

**INCH-POUND**

**MIL-STD-2003-1A(SH)**

**3 September 2009**

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**SUPERSEDING**

**DOD-STD-2003-1(NAVY)**

**24 June 1987**

**DEPARTMENT OF DEFENSE  
STANDARD PRACTICE  
ELECTRIC PLANT INSTALLATION  
STANDARD METHODS FOR  
SURFACE SHIPS AND SUBMARINES  
(CABLE)**



## MIL-STD-2003-1A(SH)

### 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 employed for submarine and surface ship electrical distribution systems.
3. These criteria apply to work on a specific ship or ships only when invoked by the Ship Specifications or similar contractual documents.
4. These criteria are for application to new construction, conversion, and alteration of existing ships.
5. Considering the magnitude of this standard, along with the changing requirements imposed on the Electric Plant, it is inevitable that changes will be required to update these criteria. Therefore, as comments arise, they should be forwarded to Naval Sea Systems Command (NAVSEA) 05Z3 to keep this standard as current as possible through subsequent revisions. Revisions will be accomplished by the issuance of additional or revised figures to be inserted in the basic standard parts. Superseded pages may be retained for reference if so desired.
6. Comments, suggestions, or questions on this document should be addressed to Commander, Naval Sea Systems Command, ATTN: SEA 05M2, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to [CommandStandards@navy.mil](mailto: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 <http://assist.daps.dla.mil>.

## MIL-STD-2003-1A(SH)

## CONTENTS

<u>PARAGRAPH</u>	<u>PAGE</u>
1. SCOPE.....	1
1.1 Scope.....	1
1.1.1 Application.....	1
1.1.2 New cable specifications.....	1
2. APPLICABLE DOCUMENTS .....	1
2.1 General.....	1
2.2 Government documents .....	1
2.2.1 Specifications, standards, and handbooks .....	1
2.2.2 Other Government documents, drawings, and publications .....	2
2.3 Non-Government publications.....	2
2.4 Order of precedence.....	2
3. DEFINITIONS .....	3
3.1 Cable repair.....	3
3.2 Flooding water level II (FWL-II).....	3
4. GENERAL REQUIREMENTS.....	3
4.1 Cable.....	3
4.1.1 Cable slack .....	3
4.1.2 Supporting cables entering enclosures .....	3
4.1.3 Cable bend radius .....	3
4.1.4 Box connectors, electrical .....	3
4.1.5 Cable connection.....	3
4.1.6 Watertight cables.....	3
4.1.6.1 Water blocked cables.....	3
4.1.6.2 Cable end-sealing .....	4
4.1.6.3 Watertight cable exceptions.....	4
4.1.7 Cable lug terminals.....	4
4.1.7.1 Application .....	4
4.1.8 Cable entrance to machinery and equipment.....	4
4.1.9 Cable entrance to switchboards.....	5
4.1.10 Cable connection to machinery .....	5
4.1.10.1 Cables connected to equipment provided with resilient mounts.....	5
4.1.11 Cable splicing.....	5
4.1.12 Cable jacket repair.....	5
4.1.13 Dead-ended cables.....	5
4.1.14 Protection during welding or hot work.....	5
4.1.15 Thimbles.....	5
5. DETAILED REQUIREMENTS.....	5
6. NOTES .....	6
6.1 Intended use .....	6
6.2 Acquisition requirements .....	6
6.3 Designation of electric plant installation standard methods figures.....	6
6.4 Subject term (key word) listing.....	6
6.5 Changes from previous issue .....	6
APPENDIX A Cable Preparation and End-Sealing.....	7
APPENDIX B Cable Entry to Equipment .....	55

MIL-STD-2003-1A(SH)

APPENDIX C	Protection of Topside Connectors .....	83
APPENDIX D	Repair of Damaged Cable .....	86
APPENDIX E	Cable Splicing .....	100

## MIL-STD-2003-1A(SH)

## 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. These installation methods are to be used by all installing activities. These methods do not identify ship or type but do establish minimum standards of acceptance for Naval ships. It is the responsibility of the user activity to determine which method satisfies their requirements. It does not authorize relaxation of any requirement specifically invoked by new construction, conversion, overhaul, or refurbishment contracts. In instances where deviated design requirements (for example, ship type, ship class, and so forth) conflict with the requirements of this standard, the requirements of this standard govern. Any deviation for electric plant installation identified in this standard is to be submitted to NAVSEA 05Z3 for resolution.

1.1.2 New 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	TPMU	7SPR-16S
FSS	1SWF	1PR-AZOE	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-16036 - Switchgear, Power, Low Voltage, Naval Shipboard  
MIL-T-16366 - Terminals, Electrical Lug and Conductor Splices, Crimp-Style

## MIL-STD-2003-1A(SH)

- |               |   |   |
|---------------|---|---|
| MIL-DTL-24640 | - | Cable, Light-Weight, Electric, for Shipboard Use, General Specification for           |
| MIL-DTL-24643 | - | Cables and Cords, Electrical, Low Smoke, for Shipboard Use, General Specification for |

## DEPARTMENT OF DEFENSE STANDARDS

- |                |   |   |
|----------------|---|---|
| MIL-STD-1310   | - | Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety |
| MIL-STD-2003-4 | - | Electric Plant Installation Standard Methods For Surface Ships and Submarines (Cableways)       |

## DEPARTMENT OF DEFENSE HANDBOOKS

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

(Copies of these documents are available online at <http://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

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-000 | - | NSTM Chapter 300, Electric Plant-General |
|------------------|---|--|

(Copies of this document are available from the Naval Logistics Library, 5450 Carlisle Pike, Mechanicsburg, PA 17055 or online at <http://nll.ahf.nmci.navy.mil/>.)

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.

## 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 from Aerospace Industries Association, 1250 Eye Street NW, Washington, DC 20005-3924 or online at [www.aia-aerospace.org](http://www.aia-aerospace.org).)

## SAE INTERNATIONAL

- |              |   |  |
|--------------|---|--|
| SAE-AS7928/1 | - | Terminals, Lugs 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 |
|--------------|---|--|

(Copies of this document are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or online at [www.sae.org](http://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.

## MIL-STD-2003-1A(SH)

## 3. DEFINITIONS

3.1 Cable repair. Cable repair refers to restoration of only the cable armor or the outermost cable sheath or both.

3.2 Flooding water level II (FWL-II). FWL-II is the highest water level that can be expected above the bulkhead deck at any particular intact watertight subdivision after any flooding elsewhere in the ship which the ship is expected to be capable of surviving. If FWL-II is unknown, consider the main deck to be the FWL.

