repair sleeve, installation – Continued.

METHOD 1D-6-1

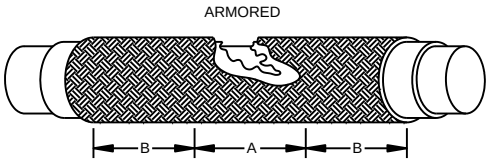
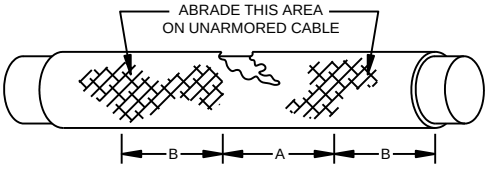
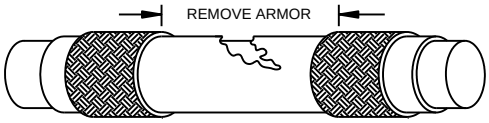


ILLUSTRATION 1
CABLE PREPARATION
(SEE NOTE 2)





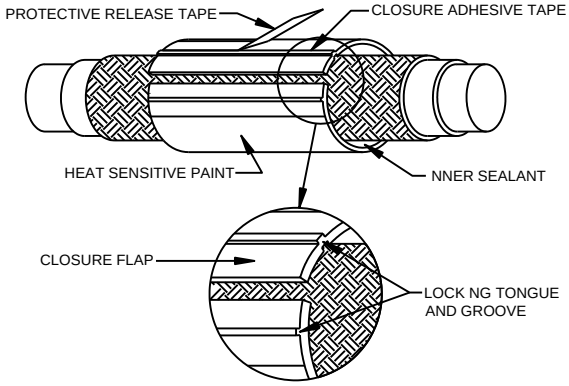


ILLUSTRATION 2
REPA R SLEEVE

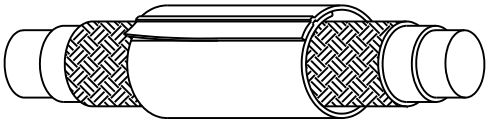


ILLUSTRATION 3A
INSTALLING REPA R SLEEVE
(SEE NOTE 5, STEP 1)

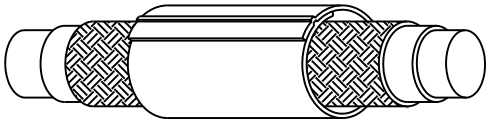
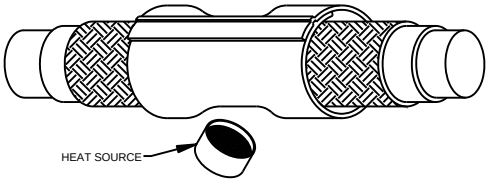


ILLUSTRATION 3B
(SEE NOTE 5, STEP 2)



LLUSTRATION 4
SHRINKING REPAIR SLEEVE
(SEE NOTE 5, STEP 3)

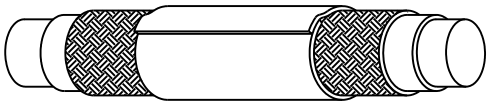


ILLUSTRATION 5
COMPLETED REPAIR
(SEE NOTE 5, STEP 4)

General notes:

1. To protect low temperature cable jackets, such as PVC, from the heat generated during the repair sleeve installation, it is recommended that a 4-inch wide aluminum heat shield tape, such as 3M™ 49 tape, or equal (see 4.2), be applied to each end of the repair area. Place two layers around the cable at each end of the repair area so that 1 inch is underneath the sleeve with 3 inches extending beyond the sleeve ends. Dress the aluminum tape eliminating all sharp edges.

FIGURE 1D6. Cable jacket repair sleeve, installation.

General notes (continued):

2. When it is required to remove an existing repair sleeve, it is not necessary to remove the adhesive residue on the cable jacket prior to the installation of another repair sleeve. Be careful to avoid contamination of the adhesive residue prior to the installation of the next sleeve.

NOTES:

1. The procedure outlined is suitable for repairing armor or sheath damage only, with conductors and water-sealing compounds being intact as an alternative to figures 1D1 and 1D4. See figure 1D7.
2. Trim damaged insulation or armor to remove frayed areas. Remove armor on armored cables as shown on illustration 1.
3. Abrade the jacket circumferentially and clean area with appropriate solvent such as MEK.
4. Select proper repair sleeve and cut to proper length as shown in table 1D6-I.
5. Repair procedure:

   Step 1:

   Center the 3M HDCW, or equal (see 4.2), sleeve over the area to be repaired with the locking tongue and groove in mating position. Snap the HDCW sleeve together working from one end to the other (illustration 3A). CAUTION: Make certain locking tongue and groove are snapped together along the entire length of the sleeve before proceeding.

   Step 2:

   Lift closure flap slightly at one end and remove protective release tapes in a smooth continuous motion (illustration 3B). Using a smooth tool handle, firmly apply pressure along the entire length and width of the enclosure flap. Heat the closure area until warm to the touch. Then reapply pressure along the entire length and width. CAUTION: Do not attempt to reopen the sleeve once the two adhesive surfaces have been mated.

   Step 3:

   Evenly preheat the closure area for about 10-20 seconds per foot. Beginning at the center to avoid possible air entrapment, shrink the 3M HDCW, or equal (see 4.2), sleeve. Working around the circumference, always keep the heat source moving; do not concentrate on only one area of the sleeve (illustration 4). Continue heating until the 3M HDCW, or equal (see 4.2), sleeve exhibits a smooth, wrinkle-free surface.

   Step 4:

   Complete color conversion of the thermo-chromatic/heat-sensitive paint and melted adhesive/sealant is evident around the entire circumference of the cable at both ends of the sleeve. NOTE: The thermo-chromatic/heat-sensitive paint will change color from white to dark gray. It will not totally disappear. NOTE: During shrinking, the tongue and groove will flatten out as the sleeve forms a skin-tight fit (illustration 5). Repaired cable may be returned to service when the sleeve is cool to the touch.
6. Configuration of cable jacket repair sleeve shall conform to table 1D6-I. Material shall conform to the performance requirements of SAE-AS23053/15. Cable jacket repair sleeve shall be fabricated into a wrap-around sleeve incorporating a two-part closure system consisting of a locking tongue and groove with two pressure-sensitive adhesive strips. It shall be adhesive lined with a thermo-chromatic indicator on the outside of the repair sleeve and supplied in lengths of five feet or less.
7. Sleeve may be cut from stock lengths.
8. This repair to be accomplished only on installed cables.

FIGURE 1D6. Cable jacket repair sleeve, installation – Continued.

TABLE 1D6-I. Dimensions in inches. (see notes 4 and 6)

B	Use on cable diameter range	Sleeve length minimum for		I.D.		Wall thickness after shrinking
		Unarmored cable	Armored cable	Minimum expanded	Maximum recovered	
3	0.50 to 1.10	A+2B	A+2B+2	1.50	0.50	0.120±0.010
3	0.60 to 1.80	A+2B	A+2B+2	2.10	0.60	0.120±0.010
4	1.20 to 3.60	A+2B	A+2B+2	4.00	1.20	0.120±0.010
5	1.60 to 4.95	A+2B	A+2B+2	4.5	1.60	0.120±0.010

FIGURE 1D6. Cable jacket repair sleeve, installation – Continued.

Method 1D-7-1
Conductor Insulation Repair

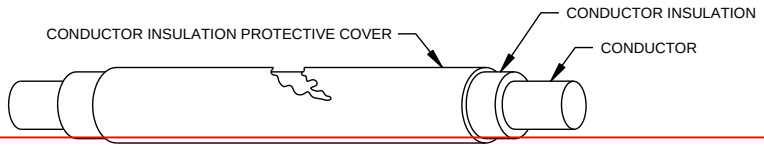
1. If the cable inspection prior to application of figures 1D1-1D6 shows damage to insulation directly over the conductor, the cable shall be replaced unless the conductor is completely intact and repair is authorized by NAVSEA. The submittal for authorization shall include objective evidence that the conductor is completely in-tact and repair versus replacement is in the best interest of the Government. If repair to insulation directly over the conductor is approved by NAVSEA, the following method shall apply:
2. The damaged cable portions other than the insulation over the conductor shall be prepared in accordance with figures 1D1-1D6, as applicable.
3. The insulation directly over the conductor shall be repaired as follows:
4. Clean conductors of foreign matter and inspect for damage. Report results of inspection to NAVSEA in the request to repair the cable with damage to conductor insulation. All surfaces to which heat shrinkable tapes and heat shrink shall be applied shall be clean and dry. Wrap white pressure sensitive silicone rubber glass tape around directly over the damaged conductor. Apply a minimum of two half-lap layers of pressure-sensitive glass-backed tape in accordance with A-A-59770, type IV-GFT, white, 0.007 inch thick. The tape shall be applied smoothly and tightly and shall extend at least 2 inches on either side of the damaged area. Slight transfer of adhesive to underlying tapes is not detrimental and is inherent to this type of tape. Care shall be exercised to keep the tape clean due to the difficulty in applying the tape once the adhesive becomes coated with dirt and contaminants. This will cause degradation of the electrical insulation properties of the tape.
5. If needed to provide a smooth surface to restore the outer portions of the cable, filler tape shall be applied over the silicone rubber glass tape. The filler tape shall be of a partially cured material. The date of filler tape use shall be within one year of the date of the manufacture. The filler tape shall be applied at least 1 inch beyond the tape applied over the conductor and shall be pulled to approximately one-half of the original thickness and shall be half-lapped.
6. Restore the outer portions of the cable using the applicable method shown in figures 1D1-1D6.
7. Perform an insulation resistance test to the same voltage required for the original cable. The acceptance limit is the same as for the original cable.

FIGURE 1D7. Cable conductor insulation repair when approved by NAVSEA.

Method 1D-8-1
Low Smoke Cable Conductor Insulation and Protective Cover Repair within an Enclosure

NOTES:

1. This method is suitable for the repair of the conductors of low smoke 450 VAC rated cable types with conductor insulation protective cover damage within an enclosure. This method is also suitable for the repair of the ground conductors of LS5KVTSGSG cable types, with conductor insulation protective cover damage within an enclosure. For cable conductors rated 1 kilovolt or less, including LS5KVTSGSG ground conductors, the insulation may be damaged but no insulation may be missing and the conductor shall not be visible. For 5-kilovolt rated cable conductors, the conductor insulation shall not be damaged. During the repair processes, all surfaces to which heat shrinkable tapes and heat shrink are applied shall be clean and dry. See illustration 1. The materials required for this repair are listed in table 1D8-I.

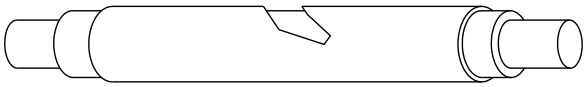


LLUSTRATION 1. CONDUCTOR WITH INSULATION PROTECTIVE COVER DAMAGE. FOR CABLES RATED 1KV OR LESS AND THE GROUND CONDUCTORS OF LS5KVTSGSG CABLE, THE NSULATION MAY BE DAMAGED BUT NO INSULATION MAY BE MISSING AND THE CONDUCTOR MUST NOT BE VISIBLE. FOR 5KV RATED CABLE CONDUCTORS, THE CONDUCTOR NSULATION MUST NOT BE DAMAGED.

2. Exercise care when removing the conductor insulation protective cover in order to prevent damage to the conductor insulation. The protective cover may consist of a factory applied extruded cover, synthetic resin tubing, or heat shrink tubing.
3. Heat shrink tapes and tubing used should be kept as clean as possible during application so that foreign matter or contaminants do not enter the repair area.

PROCEDURE:

1. Trim loose or frayed parts of the conductor insulation protective cover. See illustration 2.



LLUSTRATION 2. REPAIR STEP 1. TR M LOOSE OR FRAYED PARTS OF CONDUCTOR INSULATION PROTECTIVE COVER.

2. Apply 2 half-lapped layers of self-sealing heat shrinkable tape or heat shrink tubing extending a minimum of 2 inches on each side of the damaged area. Use a heat gun to carefully shrink the tape or tubing over the repair while avoiding the possibility of damaging surrounding areas and the repair. For the tubing, as heat is applied, move the heat source back and forth around the part to be shrunk. Shrink from center to avoid trapping air inside the cover. This will ensure even shrinking. When the tubing has recovered enough to assume the configuration of item covered, discontinue heating. Additional heating will not make the tubing shrink tighter. For the tape, follow the manufacturer's instructions. See illustration 3 for tape application and illustration 4 for heat shrink tubing application.

FIGURE 1D8. Low smoke cable conductor insulation and protective cover repair within an enclosure.