## 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 to bulkheads and shall not exceed the cable bend radius.

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. Cables terminating at the following equipment, located below FWL-II (see 3.2), shall be watertight. There are two acceptable methods for watertight cables: water blocked and end-sealing.

- 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 panel, 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 Water blocked cables. Water blocked cables shall be in accordance with MIL-DTL-24640 or MIL-DTL-24643. Water blocked cables are the preferred method and shall be used unless end-sealing is approved for use by NAVSEA.

## MIL-STD-2003-1A(SH)

4.1.6.2 Cable end-sealing. Although end-sealing is an acceptable method, it is usually less economical and therefore only used when approved by NAVSEA.

4.1.6.3 Watertight cable exceptions. 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, cable Types TTSU and MSCU, and all electronic, communication and instrumentation two, three, and four-conductor cable of size 9 and smaller.

4.1.7 Cable lug terminals. Cable lug terminals shall be installed on each connected conductor unless cable is terminated by a connector. Lug terminals shall conform to MIL-T-16366 (solderless type), SAEAS7928/1 (insulated barrel solderless type), NASM 77072 (solder type), or NASM 77073 (solder type).

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

4.1.8 Cable entrance to machinery and equipment. Cable entry into bulkhead-mounted non-watertight equipment shall be through the bottom or lower half of the side unless otherwise approved by NAVSEA. 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, at locations where the cables pass from the structure of the ship to the machinery. Cables connected to equipment 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. 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.

## MIL-STD-2003-1A(SH)

4.1.9 Cable entrance to switchboards. Switchboards designed in accordance with MIL-DTL-16036 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 without the use of stuffing tubes. 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 provision 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 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. Where armored cable use is permitted, the armor shall be removed from that portion of all cables which are within the switchboard structure.

4.1.10 Cable connection to machinery. Sufficient slack shall be allowed to prevent damage to cables, due to vibration, 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 provided with resilient mounts. These cables shall have a minimum length between the equipment and the last point of support of the cable of 18 inches with at least three inches of slack to provide for flexibility and movement of the equipment under shock.

4.1.11 Cable splicing. Cables identified on figure 1E1 shall not be spliced. 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 or repaired 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 technology of tape wrap and poured epoxy molds shown in MIL-STD-2003-1 dated 24 June 1987 may still be used. Because of high temperature requirements placed on cables identified on figures 1E4 and 1E5, special taping methods are retained for these cables (refer to NSTM Chapter 300).

4.1.12 Cable jacket 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.

4.1.13 Dead-ended cables. Dead-ended cables shall be permanently labeled for either future use or removal.

4.1.14 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.

4.1.15 Thimbles. The use of thimbles on power cable conductors where mechanical connections are made without lugs is prohibited for new construction. In existing non-nuclear applications, thimbles should be removed from equipment during overhaul or other extended maintenance period. For existing nuclear applications, NAVSEA 08 should be contacted prior to making any changes to electrical connections with thimbles.

## 5. DETAILED REQUIREMENTS

(See figures.)

## MIL-STD-2003-1A(SH)

## 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 section 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.

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 providing similar functions. These groups are:

MIL-STD-2003-1 (Cables)

Group A. Cable Preparation and End-Sealing

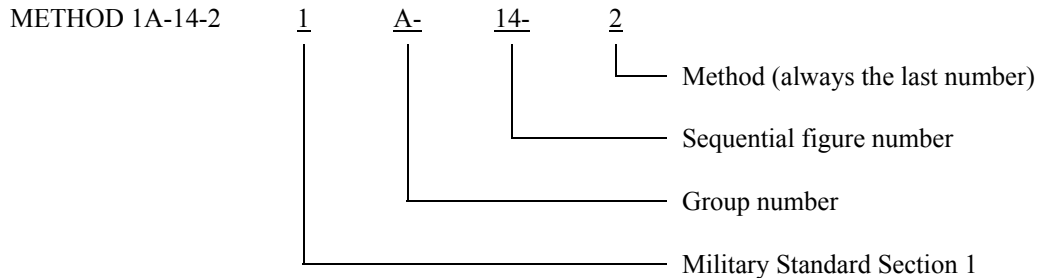
B. Cable Entry to Equipment

C. Protection of Topside Connectors

D. Repair of Damaged Cable

E. Cable Splicing

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



Thus, Method 1A-14-2 identifies Method 2, figure number 14 in Group A of MIL-STD-2003-1.

6.4 Subject term (key word) listing.

End-sealing

Equipment entry

Connectors

Connection preparation

Splicing

Water blocked

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.

MIL-STD-2003-1A(SH)  
APPENDIX A

GROUP 1A - CABLE PREPARATION AND END-SEALING

A.1 SCOPE

A.1.1 Scope. This appendix describes procedures for cable end preparation and end-sealing.

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-STD-2003-1A(SH)  
APPENDIX A

MIL-I-24391	-	Insulation Tape, Electrical, Plastic Pressure-Sensitive
MIL-DTL-24640	-	Cable, Light-Weight, Electric, for Shipboard Use, General Specification for
MIL-DTL-24643	-	Cables and Cords, Electrical, Low Smoke, for Shipboard Use, General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202	-	Electronic and Electrical Component Parts
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(Copies of these documents are available online at <http://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

A.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

S9AA0-AB-GOS-010/GSO Section 304	-	General Specifications for Overhaul of Surface Ships (GSO), Section 304
S9AA0-AB-GOS-010/GSO Section 305	-	General Specifications for Overhaul of Surface Ships (GSO), Section 305

(Copies of these documents are available from the Naval Logistics Library, 5450 Carlisle Pike, Mechanicsburg, PA 17055 or online at <http://nll.ahf.nmci.navy.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 from ASTM International, 100 Barr Harbor Dr., P.O. Box C700, West Conshohocken, PA 19428-2959 or online at [www.astm.org](http://www.astm.org).)

IPC

J-STD-006	-	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications
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(Copies of this document are available from IPC, 3000 Lakeside Drive, 309 S, Bannockburn, IL 60015 or online at [www.ipc.org](http://www.ipc.org).)

SAE INTERNATIONAL

SAE-AMS-DTL-23053/4	-	Insulation Sleeving, Electrical, Heat-shrinkable, Polyolefin, Dual-Wall, Outer Wall Crosslinked
SAE-AMS-DTL-23053/5	-	Insulation Sleeving, Electrical, Heat-shrinkable, Polyolefin, Flexible, Crosslinked

MIL-STD-2003-1A(SH)  
APPENDIX A

- |                      |  |
|----------------------|--|
| SAE-AMS-DTL-23053/15 | - Insulation Sleeving, Electrical, Heat-shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked |
| SAE-AS7928           | - Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification For                                 |
| SAE-AS81765/1        | - Insulating Components, Molded, Electrical, Heat-shrinkable Polyolefin, Crosslinked, Semi-Rigid and Flexible        |

(Copies of these documents are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or online at [www.sae.org](http://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 section, all dimensions are in inches unless otherwise noted.

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

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

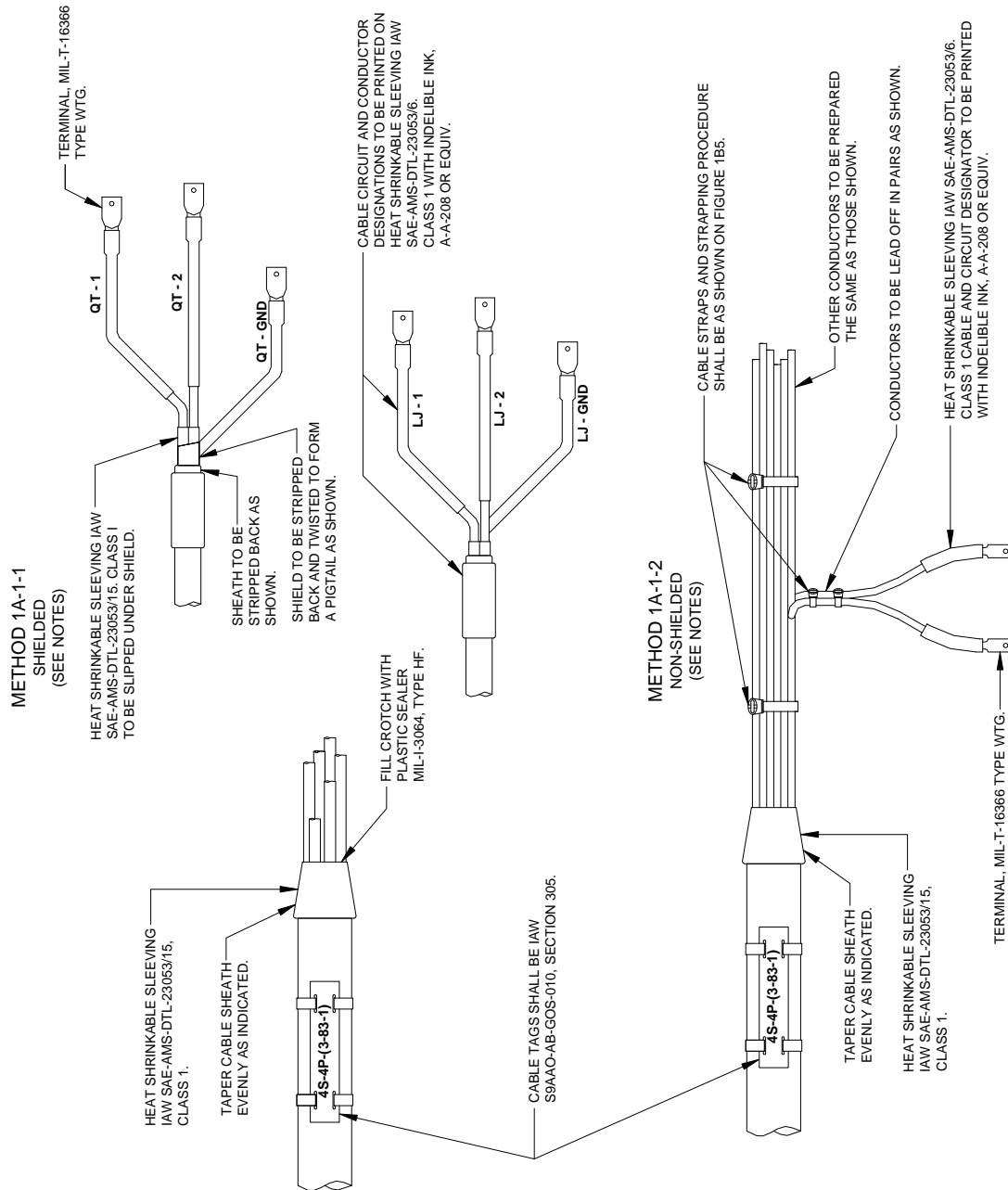
Figure number	Cable preparation and end-sealing	Page
1A1	Cable end preparation for open equipment (This method for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.)	11
1A2	Cable end preparation for open equipment (This method for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.)	12
1A3	Cable end preparation for enclosed equipment (This method for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.)	14
1A4	Cable end preparation for non-watertight equipment (This method for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.)	16
1A5	Attachment of solderless lugs to cables	19
1A6	Cable end-sealing with heat-shrinkable cable crotch boots (This method for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.)	21
1A7	Cable end-sealing with heat-shrinkable tubing	24
1A8	Cable conductor end-sealing (This method for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.)	27

MIL-STD-2003-1A(SH)  
APPENDIX A

TABLE 1A1. Figures for cable preparation and end-sealing - Continued.

<b>Figure number</b>	<b>Cable preparation and end-sealing</b>	<b>Page</b>
1A9	Cable end-sealing with heat-shrinkable tubing and end caps for disconnected, deactivated, and unused cables	29
1A10	Cable end-sealing when exposed to weather	31
1A11	Cable end-sealing when exposed to weather	33
1A12	Cable end-sealing when exposed to weather	35
1A13	Cable end-sealing – disconnected and stored cable	36
1A14	Cable end-sealing for inboard pressure-proof installations on submarines	38
1A15	Cable end-sealing for inboard pressure-proof installations on submarines	40
1A16	End-sealing cables in coils or reels in covered stowage not subject to entrance of water	42
1A17	Grounding of shields of multiple conductor cables	43
1A18	Grounding of shields of multiple conductor cables	46
1A19	End preparation of position indicator type cables	50

MIL-STD-2003-1A(SH)  
APPENDIX A



NOTES:

1. These methods cover protection and finish of cable ends entering open equipment (non-watertight cables without P.P. packing or end seals).
2. This method is for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.

FIGURE 1A1. Cable end preparation for open equipment.