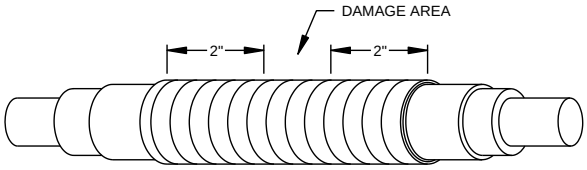


ILLUSTRATION 3. REPAIR STEP 3 - OPTION 1. TWO HALF LAPPED LAYERS OF HEAT SHR NKABLE SELF SEAL NG TAPE APPLIED EXTENDING A MIN MUM OF 2 INCHES ON EACH SIDE OF THE DAMAGED AREA.

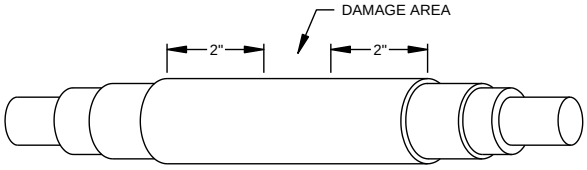


ILLUSTRATION 4. REPAIR STEP 3 - OPTION 2. SAE-AMS-DTL-23053/5 HEAT SHRINK TUBING APPL ED EXTENDING A M NIMUM OF 2 INCHES ON EACH SIDE OF THE DAMAGED AREA.

TABLE 1D8-I. Repair materials.

Material	Use	Width or size	Specification or standard
Shrinkable tubing	Conductor insulation protective cover	Size to suit	SAE-AS23053/5, class 1
Tape, self-sealing heat shrinkable	Conductor insulation protective cover	1.5"	Ampliseal heat shrinkable self-sealing tape, type 2, or equal

FIGURE 1D8. Low smoke cable conductor insulation and protective cover repair within an enclosure – Continued.

Method 1D-9-1
5-Kilovolt Rated Cable Conductor Insulation Repair within an Enclosure

NOTES:

1. This method is suitable for the repair of the conductors of LS5KVTSGU cable types with conductor insulation damage, without conductor damage, and the 5-kilovolt rated conductors (not including the ground conductors) of LS5KVTSGSG cable types with conductor insulation damage, without conductor damage within enclosures. During the repair processes, all surfaces to which tapes, heat shrink, and coatings are applied shall be clean and dry. See illustration 1. The materials required for this repair are listed in table 1D9-I.

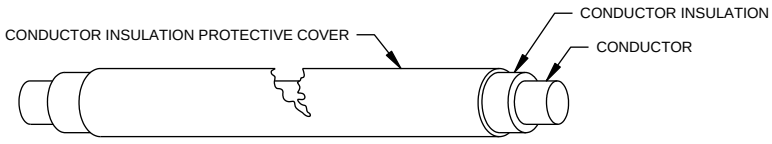


ILLUSTRATION 1. CONDUCTOR WITH INSULATION PROTECTIVE COVER AND INSULATION DAMAGE.

2. During the repair, the repair region shall be located such that the repair region (the full length of the repaired area covered by heat shrink tubing) and 1 inch of the conductor on both ends of the repair region remain straight without any bends or twists. After completing the repair, bending the conductor in the repair region should be avoided. After the repair, if it is necessary to bend the conductor at the repair region, the heat shrink tubing should be heated to approximately 200 °F so that the repair material will soften for bending and conform to the conductor insulation and protective coverings while shaping. The conductor shall have a minimum bend radius not less than eight times the outside diameter of the center of the completed repair.
3. Care shall be exercised when removing conductor insulation protective covering in order to prevent damage to the conductor insulation. Care shall be exercised when removing conductor insulation over the copper conductor in order to prevent cuts or nicks on the individual conductors or conductor strands.
4. Binding should be applied over the ends of tapes on conductors to prevent unwinding of the insulation. These bindings shall be removed unless MIL-I-22444 (see 4.5) pressure-sensitive silicone rubber glass tape was used for the binding purpose.
5. Tapes used should be kept as clean as possible during application so that foreign matter or contaminants do not enter the repair area.
6. An insulation resistance test and any other tests required to be performed on installed cables shall be performed to verify that insulation integrity in the repair area is equivalent to the original cable. For insulation resistance tests, the acceptance criteria of S9086-KC-STM-010/300 shall apply. For other tests, approved procedures shall be used to determine acceptance criteria for all tests performed on the cable subsequent to repair.

PROCEDURE:

1. Prepare damaged area by removing the protective cover and any tapes over the insulation 2 inches from each side of the damaged insulation, taking care not to damage the conductor insulation. The protective cover may consist of a factory applied extruded cover, synthetic resin, or heat shrink tubing. See illustration 2.

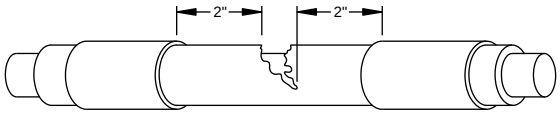
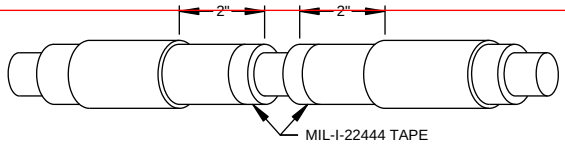


ILLUSTRATION 2. REPAIR STEP 1. CONDUCTOR INSULATION PROTECTIVE COVER REMOVED.

FIGURE 1D9. 5-kilovolt rated cable conductor insulation repair within an enclosure.

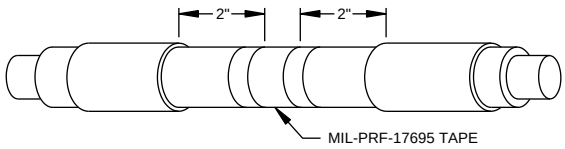
PROCEDURE (continued):

2. Remove the damaged insulation, taking care not to damage the conductor or conductor strands. Use MIL-I-22444 (see 4.5) pressure sensitive silicone rubber glass tape to hold the conductor insulating tapes in place on each side of the damaged area. See illustration 3.



LLUSTRATION 3. REPAIR STEP 2. CONDUCTOR INSULATION REMOVED FROM DAMAGED AREA. INSULATING TAPES HELD N PLACE WITH M L-I-22444 TAPE.

3. Apply MIL-PRF-17695 filler tape over the bare conductor. This filler tape is partially cured material that has a relatively short shelf life and should not be used if the date of manufacture is older than 1 year. When used in a taping application, the filler tape should be pulled to approximately one half of the original thickness and half-lapped. Mold by hand to form a uniform surface for subsequent taping. Make sure that the void is completely filled; see illustration 4.



LLUSTRATION 4. REPAIR STEP 3. MIL-PRF-17695 TAPE APPL ED OVER BARE CONDUCTOR.

4. Apply MIL-I-22444 (see 4.5) pressure-sensitive silicone rubber glass tape, approximately 17 mils thick. Apply five half-lapped layers, alternating the direction of taping for each layer. Overlap conductor insulation layers to approximately 1½ inches, gradually tapering to ¾-inch overlap. The tape should be applied as smoothly and tightly as possible. Slight transfer of the adhesive to underlying tapes is not considered detrimental and is inherent in this type of tape. Care should be exercised to keep this tape clean because it is difficult to apply when the adhesive becomes coated with dirt and contaminants and degradation of the tape's electrical properties could occur. See illustration 5.

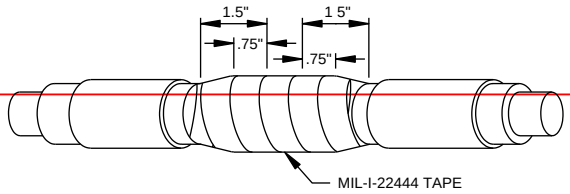


ILLUSTRATION 5. REPAIR STEP 4. FIVE HALF LAPPED LAYERS OF MIL-I-22444 TAPE APPL ED OVER CONDUCTOR INSULATION AND MIL-PRF-17695 TAPE. USE ALTERNAT NG DIRECTION OF TAPING FOR EACH LAYER.

5. Apply one half-lapped layer of pressure sensitive vinyl tape in accordance with MIL-I-24391 followed by two coats of coating material, commercial 3M Scotchkote, or equal (see 4.2). Allow coating material to dry between coats. See illustration 6.

FIGURE 1D9. 5-kilovolt rated cable conductor insulation repair within an enclosure – Continued.

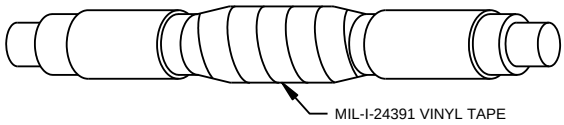


ILLUSTRATION 6. REPAIR STEP 5. ONE HALF LAPPED LAYER OF MIL-I-24391 TAPE APPLIED OVER MIL-I-22444 TAPE, AND TWO COATS OF SCOTCHKOTE APPLIED.

6. Position a length of SAE-AS23053/15 heat shrink tubing over the repair area such that to overlap the conductor insulation protective covering by at least 2 inches. Use a heat gun to carefully shrink the tubing over the repair while avoiding the possibility of damaging surrounding areas and the repair. Tubing starts to shrink at 250-275 °F. As heat is applied, move the heat source back and forth and around the part to be shrunk. Shrink from center to avoid trapping air inside the cover. This will ensure even shrinking. When the tubing has recovered enough to assume the configuration of the item covered and the sealant is seen to flow, discontinue heating. Additional heating will not make the tubing shrink tighter. See illustration 7. See table 1D9-II for selecting the proper size shrink tubing.

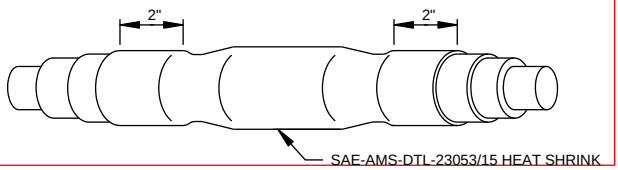


ILLUSTRATION 7. REPAIR STEP 6. SAE-AMS-DTL-23053/15 HEAT SHR NK TUB NG APPL ED OVER CONDUCTOR PROTECTIVE COVERING, CONDUCTOR INSULATION, AND M L-I-24391 TAPE.

TABLE 1D9-I. Repair materials.

Material	Use	Width or size	Specification
Silicone rubber glass type	Conductor insulation	0.5"	MIL-I-22444 (see 4.5)
Thick-walled heat shrinkable tubing with meltable sealant	Conductor insulation protective cover and conductor insulation	See table 1D9-II	SAE-AS23053/15, class 1
Filler tape	Filler material	1.5"	MIL-I-17695
Vinyl tape	Conductor insulation and insulation binder	0.5"	MIL-I-24391
3M Scotchkote electrical coating, or equal (see 4.2)	Sealant		---

FIGURE 1D9. 5-kilovolt rated cable conductor insulation repair within an enclosure – Continued.

TABLE 1D9-II. Heat shrinkable tubing size.

Conductor diameter over insulating tapes (before repair)/conductor size	Shrink tube dimensions		
	Expanded I.D.	Fully recovered	
		I.D.	Wall thickness
0.675"/100	1.50"	0.50"	0.14"
0.769"/150	2.00"	0.75"	0.155"
0.889"/250	2.00"	0.75"	0.155"
0.994"/350	2.70"	0.90"	0.155"
1.054"/400	2.70"	0.90"	0.155"

FIGURE 1D9. 5-kilovolt rated cable conductor insulation repair within an enclosure – Continued.

APPENDIX 1E – CABLE SPLICING

E.1 SCOPE

E.1.1 Scope. This appendix describes procedures for splicing of Navy shipboard cables. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

E.2 APPLICABLE DOCUMENTS

E.2.1 General. The documents listed in this section are specified in this appendix. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in this appendix, whether or not they are listed.

E.2.2 Government documents.

E.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

COMMERCIAL ITEM DESCRIPTIONS

A-A-59163	-	Insulation Tape, Electrical, Self-Adhering Unsupported Silicone Rubber (see 4.5)
A-A-59770	-	Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-915	-	Cable, Electrical, for Shipboard Use, General Specification for
MIL-T-16366	-	Terminals, Electrical Lug and Conductor Splices, Crimp-Style
MIL-PRF-17695	-	Insulation Tape, Electrical, Filler Type, Flameproof, Synthetic
MIL-I-24391	-	Insulation Tape, Electrical, Plastic, Pressure-Sensitive
MIL-DTL-24640	-	Cables, Lightweight, Low Smoke, Electric, for Shipboard Use, General Specification for
MIL-DTL-24643	-	Cables, Electric, Low Smoke Halogen-Free, for Shipboard Use, General Specification for
MIL-DTL-24643/33	-	Cable, Electrical, -20 °C to +90 °C, Type LS2SWU

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-2003-5	-	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Connectors)

(Copies of these documents are available online at https://quicksearch.dla.mil.)

E.2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

S9086-KC-STM-010/300 - Naval Ships' Technical Manual Chapter 300, Electric Plant-General

(Copies of this document are available online via Technical Data Management Information System (TDMIS) at https://mercury.tdmis navy mil/. Refer questions, inquiries, or problems to: DSN 296-0669, Commercial (805) 228-0669. This document is available for ordering (hard copy) via the Naval Logistics Library at https://nll.navsup.navy.mil. For questions regarding the NLL, contact the NLL Customer Service at nllhelpdesk@navy mil, (866) 817-3130, or (215) 697-2626/DSN 442-2626.)

E.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM F1835 - Standard Guide for Cable Splicing Installations

(Copies of this document are available online at www.astm.org.)

SAE INTERNATIONAL

SAE-AS21608	-	Ferrule, Shield Terminating, Crimp Style
SAE-AS21980	-	Ferrule, Outer, Uninsulated, Shield Terminating, Type I, Two Piece, Class I, for Shielded Cables
SAE-AS21981	-	Ferrule, Inner, Uninsulated, Shield Terminating, Type I, Two Piece, Class I, for Shielded Cables
SAE-AS22520	-	Crimping Tools, Wire Termination, General Specification for
SAE-AS23053/5	-	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked
SAE-AS23053/15	-	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked

(Copies of these documents are available online at www.sae.org.)

E.2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

E.3 REQUIRED EQUIPMENT AND MATERIALS

E.3.1 Required equipment and materials. The required equipment and materials shall be standard tools and materials for working with electrical cables in addition to the special tools and materials identified herein.

E.4 NOTES AND PROCEDURES

E.4.1 Dimensions. For figures and tables in this appendix, all dimensions are in inches unless otherwise noted.

E.4.2 Figures. Table 1EI provides information for the figures in this appendix.

TABLE 1EI. Figures for Navy shipboard cable splicing methods.

Figure number	Navy shipboard cable splicing methods	Page
1E1	Splicing cable – power, control, telephone, and electronic with heat-shrink tubing	148
1E2	Splicing cable – power, control, telephone, and electronic with heat-shrink tubing	150
1E3	Splicing cable – power, control, telephone, and electronic using heat-shrink tubing	158
1E4	Splicing high temperature cable	161
1E5	Splicing high temperature cables	165
1E6	Splicing 5-kilovolt rated cables	166

General Requirements for Cable Splicing

These requirements apply to all splicing methods in Appendix 1E:

1. MIL-DTL-915, MIL-DTL-24640, and MIL-DTL-24643 cable may be spliced. The following shall not be spliced without prior written approval from NAVSEA:
   a. Flexing service cable
   b. Cable subject to oil immersion
   c. Cable in inaccessible spaces (masts, tanks, voids, chain lockers, etc.)
   d. Cable in hazardous spaces (spaces requiring explosion proof enclosure)
   e. Cable exposed to weather on surface craft and MDU cable on submarines
   f. DC bus tie cable on submarines
   g. Reactor plant system cable
   h. Non-nuclear cable in reactor compartments
   i. Cables used in services rated above 600 VAC. For 5-kilovolt rated cables, figure 1E6 may be used as long as the requirements of 4.8 are met. For cables rated above 5 kilovolts, the request for NAVSEA approval shall address the requirements of 4.8.
   j. Antenna system cables, both inboard and outboard
2. No more than two splices shall be allowed per cable.
3. Cable splices are not permitted in cable bends.
4. Cable splices shall be accessible and shall not be located behind permanently installed equipment or other fixed barriers.
5. Cable splices shall be in accordance with the requirements of the illustrations and procedures of the methods in this appendix. The splice shall connect the ends of the two conductors, prepared in accordance with these instructions, in such a manner that the conductor ends are butted against the conductor stops. The axes of the conductors shall coincide.
6. Where cable or wire sizes are not specified in these instructions, cable and conductor diameters specified in MIL-DTL-915, MIL-DTL-24640, and MIL-DTL-24643 shall apply.
7. Cable splices shall have the conductor splices staggered as shown on the illustrations of the methods in this appendix. Splicing dimensions shall be in accordance with tables 1E2-I and 1E2-II.
8. Heat-shrink sleeving material for replacement jackets and conductor insulation shall be in accordance with SAE-AS23053/15 and shall conform to the dimensional requirements of tables 1E2-III and 1E2-IV. Cold shrink sleeving materials may be used as a substitute for heat shrink sleeving in accordance with the requirements of ASTM F1835 for splices of cables rated less than or equal 600 volts above the ship waterline where watertight integrity is not required.
9. Care shall be exercised when preparing cable ends so that the conductor insulation is not cut when removing armor, sheath, or shield. Similar care is required when removing shield or conductor insulation protecting the copper conductor in order to prevent cuts or nicks on the individual conductor strands.
10. Support cable ends to be spliced by tying or clamping in a position as close as practicable to the position they will be in after the splice has been completed. After a splice has been completed on a cable, the cable shall be supported as close as possible to the splice.
11. Since the wall thickness of thick-wall heat-shrink tubing is approximately the thickness of the existing cable sheath, it is not necessary to replace the sheathing that has been removed for splicing.
12. Both the thermally stabilized polyolefin tubing and the sealant used for this splicing method have an indefinite shelf-life.
13. Heat-shrink tubing and the sealant are virtually inert. There are no adverse effects from acid, salts, bases, or alkalis. However, they are affected by constant immersion at elevated temperatures by some fuels and oils.
14. Where a watertight splice is required, use a meltable sealant which is compatible with thick-wall heat-shrink tubing and meets the requirements of figure 1A6. For approved manufacturers, contact NAVSEA 05Z3.

FIGURE 1E1. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing.

General Requirements for Cable Splicing (continued):

15. MIL-T-16366 CCBC connectors suitable for each conductor size are shown in table 1E3-I on figure 1E3. The conductor shall be long enough to reach the full depth of the connector and the conductor insulation shall be flush with the butt of the connector. Unless approved by NAVSEA or shown on ship class specific drawings, splice connector contact surfaces shall be plated over the entire conducting surface in accordance with the requirements of MIL-T-16366; the plating shall be tin for size 9 (9,000 circular mils) and smaller connectors and silver for greater than size 9 (9,000 circular mils) connectors. For high temperature cable splices, the plating shall be silver, regardless of connector size.
16. Circuit integrity cables shall have the crimped CCBC connectors completely wrapped with A-A-59770 glass tape. Apply a minimum of two half-lap layers of pressure-sensitive glass-backed tape in accordance with A-A-59770, type IV-GFT, white, 0.007 inch thick.
17. Armor over splices of armored cable may be omitted except when armor is mandatory. A jumper cable may be installed at the splice to maintain electrical continuity if required.
18. Shields over splices of shielded conductors in cables are mandatory. See figures 1A17 and 1A18 for conductor shield termination and grounding methods. See methods 1E-2-2 and 1E-2-3 for establishing shield continuity across conductor splices and cable splices.
19. Twisted shielded pair cables such as LS2SWU shall have sleeving placed over the spliced shielded braid and shall have a shield to shield dielectric test in accordance with MIL-DTL-24643/33.

FIGURE 1E1. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing – Continued.

Method 1E-2-1
Splicing cables rated 600 volts or less

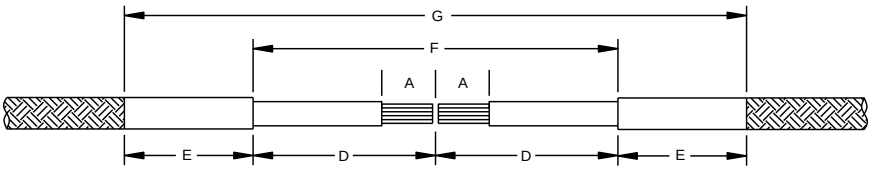
Installation procedure:

1. Slide expanded heat-shrinkable part over item to be covered.
2. Shrink tubing by applying heat using a hot air blower or other heat source. Tubing starts to shrink at 250 to 275 °F (121.1 to 135 °C). Higher temperature rating of heat gun is sometimes required to offset heat-shrink effect of conductor, connector, shielding, etc.
3. As heat is applied, move heat source back and forth and around the part to be shrunk. For splice cover, shrink from center to avoid trapping air inside the cover. This will ensure even shrinkage.
4. When the part has recovered enough to assume the configuration of the item covered and when the sealant is seen to flow, discontinue heating. Additional heating will not make the part shrink tighter.
5. Use tables 1E2-I through 1E2-IV and illustrations 1-6 as guides to diameters and length of tubing required for splicing common sizes of cable.

FIGURE 1E2. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing.

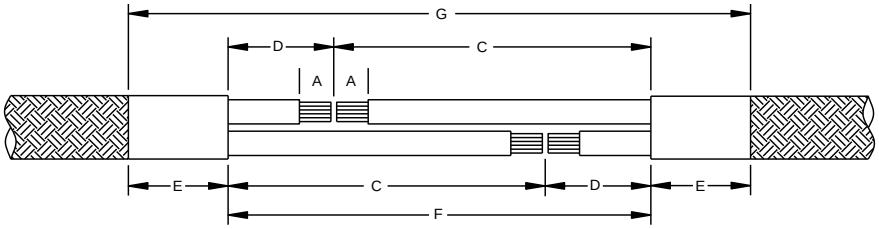
METHOD 1E-2-1

LLUSTRATION 1
SPLICING DIMENSIONS FOR S NGLE CONDUCTOR CABLE



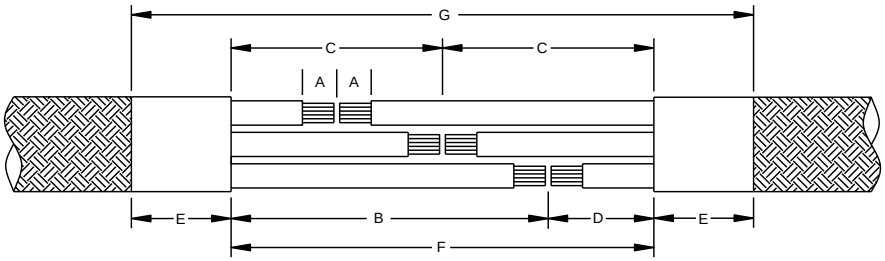
BARE COPPER ON CONDUCTOR EQUALS "A"
(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE D MENSIONS)

ILLUSTRATION 2
SPLICING DIMENSIONS FOR TWO-CONDUCTOR CABLE



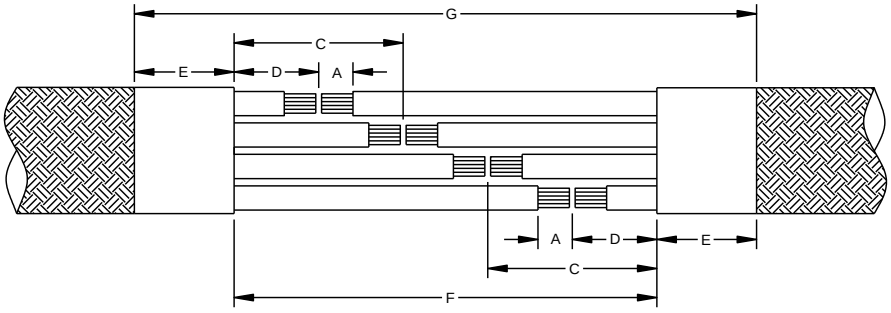
BARE COPPER ON EACH CONDUCTOR EQUALS "A"
(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE D MENSIONS)

ILLUSTRATION 3
SPLICING D MENSIONS FOR THREE-CONDUCTOR CABLE



BARE COPPER ON EACH CONDUCTOR EQUALS "A"
(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE D MENSIONS)

ILLUSTRATION 4
SPLICING DIMENSIONS FOR FOUR-CONDUCTOR CABLE

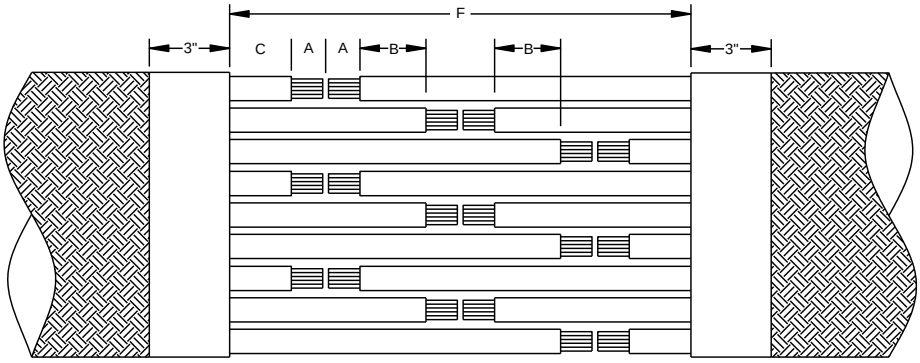


BARE COPPER ON EACH CONDUCTOR EQUALS "A"
(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE D MENSIONS)

FIGURE 1E2. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing – Continued.