MIL-STD-2003-1A(SH)  
APPENDIX A

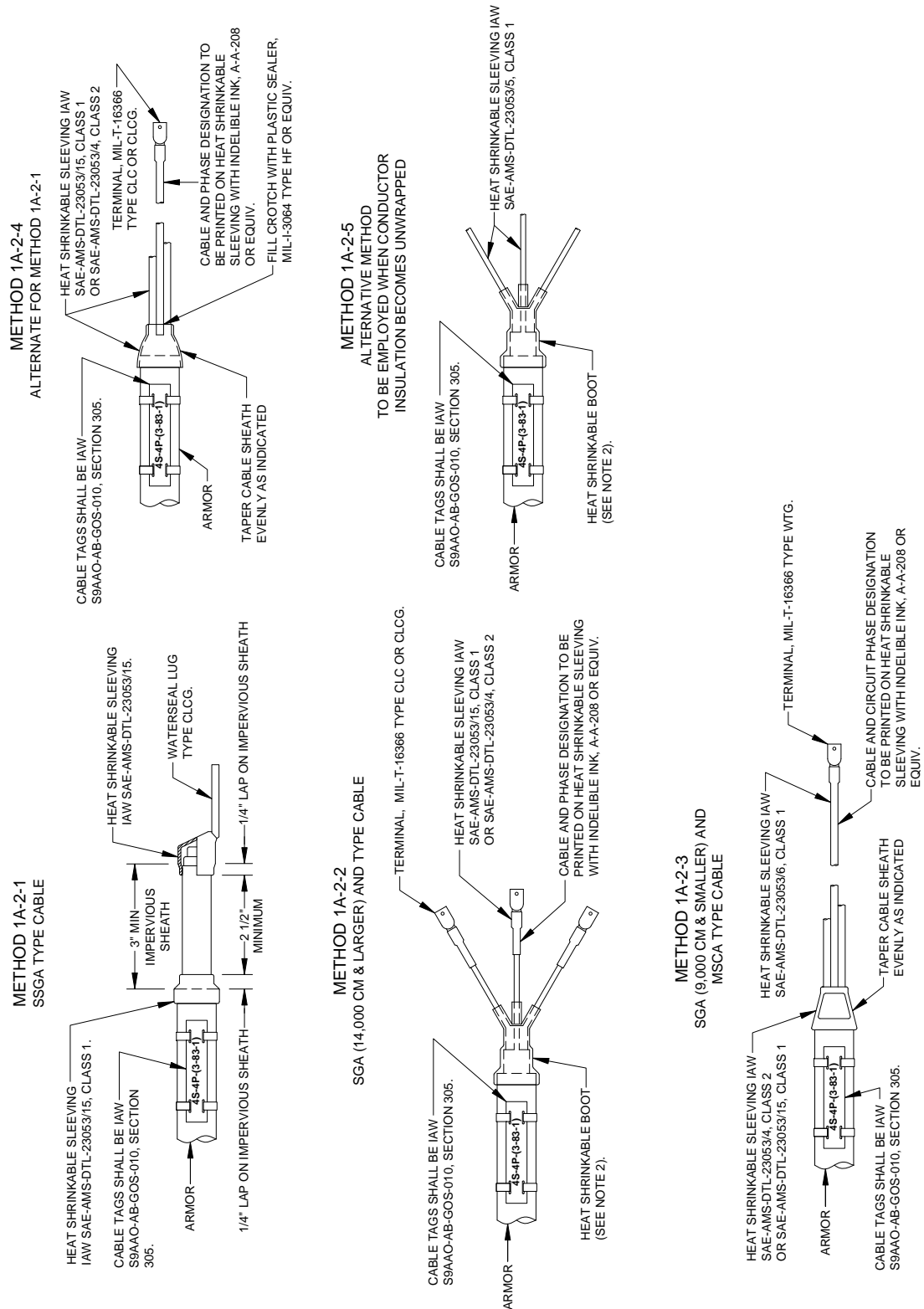
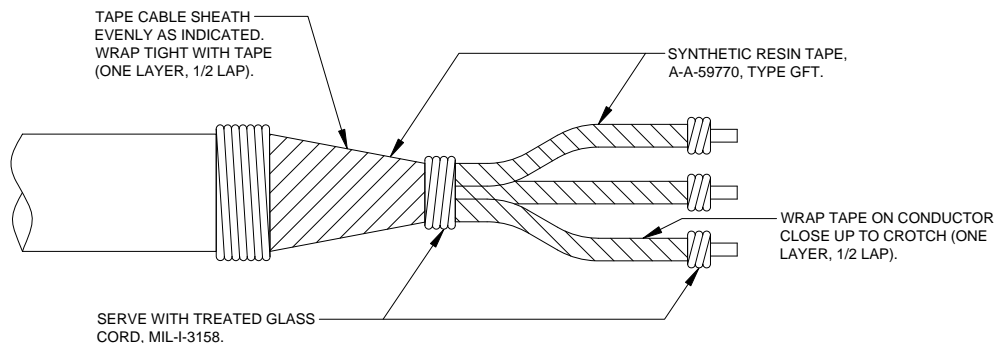


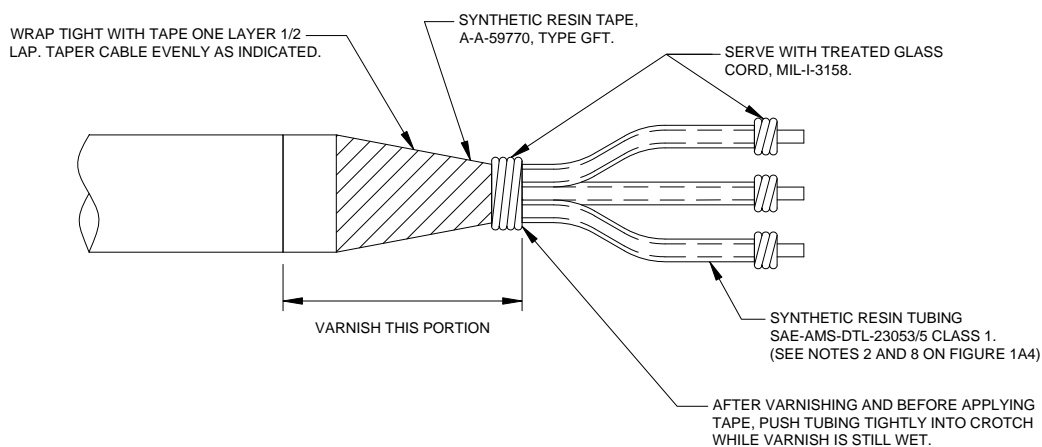
FIGURE 1A2. Cable end preparation for open equipment.