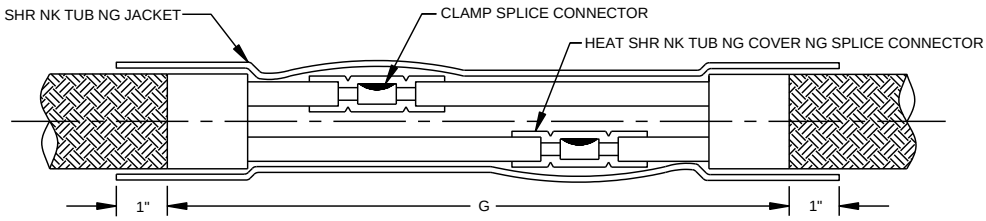
METHOD 1E-2-1

ILLUSTRATION 5
SPLIC NG DIMENSIONS FOR MULTI-CONDUCTOR CABLE



BARE COPPER ON EACH CONDUCTOR EQUALS "A"
(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE DIMENSIONS)

ILLUSTRATION 6
SPLICING D MENSIONS AND SHRINK TUBING INSTALLATION FOR
POWER CABLES AND SINGLE CONDUCTOR DEGAUSS NG CABLE



(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE DIMENSIONS)

NOTE: Length of the replacement conductor insulation tubing shall be 2¼ inches longer than the butt-crimp connector length. See table 1E3-I for crimp connector length.

NOTES:

1. See tables 1E2-I and 1E2-II for splice dimensions.
2. For guidance, see ASTM F1835.

FIGURE 1E2. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing – Continued.

TABLE 1E2-I. Splice dimensions (inches) for single, two-, three-, and four-conductor cable. (see illustrations 1, 2, 3, and 4)

Conductor size AWG/MCM	Dimensions												
	A	B	C	D	E	F				G			
						1 CDR	2 CDR	3 CDR	4 CDR	1 CDR	2 CDR	3 CDR	4 CDR
16 to 10	*	8	5	2	3	4	7	10	13	10	13	16	19
9 to 4	*	11	7	3	3	6	10	14	18	12	16	20	24
3 to 1/0	*	13	8	3	4	6	11	16	23	14	19	24	31
2/0 to 250	*	15	10	5	4	10	15	20	25	18	23	28	33
300 to 500	*	19½	13	6½	4	13	19½	26	-	21	27½	34	-
650 to 2000	*	-	-	10	4	20	-	-	-	28	-	-	-

* Dimension “A” (amount of insulation to be removed from individual conductors) equals the splice lug barrel depth as listed in table 1E3-I or from direct measurement of the barrel depth. The amount of conductor outside the barrel shall be minimized. No insulation shall be captured inside the splice connector.

TABLE 1E2-II. Splice dimensions (inches) for multi-conductor cable. (see illustration 5)

Number of conductors	Dimensions **
	F
1-9	5
10-19	8
20-29	10
30-39	12
40-49	14
50-59	16
60-69	18
70-79	20
80-89	24

(For multi-conductor cable only):

** Dimension “A” (amount of insulation to be removed from individual conductors) equals the splice lug barrel depth as listed in table 1E3-I or from direct measurement of the barrel depth. The amount of conductor outside the barrel shall be minimized. No insulation shall be captured inside the splice connector.

Dimension “B” equals 4*A – distance between any two adjacent butt splices

Dimension “C” equals 4*A – distance from sheath, either side, to the first butt splice on that side

Dimension “F” equals the length of stripped back cable for wire. The listed values for dimension “F” are approximate and will vary to meet the requirements for dimensions “A”, “B”, and “C” depending on the number of conductors to be spliced.

FIGURE 1E2. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing – Continued.

TABLE 1E2-III. Shrink tubing for completed cable splice.
(see illustration 6)

Range of cable diameter	Jacket size length	Expanded I.D.
0.22 to 0.50	G+2 (illustration 6)	0.75"
0.40 to 0.87	G+2 (illustration 6)	1.10"
0.87 to 1.75	G+2 (illustration 6)	2.00"
1.50 to 2.75	G+2 (illustration 6)	3.00"
2.00 to 3.85	G+2 (illustration 6)	4.00"

TABLE 1E2-IV. Shrink tubing dimensions. (see illustration 6)

Expanded I.D.	Fully recovered	
	I.D.	Wall thickness
0.40	0.15	0.060
0.75	0.22	0.095
1.10	0.375	0.120
1.50	0.50	0.140
2.00	0.75	0.155
3.00	1.25	0.155
4.00	1.75	0.155

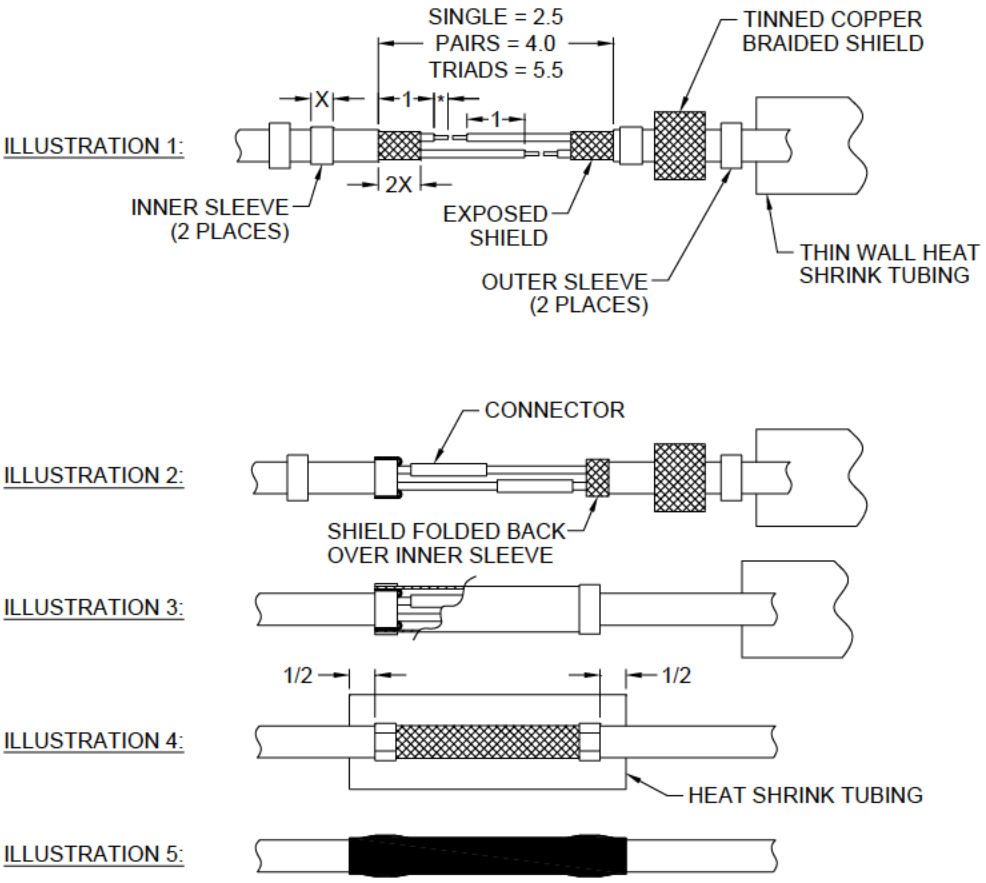
FIGURE 1E2. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing – Continued.

Method 1E-2-2
Splices of shielded conductors

The following steps shall be used to provide continuity of the shield for spliced conductors:

1. Select an uninsulated inner sleeve that is in accordance with SAE-AS21608, type 1 or SAE-AS21981 as follows:
   a. Determine the diameter of the cable insulation or overall diameter of the multiple conductors.
   b. Add 0.005-inch clearance.
   c. Select an inner sleeve with that or the next larger diameter.
2. Select an uninsulated outer sleeve that is in accordance with SAE-AS21608, type 1 or SAE-AS21980 as follows:
   a. Determine the outer diameter of the inner sleeve previously selected.
   b. Add 0.025 inch for the thickness of a single braid shield or 0.05 inch for a double shield.
   c. Select an outer sleeve with that or the next larger diameter.
3. Select thin-wall heat shrink tubing that is in accordance with SAE-AS23053/5, class 1, black, without sealant.
4. See illustration 1. After conductors, insulation, and shields have been cut and trimmed as shown, slide on the inner sleeves (2), the outer sleeves (2), tinned copper shield, and heat shrink.
   NOTE: * means half of the connector length plus 1/16 inch. "X" is the width of the inner sleeve.
5. See illustration 2. Crimp the conductor connector and fold back the exposed shield over the inner sleeves in two places.
6. See illustration 3. Roll the tinned copper shield over the entire splice area such that the edges of the copper shield are flush with the conductor shield (two places) that is folded over the inner sleeve. Crimp the outer sleeve over the braided shield.
7. See illustration 4. Position heat shrink over the splice.
8. See illustration 5. Shrink the heat shrink to complete the splice.

FIGURE 1E2. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing – Continued.



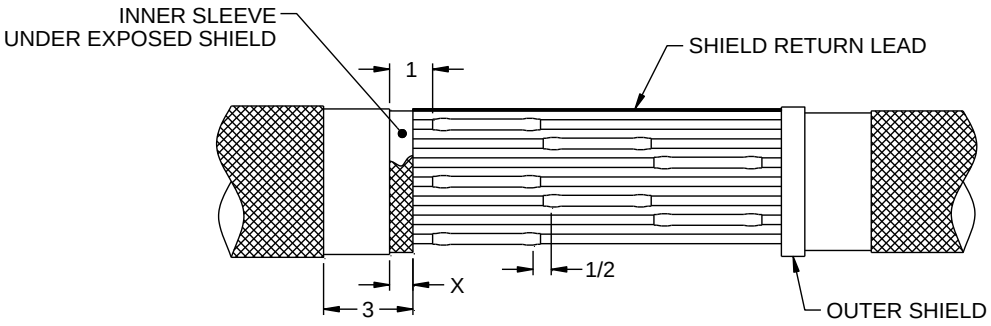
PRIMARY SPLICE OF SHIELDED CONDUCTORS

FIGURE 1E2. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing – Continued.

Method 1E-2-3
Outer shield connection of spliced cables

The following steps shall be used to provide continuity of the shield for a spliced cable:

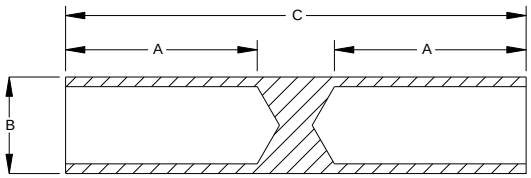
1. Cut cable, cable shields, and conductors as shown in the following illustration. Splice conductors as shown using the procedure in figure 1E1. The shield return lead should have the same characteristics as the cable conductors.
2. Slide on the inner sleeves (2) under the exposed shield on both sides of the cable splice. "X" is the width of the inner sleeves.
3. Place the bare portions of shield return lead on the inner sleeve on both sides of the cable splice.
4. Crimp the outer shields (2) over the cable shield, inner sleeve, and shield return lead.
5. Complete cable splice in accordance with figure 1E1.



OUTER SHIELD CONDUCTION
X = WIDTH OF INNER SLEEVE

FIGURE 1E2. Splicing cable – power, control, telephone, and electronic with heat-shrink tubing – Continued.

METHOD 1E-3-1



CCBC CONNECTOR MIL-T-16366
(SEE TABLE 1E3-I)

FIGURE 1E3. Splicing cable – power, control, telephone, and electronic using heat-shrink tubing.

TABLE 1E3-I. Connector to type CCBC, connector and CCBC and connector dimensions.

Number standard appear on splices	Size designation MIL-DTL-915			Size designation			CCBC connector dimensions			Pull-out strength min. (pounds)	NSN (where available)
	Cable size designation	Size (cir mils)	Diameter over copper nominal (inches)	Standard cable size designation (AWG)	Size (cir mils)	Diameter over copper nominal (inches)	Length of each barrel "A" (min.)	Overall diameter "B" (approx.)	Overall length "C" (min.)		
1-2	3/5(7)	700	0.030	22	640	0.030	¼	0.150	⅝	10	5940-00-186-2878
	1(7)	1,020	0.039	20	1,020	0.036	¼	0.150	⅝	16	5940-00-186-2878
	1(10)	1,005	0.038	20	1,020	0.038	¼	0.150	⅝	15	5940-00-186-2878
	1½(16)	1,608	0.049	18	1,620	0.049	¼	0.150	⅝	23	5940-00-186-2878
	1½(41)	1,630	0.049	18	1,620	0.049	¼	0.150	⅝	24	5940-00-186-2878
	2(7)	1,779	0.048	18	1,620	0.046	¼	0.150	⅝	24	5940-00-186-2878
2½-4	2½(19)	2,407	0.060	16	2,580	0.061	¼	0.150	⅝	38	5940-00-186-2877
	2½(26)	2,613	0.061	16	2,580	0.061	¼	0.150	⅝	41	5940-00-186-2877
	3(7)	2,828	0.060	16	2,580	0.058	¼	0.150	⅝	43	5940-00-186-2877
	4(41)	4,121	0.077	15	4,110	0.078	¼	0.150	⅝	70	5940-00-186-2877
6-9	6(7)	6,512	0.092	12	6,530	0.092	5⁄16	0.212	¾	105	5940-00-186-2876
	9(7)	9,016	0.108	10	10,380	0.116	5⁄16	0.212	¾	140	5940-00-186-2876
14	14(7)	14,340	0.136	9	13,090	0.130	13⁄16	¼	1¾	190	5940-00-258-5891
23	23(7)	22,800	0.171	7	20,820	0.164	13⁄16	5⁄16	1¾	250	5940-00-258-5890
30	30(19)	30,860	0.202	5	33,090	0.221	1⅛	5⁄16	2⅜	290	5940-00-258-5893
40	40(19)	38,910	0.226	4	41,740	0.239	1⅛	5⁄16	2⅜	340	5940-00-258-5892
50	50(19)	49,080	0.254	3	52,620	0.260	1¼	⅜	2⅝	390	5940-00-258-5907
60	60(37)	60,090	0.282	2	66,360	0.300	1¼	7⁄16	2⅝	440	5940-00-258-5895

FIGURE 1E3. Splicing cable – power, control, telephone, and electronic using heat-shrink tubing – Continued.