MIL-STD-2003-1A(SH)  
APPENDIX A

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



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

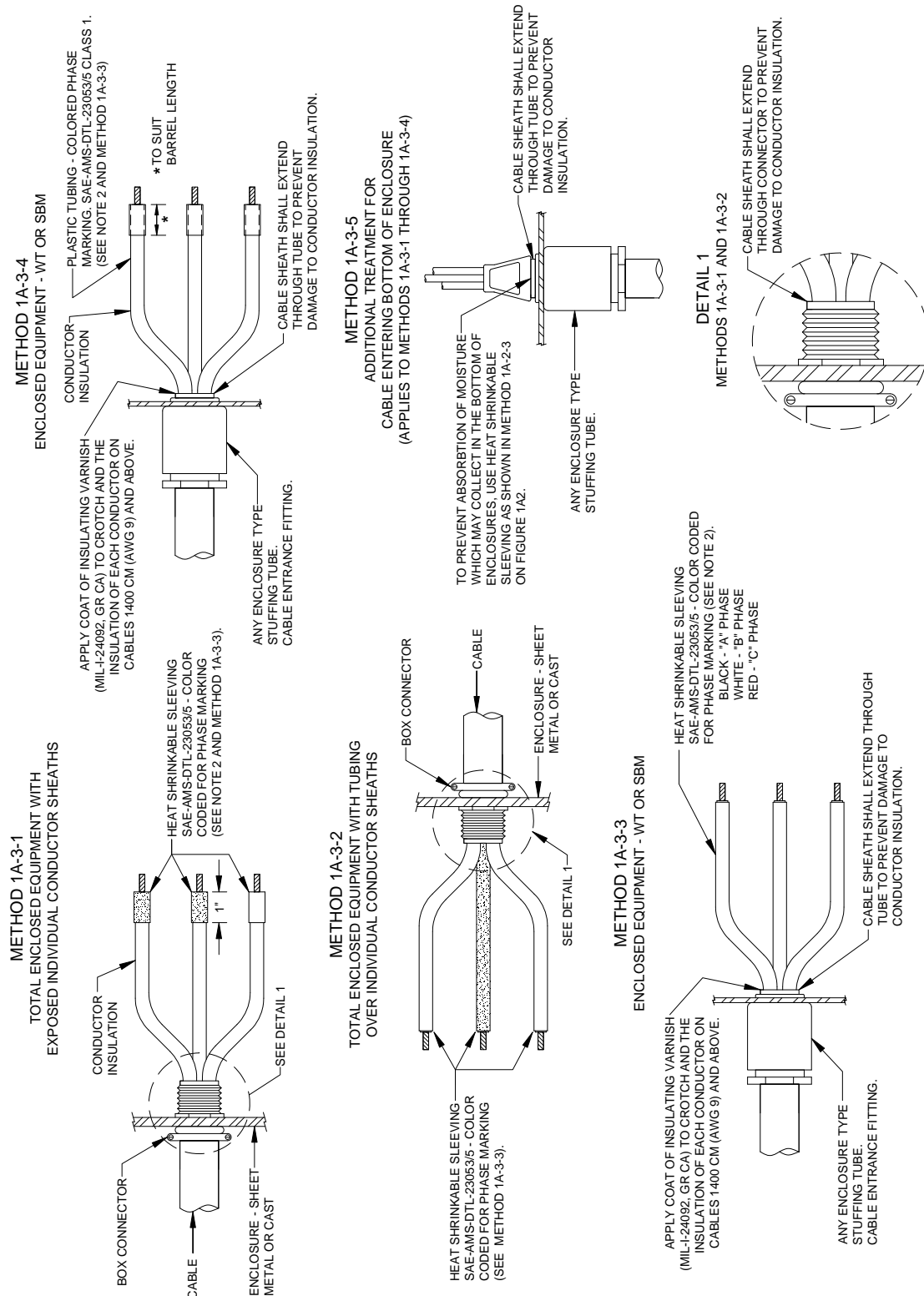


NOTES:

1. These methods cover protection and finish of cable ends entering open equipment (watertight cables without P.P. 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-waterblocked cable has been approved for use by NAVSEA.

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

MIL-STD-2003-1A(SH)  
APPENDIX A



NOTES:

1. These methods cover protection and finish of cable ends entering enclosed equipment.

FIGURE 1A3. Cable end preparation for enclosed equipment.

MIL-STD-2003-1A(SH)  
APPENDIX A

NOTES (continued):

2. Tubing on conductors of single-phase cable need not be colored for phase-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-AMS-DTL-23053/5, Class 1.
6. This method is for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.

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

# MIL-STD-2003-1A(SH) APPENDIX A

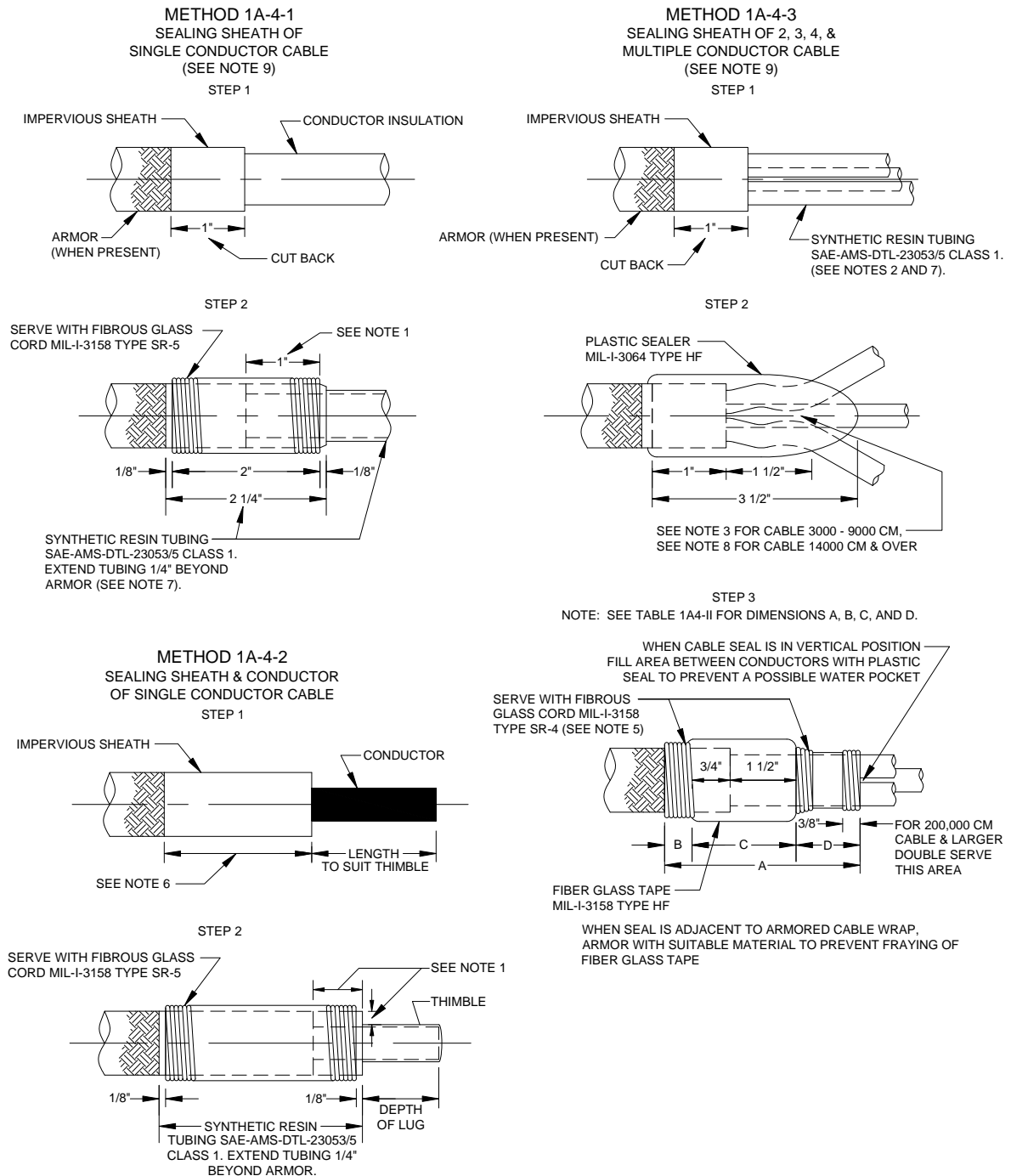


FIGURE 1A4. Cable end preparation for non-watertight equipment.

MIL-STD-2003-1A(SH)  
APPENDIX A

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-AMS-DTL-23053/5 Class 1) for use over		Size of MIL-DTL-24643 cable (AWG) see note below
	MIL-DTL-915 & 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 (1000 cm)	Dimensions (inches)			
	A	B	C	D
3 to 9 M-7 to M-10 TT-1 To TT-25	4 $\frac{1}{4}$	$\frac{3}{4}$	2 $\frac{1}{4}$	1 $\frac{1}{4}$
14 to 100 M-14 to M-44 TT-30 to TT-60	5	$\frac{3}{4}$	2 $\frac{1}{4}$	2
125 to 400	6	$\frac{3}{4}$	2 $\frac{1}{4}$	3

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

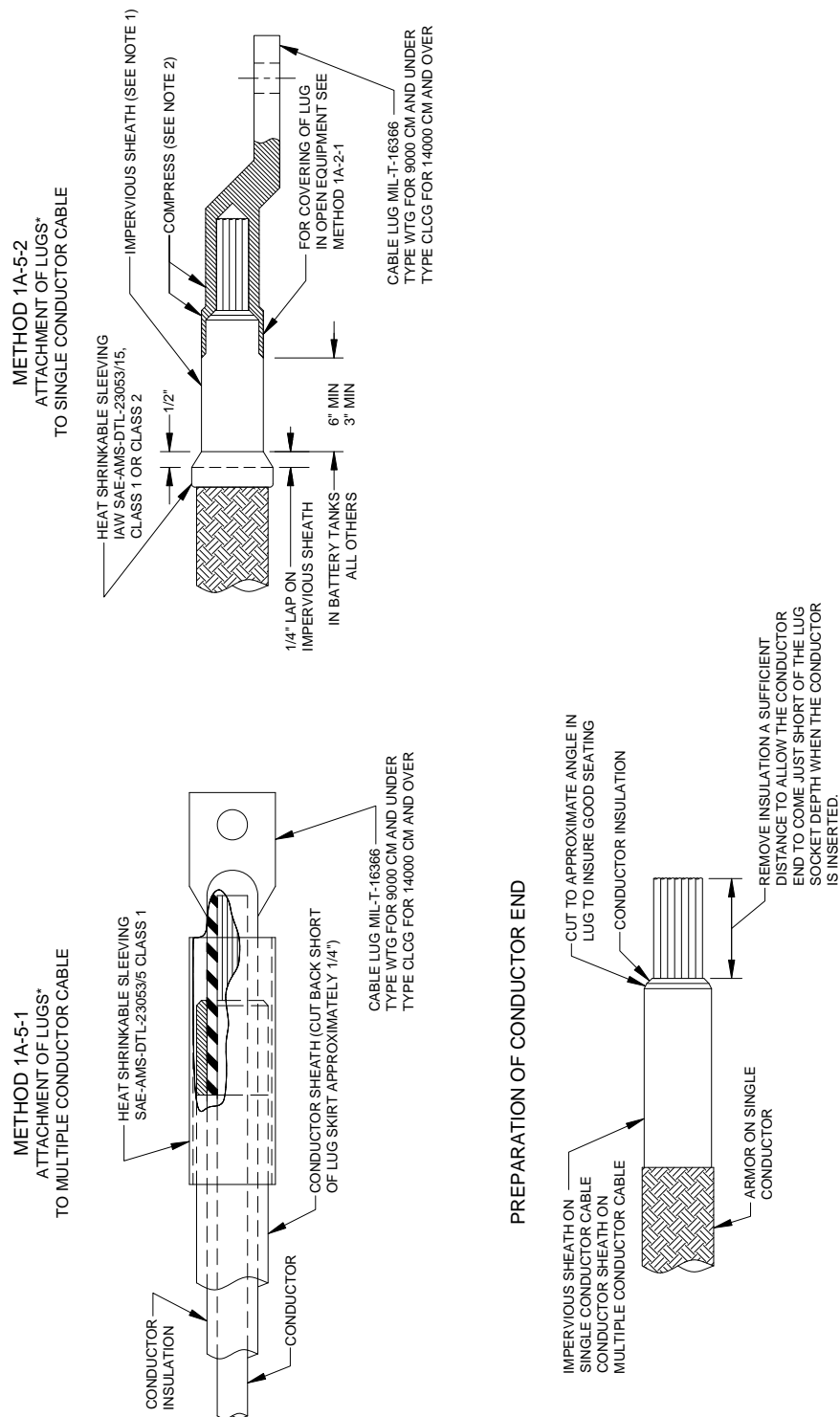
MIL-STD-2003-1A(SH)  
APPENDIX A

PROCESS STEPS AND NOTES:

1. Build diameters indicated to I.D. of synthetic tubing with synthetic resin tape, MIL-I-19166, Scotch #69, or equal, 3/4" wide X 0.010" thick and bonding agent and allow to dry before applying synthetic resin tape.
2. Synthetic resin tubing is not required for multiple conductor cable or 2, 3, & 4 conductor cable, 3,000 through 14,000 cm.
3. Spread conductors just above the crotch & insert a 1/2" diameter ball against which the conductors are to 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 5.
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 & between individual conductors. Pull conductors together, cover with two turns plus 1" overlap of glass tape & serve tightly with fibrous glass cord. Coat with insulating varnish 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 4 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 water blocked cable in accordance with MIL-DTL-24643 or MIL-DTL-24640 is used.
11. This method is for guidance and use only when non-water blocked cable has been approved for use by NAVSEA.