TABLE 1E3-I. Connector to type CCBC, connector and CCBC and connector dimensions – Continued.

Number standard appear on splices	Size designation MIL-DTL-915			Size designation			CCBC connector dimensions			Pull-out strength min. (pounds)	NSN (where available)
	Cable size designation	Size (cir mil)	Diameter over copper nominal (inches)	Standard cable size designation (AWG)	Size (cir mil)	Diameter over copper nominal (inches)	Length of each barrel "A" (min.)	Overall diameter "B" (approx.)	Overall length "C" (min.)		
75	75(37)	75,780	0.317	1	83,690	0.332	1⅜	½	2⅞	500	5940-00-258-5894
100	100(61)	99,060	0.363	1/0	105,600	0.373	1⅜	½	2⅞	600	5940-00-258-5897
125	125(61)	124,900	0.407	2/0	133,100	0.419	1½	9/16	3⅛	675	5940-00-258-5896
150	150(61)	157,600	0.457	3/0	167,800	0.470	1½	⅝	3⅛	750	5940-00-258-5898
200	200(61)	198,700	0.514	4/0	211,600	0.528	1⅝	11/16	3⅜	900	5940-00-258-5899
250	250(61)	250,500	0.577	250MCM	250,000	0.576	1⅝	¾	3⅜	1,000	5940-00-258-5900
300	300(91)	296,400	0.628	300MCM	300,000	0.630	2	13/16	4⅛	1,120	5940-00-258-5902
350	350(91)	349,800	0.682	350MCM	350,000	0.682	2	⅞	4⅛	1,125	5940-00-258-5901
400	400(127)	413,600	0.742	-	413,600	0.742	2⅛	15/16	4⅜	1,325	
500	500(127)	521,600	0.832	500MCM	521,600	0,832	2¼	1 1/16	4⅝	1,500	5940-00-258-5904
650	650(127)	657,600	0.936	650MCM	650,000	0.930	2 13/16	1¼	5¾	1,750	5940-00-258-5905
800	800(127)	829,300	1.050	800MCM	800,000	1.031	2 15/16	1⅜	6	2,000	
1000	1000(127)	1,046,000	1.180	1000MCM	1,000,000	1.152	3	1½	6⅛	-	
1600	1600(127)	1,662,000	1.485	1600MCM	1,600,000	1.459	3 3/16	1 15/16	6¾	3,000	

FIGURE 1E3. Splicing cable – power, control, telephone, and electronic using heat-shrink tubing – Continued.

Material information:

A-A-59163 (see 4.5) and A-A-59770

RTV Silastic, Dow Corning 731 or Dow Corning 732, or RTV 102 silicone rubber, G.E. Company, or equal (see 4.2).

Unsupported rubber tape with silicone pressure sensitive adhesive, 3M No. 70, or equal (see 4.2).

Method 1E-4-1:

1. Method for splicing cables, special purpose, electrical (Types LSTPS, LSFPS, and LS7PS-6).
2. This section describes the method for splicing the following types and sizes of electrical cables for operations in high temperature ambient conditions aboard naval vessels:

LSDPS-3	LSTPS-3	LSFPS-14
LSDPS-4	LSTPS-4	LS7PS-6
LSDPS-6	LSTPS-6	
LSDPS-9	LSTPS-9	
	LSTPS-14	

3. Remove a section of basketweave armor approximately 6 inches longer than the length of armor to be removed from the cables to be spliced from a piece of scrap cable of slightly larger diameter. Slide the basketweave armor over the end of one of the cables to be spliced. Position this armor well back from the splicing area so that it does not interfere with subsequent splicing operations.
4. Remove armor and sheath material from the end of each cable to be spliced as follows:

Type cable	Length to be removed (inches)	
	Armor	Sheath
LSDPS-3, 4, 6, and 9	10	7
LS7PS-6	10	7
LSTPS-3, 4, 6, 9, and 14	13	10
LSFPS-14	16	13

Select connector for above cables from the following:

Type cable	CCBC connector
LSPS-3 and 4	2½ – 4
LSPS-6 and 9	6 – 9
LSPS-14	14

NOTE: Use a crimping tool in accordance with SAE-AS22520 for up to size 9 conductors, and use manufacturer's recommended tool for size 14 conductors. Place cable ends in a position as close as practical to the position the cable will be in after installation with the ends of the conductors reaching the crotch of the other cable, and support the cables rigidly in this position by temporary ties or clamps. See illustration 97 on figure 1E5.

5. The splice in the type LSPS cable shall be assembled by cutting matching conductors so that the conductor splices will be approximately 2 inches from the crotch and 3 inches from each other. No conductor splices shall be adjacent, except that in the LS7PS-6 cable alternate conductors in the outer layer may be spliced at the same point. Remove insulation from the end of the conductors equal to approximately ⅛ inch more than half of the connector length. Insert the conductor to the stop in the connector and crimp. Apply three layers, half-lapped, of self-bonding silicone rubber bias weave glass tape over the connector approximately 1 inch from each end of the connector. Then apply one layer of tape, half-lapped, over the insulated conductor from crotch-to-crotch. See illustration 98 on figure 1E5.
6. After splicing all conductors, stretch the cable and lay the original fillers back in place. See illustration 99 on figure 1E5.

FIGURE 1E4. Splicing high temperature cable.

Method 1E-4-1 (continued):

7. Apply one layer, half-lapped, of self-bonding silicone rubber bias weave tape over the grouped conductors between the cable sheath ends. See illustration 100 on figure 1E5.
8. Apply a coating of room-temperature vulcanized silicone rubber compound over the binder tape and approximately 1 inch on the ends of the cable sheath. Apply two layers, half-lapped, of unsupported pressure sensitive silicone rubber tape over the vulcanized silicone rubber compound and approximately 2 inches on the ends of the cable sheath. See illustration 101 on figure 1E5.
9. Apply two layers, half-lapped, of self-bonding silicone rubber bias weave glass tape between the armor ends. See illustration 102 on figure 1E5.
10. Slide armor sleeve over splice area and secure ends tightly with stainless steel clamps. After securing one end, pull sleeve to provide a snug fit before putting second clamp in place. Trim off any protruding armor wire strands. See illustration 103 on figure 1E5.

Method 1E-4-2:

1. Method for splicing cables, special purpose, electrical (types LSTCTX, LSTCJX, and LSTCKX).
2. This section describes the method for splicing the following types and sizes of electrical cables for operations in high temperature ambient conditions aboard naval vessels:

LSTCTX-3	LSTCJX-3	LSTCKX-1
LSTCTX-7	LSTCJX-7	LSTCKX-3
LSTCTX-12	LSTCJX-12	LSTCKX-7
		LSTCKX-12

3. Remove a section of basketweave armor approximately 6 inches longer than the length of armor to be removed from the cables to be spliced from a piece of scrap cable of slightly larger diameter. Slide the basketweave armor over the end of one of the cables to be spliced. Position this armor well back from the splicing area so that it does not interfere with subsequent splicing operations.
4. Remove armor and sheath material from the end of each cable to be spliced as follows:

Type cable	Length to be removed (inches)	
	Armor	Sheath
LSTC-X (all)	7	5

Do not untwist paired conductors until they are to be spliced. Select connector for above cables from the following:

Type cable	CCBC connector
LSTCTX	½
LSTCJX and LSTCKX	2½ – 4

NOTE: Use a crimping tool in accordance with SAE-AS22520. Place cable ends in a position as close as practical to the position the cable will be in after installation with the ends of the conductors reaching the crotch of the other cable, and support them rigidly in this position by temporary ties or clamps. See illustration 108 on figure 1E5.

5. The splice in the type LSTC-X cable is assembled by starting with a center pair of conductors. Untwist the conductors of a matching pair of conductors and cut the matching conductors so that there will be a 1-inch overlap. Stagger the splices between conductors of the same pair approximately 1 inch. Remove sufficient insulation from the ends of the conductors to allow the conductor to be inserted to the center stop of the connector. Slip a 2-inch length of silicone rubber insulation glass tubing over the longer insulated conductor and then splice the conductor with the recommended connector and crimping tool. When a pair of conductors has been spliced, center the insulation tubing over the connectors, and apply unsupported silicone rubber tape over the tubing on one conductor and the end of the tubing and the original insulation on the other conductor to hold the insulation tubing in place. See illustrations 108 and 109 on figure 1E5.

FIGURE 1E4. Splicing high temperature cable – Continued.

Method 1E-4-2 (continued):

6. Repeat the above procedure on each pair of conductors, staggering the conductor splices as much as possible between pairs. After all conductors have been spliced, pull the cable to remove the slack in the conductors. See illustration 110 on figure 1E5.
7. Follow steps 7, 8, 9, and 10 of method 1E-4-1 to complete this splice.

Method 1E-4-3:

1. Method for splicing cables, special-purpose, electrical (type LSPI).
2. This section describes the method for splicing the following types and sizes of electrical cables for operations in high temperature ambient conditions aboard naval vessels:

   LSPI-3 LSPI-7 LSPI-12
3. Remove a section of basketweave armor approximately 6 inches longer than the length of armor to be removed from the cables to be spliced from a piece of scrap cable of slightly larger diameter. Slide the basketweave armor over the end of one of the cables to be spliced. Position this armor well back from the splicing area so that it does not interfere with subsequent splicing operations.
4. Remove armor and sheath material from the end of each cable to be spliced as follows:

Type cable	Length to be removed (inches)	
	Armor	Sheath
LSPI-3	11	9
LSPI-7 and LSPI-12	13	11

Do not untwist paired conductors until they are to be spliced. Select connector for above cables from the following:

Type cable	CCBC connector
LSPI	½

NOTE: Use a crimping tool in accordance with SAE-AS22520. Inner and outer rings for use in splicing shielding braid on type LSPI cable shall be Burndy Engineering Company YIC-194 inner ring and YDC-200 outer ring, or equal (see 4.2). Crimp with die set R20VT in tool Y10Q-1. The braid wire used to replace the shield over the splice in type LSPI cable shall be Alpha Wire Corporation No. 1231, or equal (see 4.2). Place cable ends in a position as close as practical to the position the cable will be in after installation with the ends of the conductors reaching the crotch of the other cable, and support them rigidly in this position by temporary ties or clamps. See illustration 104 on figure 1E5.

FIGURE 1E4. Splicing high temperature cable – Continued.

Method 1E-4-3 (continued):

5. The splice in the type LSPI cable is assembled by starting with a matching shielded pair of conductors and marking the shielded pair 2½ inches in each direction from the center of the splice area so there will be an overlap of 5 inches when the excess is removed. Remove 4½ inches of glass braid from each pair. Slip an inner ring (YIC 194) over the shield up to the end of the glass braid. Remove shield wire up to ¾ inch from the inner ring. Unbraid the remaining shield wire. Fold the wire back over the inner ring and tape the ends to hold them in place. Slip a 6-inch length of braid wire over one pair of conductors and slip one outer ring (YOC 200) over the braid wire and a second outer ring over the corresponding pair on the other cable. Cut the black and white conductors 1 inch and 3 inches, respectively, from the shield wire on one pair and 3 inches and 1 inch, respectively, on the matching pair. Remove a ¼ inch of insulation from the end of each conductor. Insert the longer conductor in the connector to the center stop and crimp the connector with the recommended crimping tool. Slip a 2-inch length of silicone rubber insulated glass tubing over the longer insulated conductor before completing the conductor splice. After splicing both conductors, slip the insulated tubing over each conductor and apply unsupported silicone rubber tape over the center of the splice area to hold the insulating tubing in place while slipping the shielding braid over the splice. Align the outer ring over the inner ring and one end of the shielding braid and crimp the ring to secure the shield. Stretch the shield over the splice and align the other outer ring over the inner ring and secure the shield by crimping the ring. Trim the excess shield wire outside of both outer rings. The above steps are depicted on illustrations 104, 105, and 106 on figure 1E5.
6. Repeat the above steps with each pair of conductors, staggering each splice ½ inch. When preparing conductors for splicing, be careful to keep all conductors lengths equal. After all conductor pairs have been spliced, straighten the cable to remove the slack in the conductors. See illustration 107 on figure 1E5.
7. Follow steps 7, 8, 9, and 10 of method 1E-4-1 to complete the splice.

FIGURE 1E4. Splicing high temperature cable – Continued.

FIGURE 98

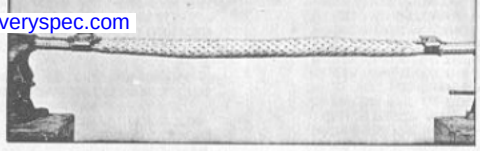
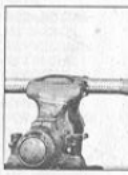


FIGURE 103



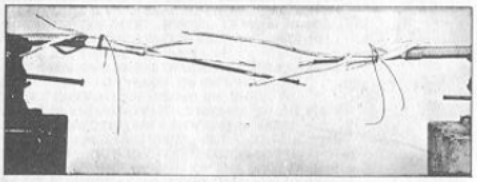


FIGURE 97

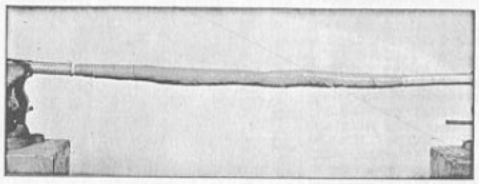


FIGURE 102

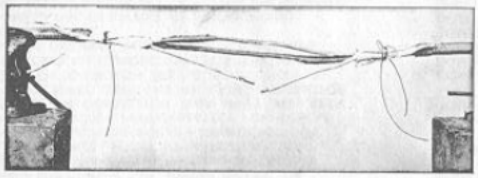


FIGURE 98

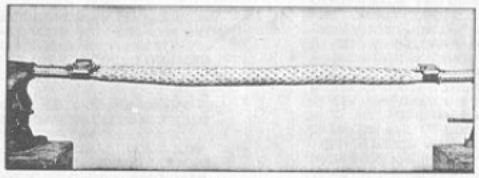
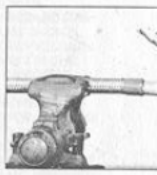
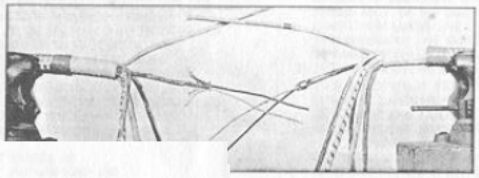
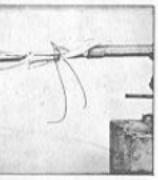


FIGURE 103





RE 104



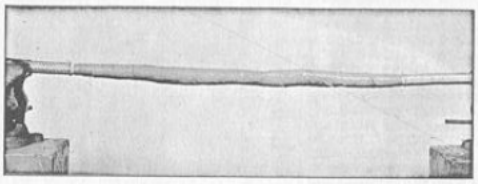


FIGURE 102

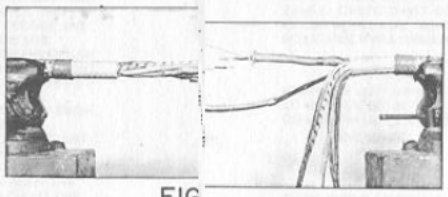
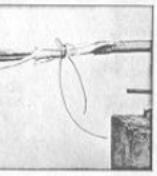


FIG E 105



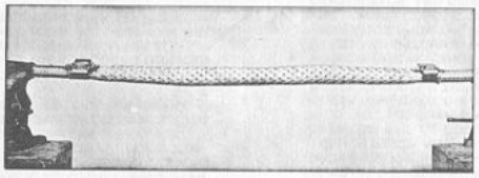
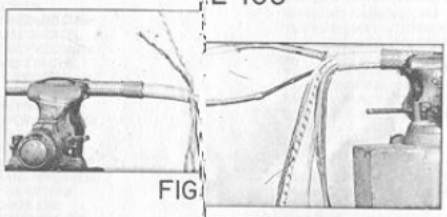


FIGURE 103



FIG

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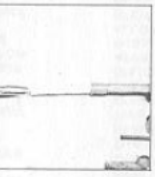
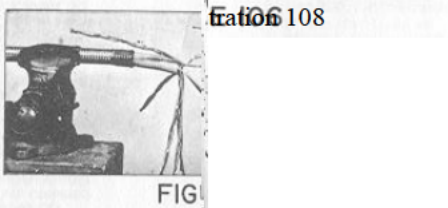
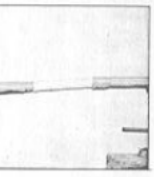


FIGURE 104



FIG



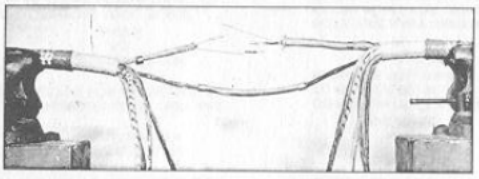
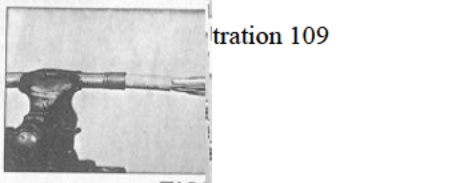


FIGURE 105

tration 109



FIG

FIGURE 106

tration 110

FIGURE 106

FIG

Method 1E-6-1
Splicing Unshielded Non-Watertight 5-Kilovolt Rated Cable

Purpose: The purpose of this method is to provide instructions for splicing of unshielded cables rated higher than 600 volts, up to 5 kilovolts.

NOTE: The use of this method requires prior approval of NAVSEA. See figure 1E1, step 1.i.

Pre-splice procedure:

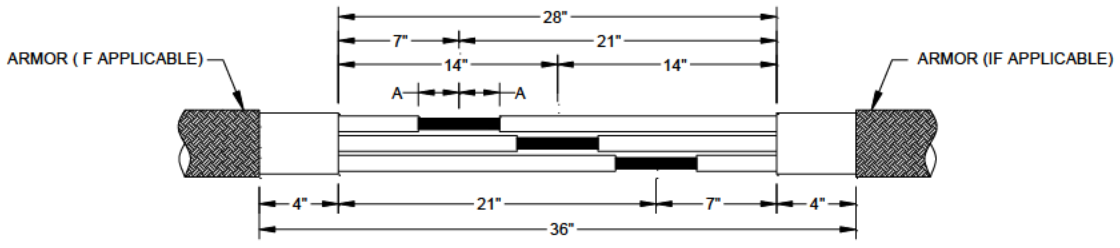
1. This procedure is a mandatory prerequisite prior to executing the splice.
2. Select the proper crimping tool recommended by the butt connector manufacturer for the type and size butt connector being used for the splice.
3. Perform a qualification crimp on one conductor of a sample specimen of cable the same size as the cable to be spliced.
4. Perform a pull test in accordance with MIL-T-16366 on the qualification crimp.
5. If the qualification crimp does not pass the pull test, the crimping tool shall be recalibrated or replaced and steps 3 and 4 above shall be repeated until the qualification crimp passes the pull test.
6. Upon passing the pull test, the crimping tool shall not be used for any other application and shall not be recalibrated until the splices with the qualified size butt connectors are completed.

General instructions:

1. During shrinking, keep the hot air tool aimed in the shrink direction to preheat the material.
2. Follow the manufacturer's handling instructions for cleaning solvents.
3. Clean and degrease all parts that will come into contact with adhesives.
4. Tubing should be cut smoothly with a sharp knife leaving no jagged edges.
5. Ensure that the tubing is recovered completely before continuing to shrink along the cable.
6. Tubing should be smooth and wrinkle free with inner components clearly defined.
7. Ensure the hot air tool is always used in a well-ventilated environment. Shrink products in a well-ventilated area.

Splice procedure:

1. Prepare cable ends by removing 21 inches of the cable jacket and 25 inches of cable armor (if installed) from the ends of the cables to be spliced. Secure the armor (if installed) against the cable jacket using one half-lapped layer of pressure sensitive tape in accordance with MIL-I-24391. Tape ¾ inch onto both the cable jacket and the armor braid.
2. If armored cable is being spliced, slide on a 42-inch length of armored braid over the end of one of the cable ends and temporarily tape the braid out of the way. Obtain the braid from a cable with a larger diameter.
3. Remove and save cable filler packing back to the cable crotch. During this step and subsequent, ensure that cable bend radius requirements are met.
4. Cut, orient, and remove conductor insulation as shown in illustration 1. Do not switch phases.



LLUSTRATION 1

NOTE: Dimension "A" equals half the connector length plus ⅛ inch.

FIGURE 1E6. Splicing 5-kilovolt rated cables.

Splice procedure (continued):

5. Slide heat shrinkable tubing, polyolefin per SAE-AS23053/5, class 1, over each conductor. Size the tubing to ensure a snug fit after shrinking along the entire connection length to cover all taping, approximately 7 to 8 inches in length, depending on the length of the butt connector.
6. Size the butt connectors to suit the conductor in accordance with MIL-T-16366. Install and crimp butt connectors in accordance with MIL-T-16366 on the three pairs of conductor ends.
7. Apply filler tape in accordance with MIL-PRF-17695. Mold by hand to form a uniform surface for subsequent taping. Make sure that voids are filled. See illustration 2.
8. Apply pressure sensitive silicone rubber glass tape in accordance with A-A-59770 – (approximately 17 mils thick) to each conductor that has been spliced. Apply five half-lapped layers (10 thicknesses), alternating the direction of taping for each layer. Overlap conductor insulation at least 1½ inches, gradually tapering back to at least ¾ inch overlap. See illustration 2.
9. Apply one half-lapped layer of pressure sensitive vinyl tape in accordance with MIL-I-24391 followed by two coats of coating material, commercial 3M Skotchkote, or equal (see 4.2), to each conductor that has been spliced. Allow coating material to dry between coats.
10. Position the heat shrink tubing over the spliced area of each conductor. Trim the tubing as necessary before shrinking. Shrink the tubing over the splice for each conductor. Keep the hot air tool aimed in the shrink direction to preheat the material.
11. Apply one half-lapped layer of silicone rubber glass tape in accordance with A-A-59770 over the exposed length of each spliced conductor, from cable crotch to cable crotch.

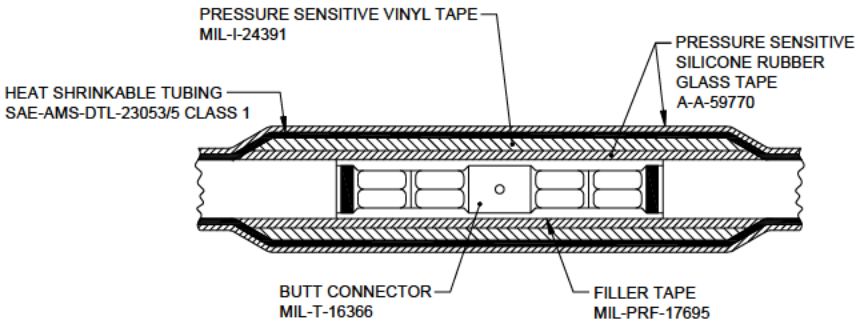


ILLUSTRATION 2

12. Lay the previously removed filler packing back in place outside the spliced conductors. The filler packing may be held in place by tying with glass cord for convenience when taping. See illustration 3.
13. Apply one half–lapped layer of silicone rubber glass binder in accordance with A-A-59770 over the grouped spliced conductors between the cable jacket ends.
14. Apply one half-lapped layer of filler tape. When taping, pull tape to approximately one-half of the original thickness. Tape over ends of the cable jacket by about 2 inches.
15. Apply two half-lapped layers of pressure sensitive vinyl tape. Tape to either ½ inch of the armor (if armored cable) or to about 4 inches beyond where cable insulation was removed.
16. Apply two coats of commercial 3M Scotchkote, or equal (see 4.2). Allow first coat to dry before applying second coat.
17. For splices of armored cable, remove temporary tape binding from armor braid and slide the armor section over the splice area. Pull the armor to a snug fit and secure the armor ends over the existing cable armor with CRES clamps. Trim the protruding armor strands.

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

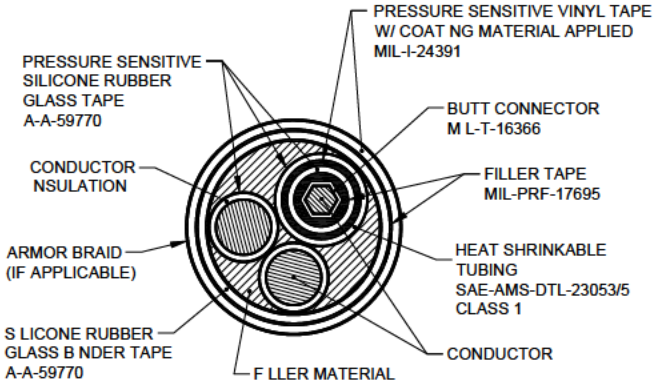


ILLUSTRATION 3

Post splice acceptance checks:

1. Disconnect and isolate the spliced cable from the power source so that the high potential test is isolated to the spliced cable.
2. Perform high potential test on spliced cable in accordance with S9086-KC-STM-010/300. Maximum leakage current is 480 microamps at 12 kilovolts DC.
3. Perform an infrared test once the cable is electrically loaded. The acceptance criterion is that no hot spots 10 °C or greater above ambient are observed in the splice area.