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

MIL-STD-2003-1A(SH)  
APPENDIX A



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.

MIL-STD-2003-1A(SH)  
APPENDIX A

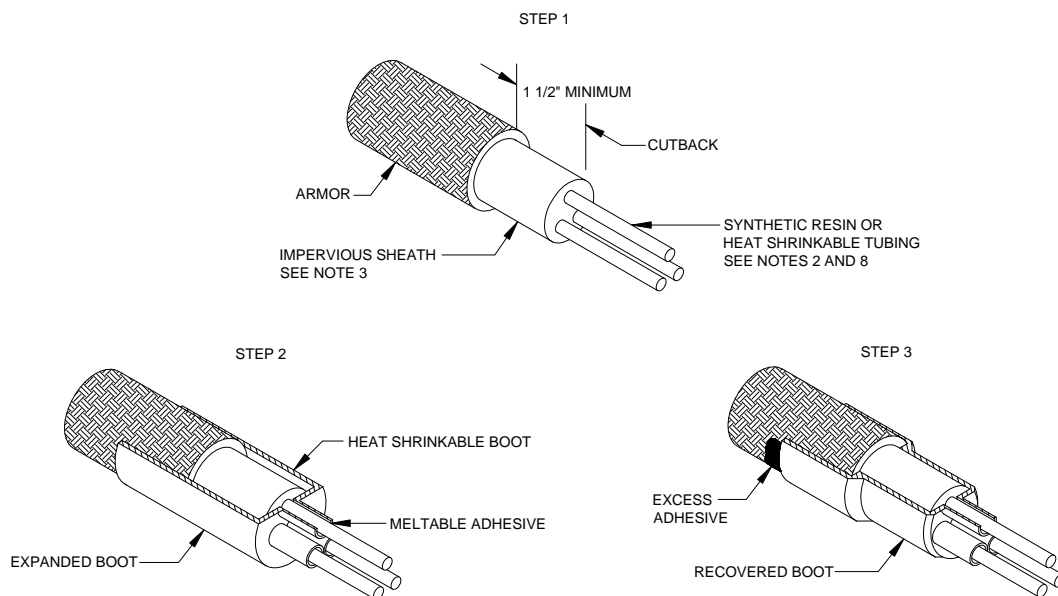
NOTES (continued):

2. The solderless lug shall be crimped to the conductor. When water blocked 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, Type WTG and CLCG, are not required when water blocked cable is installed.

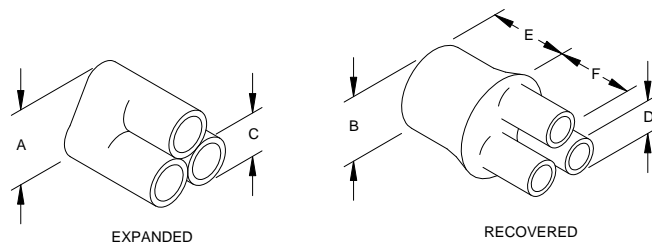
FIGURE 1A5. Attachment of solderless lugs to cables - Continued.

# MIL-STD-2003-1A(SH) APPENDIX A

## METHOD 1A-6-1 SEALING SHEATH OF MULTIPLE CONDUCTOR CABLE



## METHOD 1A-6-2 CABLE CROTCH BOOT (SEE TABLE 1A6-1 AND NOTE 1)



### ADHESIVE REQUIREMENTS ILLUSTRATION

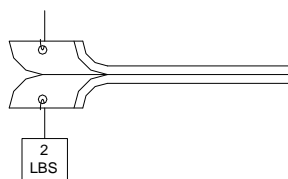

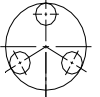
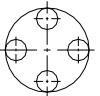
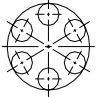


FIGURE 1A6. Cable end-sealing with heat-shrinkable cable crotch boots.

MIL-STD-2003-1A(SH)  
APPENDIX A

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	0.80	0.39	0.33	0.11	2.0	0.7	0.05
		1A62-2	1.20	0.60	0.50	0.17	2.5	1.0	0.07
		1A62-3	1.90	0.90	0.75	0.35	3.0	1.2	0.10
		1A62-4	3.00	1.50	1.45	0.50	3.5	1.5	0.12
 3 Legs	3, 4, 6, 9 14, 23  42, 50, 75, 100 150, 200, 250, 300 400 500, 600	1A62-5	0.90	0.36	0.33	0.12	2.0	0.7	0.08
		1A62-6	1.20	0.50	0.50	0.16	2.3	1.0	0.09
		1A62-7	1.50	0.69	0.65	0.18	1.8	2.2	0.09
		1A62-8	1.70	0.90	0.82	0.35	2.3	1.2	0.12
		1A62-9	2.40	1.40	1.25	0.50	3.5	1.6	0.12
		1A62-10	3.20	2.00	1.40	0.75	3.5	1.6	0.14
		1A62-11	4.90	2.32	2.00	1.00	7.5	2.5	0.12
 4 Legs	3, 4, 6, 9 23 42, 50, 60 75, 100 133, 150, 200	1A62-12	0.90	0.47	0.28	0.11	2.0	0.75	0.05
		1A62-13	1.25	0.80	0.50	0.19	2.3	1.0	0.09
		1A62-14	1.75	0.98	0.79	0.28	2.3	1.2	0.14
		1A62-15	2.35	1.00	1.00	0.35	6.8	1.7	0.14
		1A62-16	2.65	1.40	1.20	0.53	3.5	1.5	0.14
		1A62-17	5.25	3.00	1.35	0.55	6.0	3.0	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 & 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". 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 cm with extruded conductor insulation.