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

Method 1E-6-2
Splicing Shielded Watertight 5-Kilovolt Rated Cable

Purpose: The purpose of this method is to provide instructions for splicing of shielded cables rated higher than 600 volts, up to 5 kilovolts.

NOTE: The use of this method requires prior approval of NAVSEA. See figure 1E1, step 1.i.

Pre-splice procedure:

1. This procedure is a mandatory prerequisite prior to executing the splice.
2. Select the proper crimping tool recommended by the butt connector manufacturer for the type and size butt connector being used for the splice.
3. Perform a qualification crimp on one conductor of a sample specimen of cable the same size as the cable to be spliced.
4. Perform a pull test in accordance with MIL-T-16366 on the qualification crimp.
5. If the qualification crimp does not pass the pull test, the crimping tool shall be recalibrated or replaced and steps 3 and 4 above shall be repeated until the qualification crimp passes the pull test.
6. Upon passing the pull test, the crimping tool shall not be used for any other application and shall not be recalibrated until the splices with the qualified size butt connectors are completed.

General instructions:

1. During shrinking, keep the hot air tool aimed in the shrink direction to preheat the material.
2. Follow the manufacturer's handling instructions for cleaning solvents.
3. Clean and degrease all parts that will come into contact with adhesives.
4. Tubing should be cut smoothly with a sharp knife leaving no jagged edges.
5. Ensure that the tubing is recovered completely before continuing to shrink along the cable.
6. Tubing should be smooth and wrinkle free with inner components clearly defined.
7. Ensure the hot air tool is always used in a well-ventilated environment. Shrink products in a well-ventilated area.

Kit components: The splice kit should include the components in table 1E6-I.

TABLE 1E6-I. Splice kit components.

Item number	Description	Quantity
1	Black phase connection sealing tube, 9-inch length	3
2	Black splice rejacketing tube, 59-inch length	1
3	Red phase connection insulating tube, 6.5-inch	3
4	Yellow stress relief material (SRM), 24-inch long	6
5	Black ground connection sealing tube, 6-inch	3
6	Roll spring	2
7	#4 AWG ground braid	1
8	2.0-inch wide copper mesh	3
9	Copper tape	4
10	Splice long barrel, conductor	3
11	Splice long barrel, shield	3

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

TABLE 1E6-II. Splice kit dimension limitations for 250 MCM cable.

Nominal cable range	Maximum jacket diameter	Insulation diameter range	Maximum connector length	Maximum connector diameter
1/0-300 kcmil	3.00 inches (75 mm)	0.65-1.05 inch (15-25 mm)	4.0 inches (100 mm)	1.00 inch (25 mm)

Splice procedure:

1. Overlapping cables, mark centerline. Position cables in place and overlap by approximately 40 inches. Mark the centerline of the overlap. See illustration 1. If cables cannot be overlapped, refer to illustration 2 for cutback dimensions.

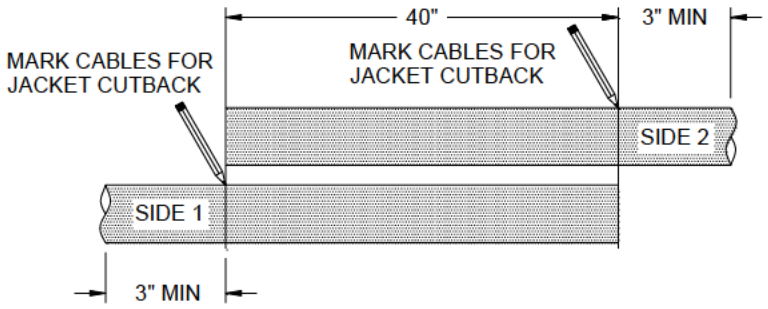


Illustration 1

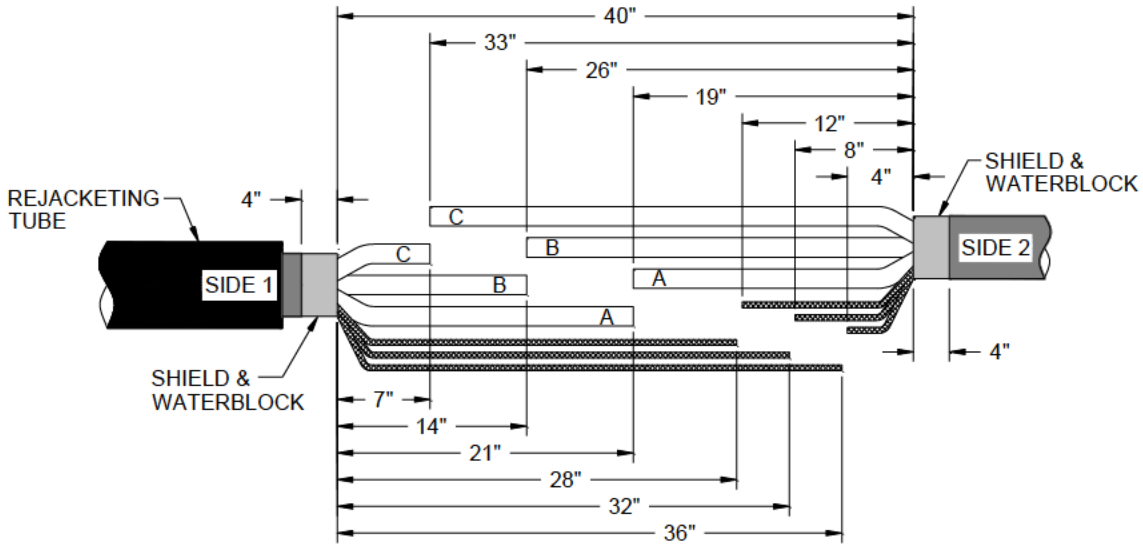


Illustration 2

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

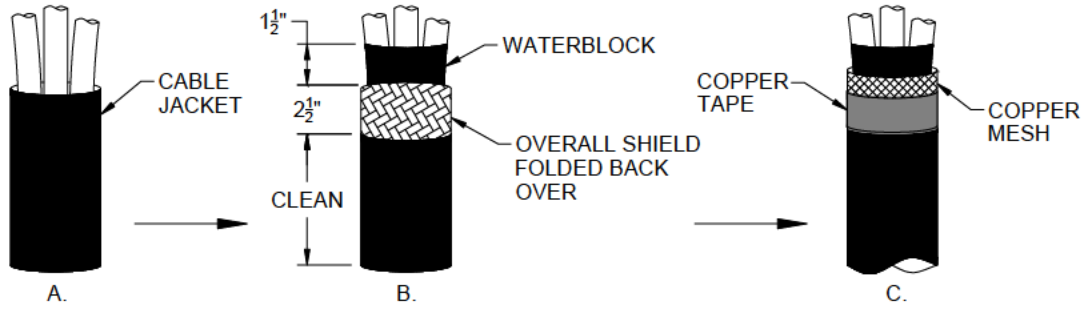


Illustration 3

Splice procedure (continued):

2. Shield and cable preparation. Perform the following on both cable ends. Strip cable jacket using a heat gun and the cable's internal rip cord. Apply ⅜ inch copper tape around shield to a point 4 inches forward of the jacket cutoff. Carefully trim excess shield around the circumference of the cable. Ensure that the underlying insulation is not damaged during this process.
   a. Clean outer jacket to a point 4 inches below the cutoff with a solvent wipe. Remove shield to a point 2.5 inches forward of the jacket cutoff. Remove core wrap and waterblock material (if used) to a point 4 inches forward of the jacket cutoff. See illustration 3.
   b. Clean waterblock material (if used) from the shield and conductors using solvent wipes as required. Fold the shield back over itself to be flush to the outer jacket insulation to create a 2½ inches wide braid shield. See illustration 3.
   c. Tightly apply three wraps of the copper mesh around the shield. Secure with a half hitch and two of the 8-inch copper tape wraps to completely surround the copper mesh. See illustration 3.
   d. Slide 60 inches rejacketing tube on side 1. See illustration 2
   e. Clean all insulated conductors with a cleaning kit.
   f. Prepare cable conductors using dimensions shown in illustration 2.
   g. Bend back the grounding conductors(s) over the jacket, being sure not to bend the conductor beyond the bending radius requirement for the cable. See illustration 5.
   h. Label phases A, B, and C as shown in illustration 2.
3. Removing conductor insulation for splicing. Cut back and remove phase conductor insulation as shown in illustration 4.

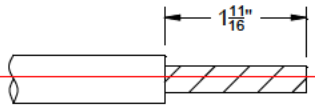


Illustration 4

4. Cleaning cable conductors. Using an oil-free solvent and lint-free cloth, clean the cables as shown in illustration 5.

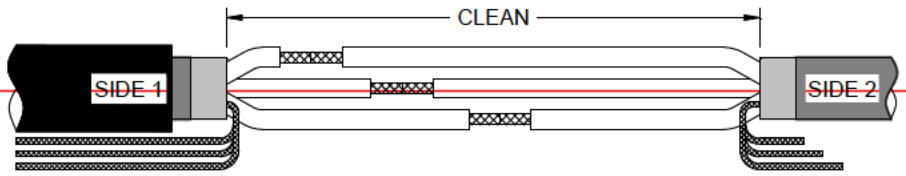


Illustration 5

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

Splice procedure (continued):

5. Placing phase connection insulating tube over phase conductors. Nest the three red phase connection insulating tubes into the black phase connection sealing tube and place one set over each phase on the side with the longer conductors as shown in illustration 6. Protect the tubes from ends of conductors as the tubes are placed over the conductor ends.

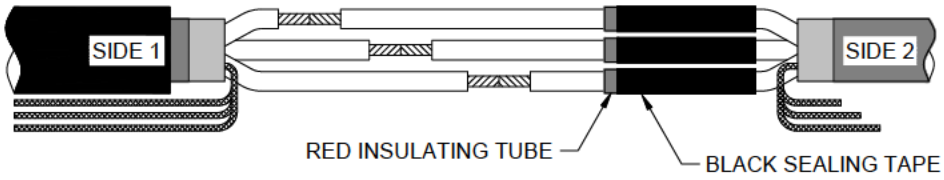


Illustration 6

6. Installing butt connectors. Using the crimp tool and die recommended by the butt connector manufacturer, install and crimp a butt connector for each conductor to be spliced. Crimp one conductor side, check for proper alignment, then crimp the second side. After connector installation, debur the connectors to remove any sharp edges.

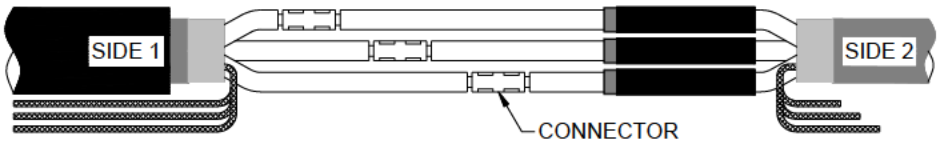


Illustration 7

7. Applying stress relief material (SRM) and positioning red insulating tubes over individual conductors. Complete the following steps on one phase conductor at a time.
   a. Clean connector area and insulation, as shown in illustration 8, using the provided cleaning kit or an appropriate oil-free solvent and lint-free cloth.

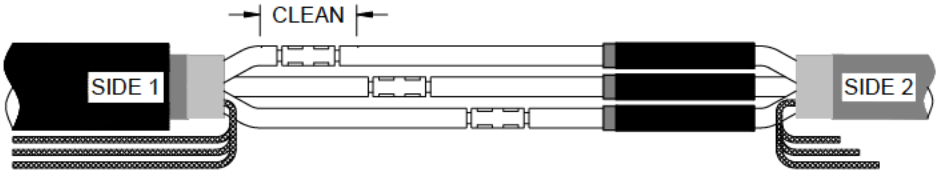


Illustration 8

   b. Remove backing from one side of the strip of stress relief material (SRM). Roll the SRM and remaining backing strip into a convenient size. Remove the remaining backing strip, and using half laps, tightly wrap the SRM around the connector and exposed conductor. Be sure to fill the gaps and low spots around the connector.

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

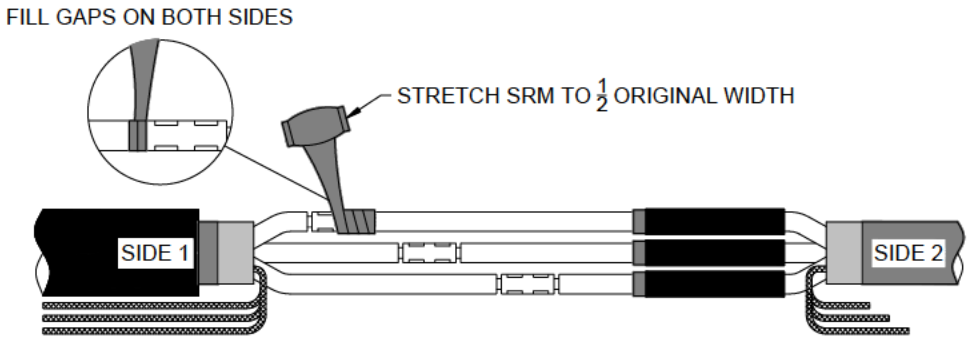


Illustration 9

Splice procedure (continued):

c. Continue to wrap the SRM onto the solvent cleaned insulation as shown in illustration 9. If connector diameter is larger than insulation diameter, apply two tightly wrapped half-lapped layers of the SRM over the entire connector in the same direction. Discard any excess SRM.

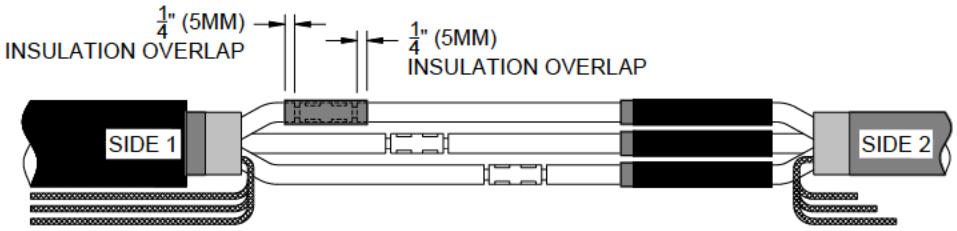


Illustration 10

d. Positioning insulating tube over connection. Center the red insulating tube over completed connector area. Do not shrink yet. Repeat steps 7.a through 7.d on the remaining phases.

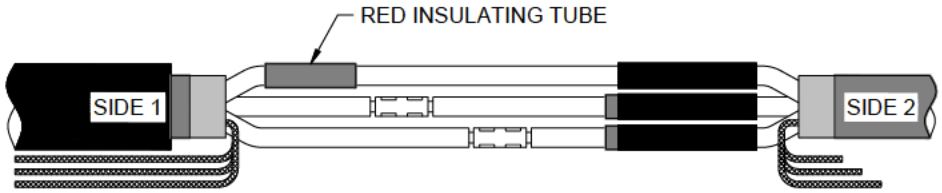


Illustration 11

8. Checking position of red insulating tubes and shrinking in place:
   a. Make sure each red insulating tube is centered over the connection area. Shrink all three tubes in place at the same time.
   b. Begin shrinking at center of tubes (item 1 of illustration 12), working heat gun in a 360-degree circular motion around the tubes.
   c. After center portion shrinks, work heat gun as before toward one end (item 2 of illustration 12), then to the opposite end (item 3 of illustration 12).
   d. Inspect tubing and allow to cool to the touch before proceeding to the next step.

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

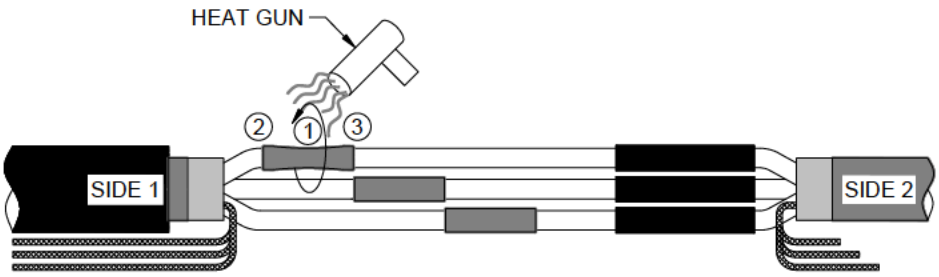


Illustration 12

Splice procedure (continued):

9. Positioning black sealing tubes; shrinking in place:
   a. Make sure each black sealing tube is centered over the connection area. Shrink all three tubes in place at the same time.
   b. Begin shrinking at center of tubes (item 1 of illustration 13), working heat gun in a 360-degree circular motion around the tubes.
   c. After center portion shrinks, work heat gun as before toward one end (item 2 of illustration 13), then to the opposite end (item 3 of illustration 13).
   d. Inspect tubing and allow to cool to the touch before proceeding to the next step.

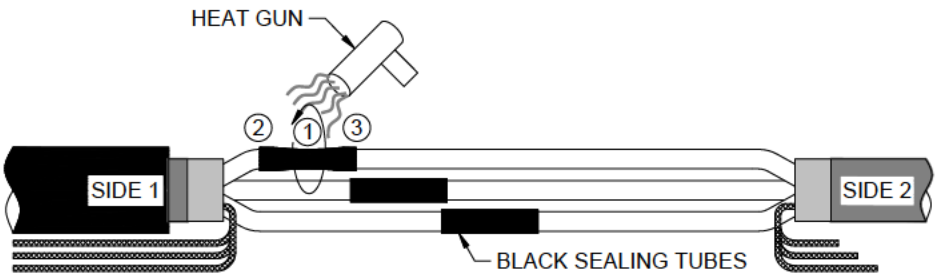


Illustration 13

10. Connecting grounding conductor:
   a. Bend the ground conductors back in place.
   b. Position the small black tube over each longer ground wire and splice with the grounding conductor butt connector.
   c. Repeat step 6 for grounding conductor connector installation and crimping.
   d. Center black tubes over each connector and shrink down.

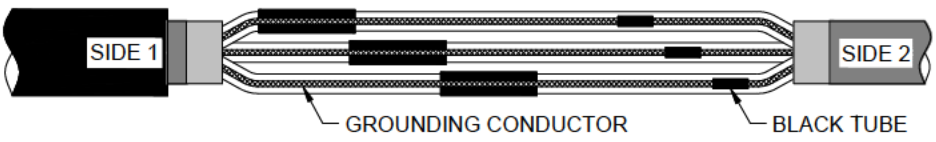


Illustration 14

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

Splice procedure (continued):

11. Installing ground connection:
    a. Flare one end of the ground braid and place it onto the metallic tape installed in step 2. See item 1 of illustration 15.
    b. Attach the braid to the shield by placing two wraps of the spring clamp over the braid. See item 2 of illustration 15.
    c. Fold the braid back over the spring clamp wraps. Continue to wrap the remaining clamp over the braid. Tighten clamp by twisting in the direction that the clamp is wrapped and secure with copper foil tape provided. See item 3 of illustration 15.

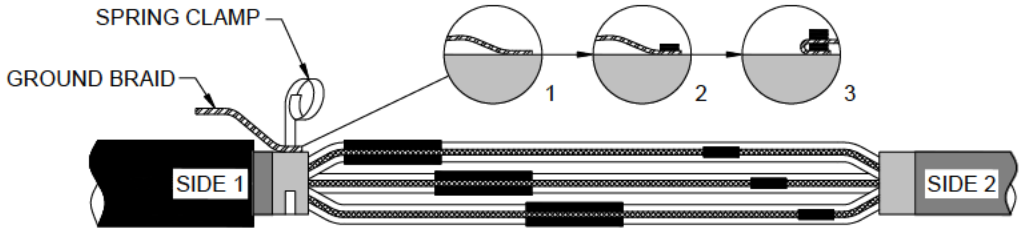


Illustration 15

    d. Lay the braid across the splice tube and onto the exposed tape shield on the other side. See item 4 of illustration 16.
    e. Make two wraps of the clamp over the braid. See item 5 of illustration 16.
    f. Fold the braid back toward the splice and finish wrapping the clamp. Tighten and secure. Cut off excess braid. See item 6 of illustration 16.

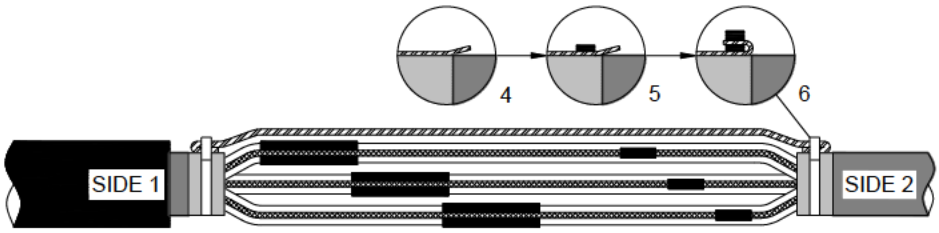


Illustration 16

12. Installing the shielding mesh:
    a. Abrade and clean cable jacket on both ends.
    b. Wrap a half-lapped layer of the mesh across the entire splice and tie off with a half hitch knot.
    c. Wrap one layer of copper tape to secure the knot.
    d. Wrap the entire length of the splice with shielding mesh with a 50 percent overlap.
    e. Repeat the tie off procedure on side 2.

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

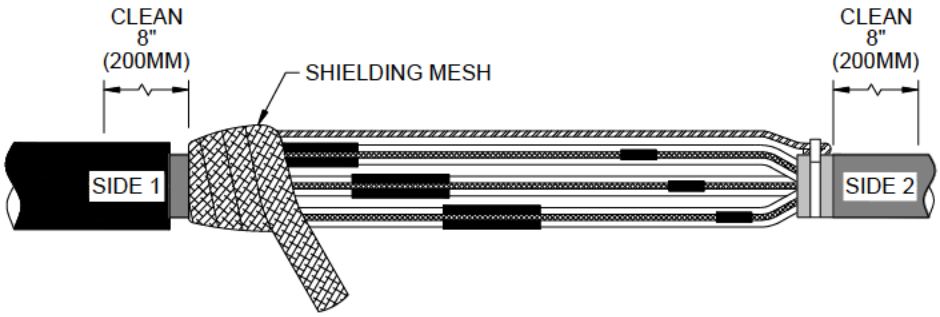


Illustration 17

Splice procedure (continued):

13. Position rejacketing tube:
    a. Remove or tape over all sharp points to prevent puncture of the rejacketing tube.
    b. Center rejacketing tube over splice (the rejacketing tube should overlap 3 inches minimum over each cable jacket).

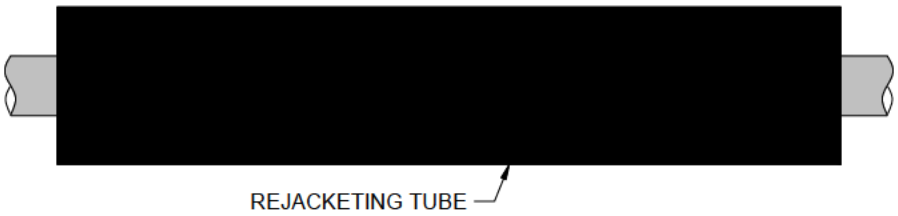


Illustration 18

14. Recovering (heat shrinking) the rejacketing tube:
    a. Begin recovering at the center of the tube and work toward each end in a 360-degree circular motion.
    b. Heat the tube uniformly until a bead of adhesive is visible at each end of cable. Inspect cable to ensure good adhesive flow.
    c. Allow to cool to the touch before moving or placing in service.

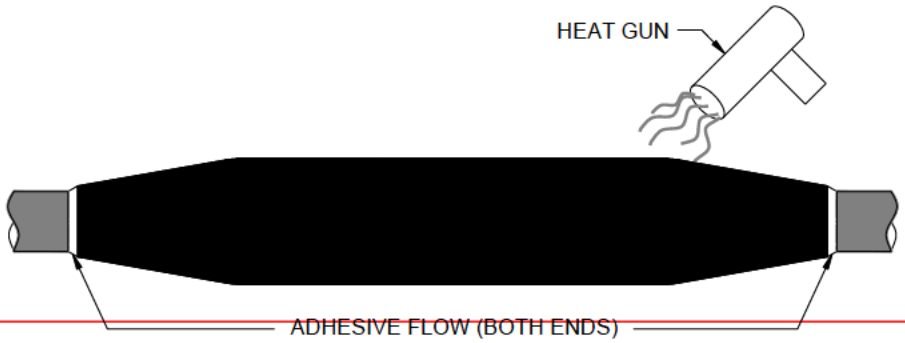


FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

Splice procedure (continued):

15. Retest. Perform the following retests on the completed splices. The performance should be the same as for the initially installed cable.
    a. Continuity test
    b. Insulation resistance test
    c. High potential test
    d. Thermal imaging test on loaded cable. Temperature at splice area shall not exceed the temperature of the rest of the cable by more than 5 °C.

FIGURE 1E6. Splicing 5-kilovolt rated cables – Continued.

CONCLUDING MATERIAL

Preparing activity:
Navy – SH
(Project SESS-2015-027)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.