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

MIL-STD-2003-1A(SH)  
APPENDIX A

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 Scott JXL 101 or equal 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" 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" 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.
10. This method is for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.

Tests	Requirement
Adhesion	
To chloroprene	15 minimum
To polyolefin	15 minimum

**Adhesive requirements**

1. Test strips ¾" by 4.5" are to be cut from the boot (see note 1).
2. The strips are bonded together using standard methods.
3. The bonded strips are to 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.

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

# MIL-STD-2003-1A(SH) APPENDIX A

## METHOD 1A-7-1 SEALING SHEATH OF SINGLE CONDUCTOR CABLE

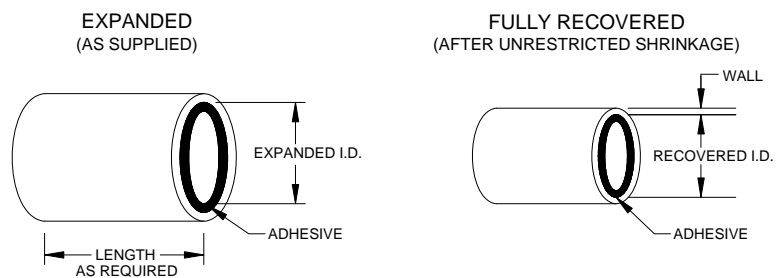
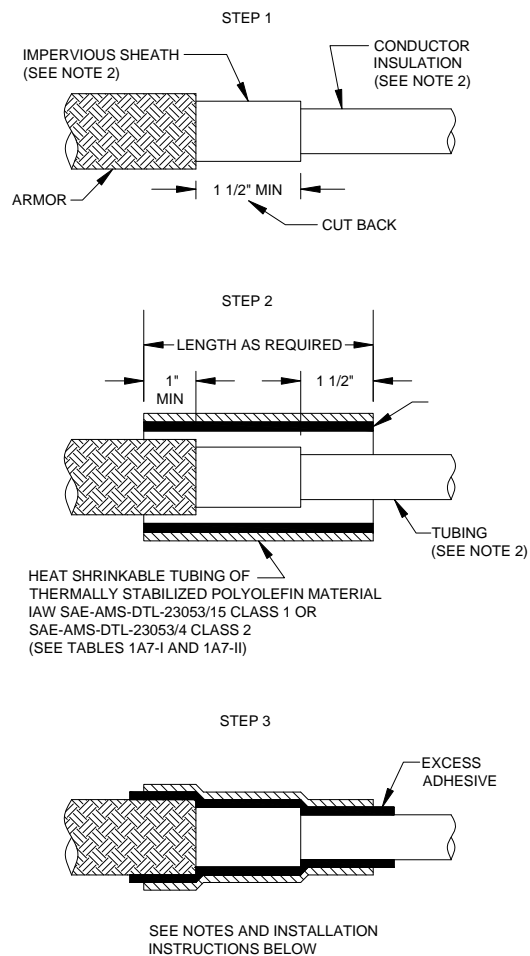


FIGURE 1A7. Cable end-sealing with heat-shrinkable tubing.

MIL-STD-2003-1A(SH)  
APPENDIX A

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.

MIL-STD-2003-1A(SH)  
APPENDIX A

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-AMS-DTL-23053/15, Class 1; SAE-AMS-DTL-23053/4, Class 2; or SAE-AMS-DTL-23053/5, 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**

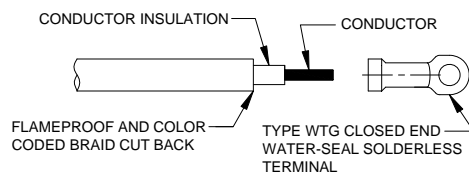
1. Tubing shall conform to SAE-AMS-DTL-23053/15, Class 1, or SAE-AMS-DTL-23053/4, Class 2.
2. Cable armor, when present, shall be cut back a minimum of 1½" to expose impervious sheath. Impervious sheath and conductor insulation shall be thoroughly cleaned of paint and any other foreign matter.
3. Slide 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.

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

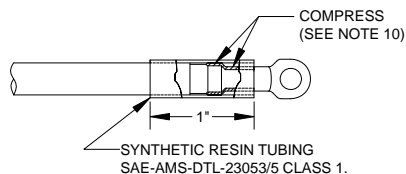
MIL-STD-2003-1A(SH)  
APPENDIX A

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

PREPARATION OF CONDUCTOR

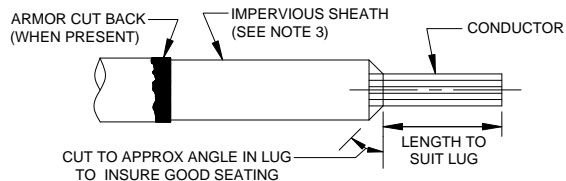


TERMINAL ATTACHED TO CONDUCTOR

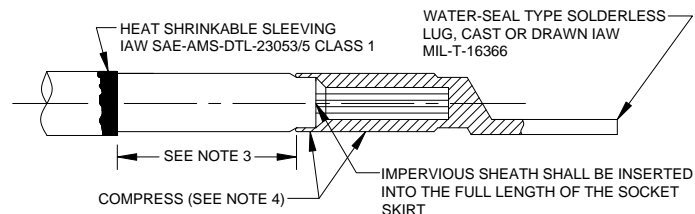


METHOD 1A-8-2  
ATTACHMENT OF WATER-SEAL SOLDERLESS  
LUG TO SINGLE CONDUCTOR CABLE

PREPARATION OF CABLE END



WATER-SEAL LUG ATTACHED TO CABLE



NOTES:

1. Built diameters indicated to I.D. of synthetic tubing for distances indicated with synthetic resin tape, MIL-I-19166, Scotch #69. Paint with bonding agent & 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 & lug after cable is inserted.

FIGURE 1A8. Cable conductor end-sealing.

MIL-STD-2003-1A(SH)  
APPENDIX A

## 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, MIL-I-19166, Scotch #69.
6. The sealing of terminal ends of telephone twisted pair conductors is not required. The crotch of the cable, however, is to 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, & 4 conductor cable 3,000 to 9,000 cm.
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" in diameter, 1" long over cable end. Insert wire into terminal & 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 Co., or equivalent.
10. Thimbles for cable conductors are not permitted. Crimped lugs are required for all power panels and switchboards electrical cable connections.
11. This method is for guidance and use only when non-waterblocked cable has been approved for use by NAVSEA.

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

MIL-STD-2003-1A(SH)  
APPENDIX A

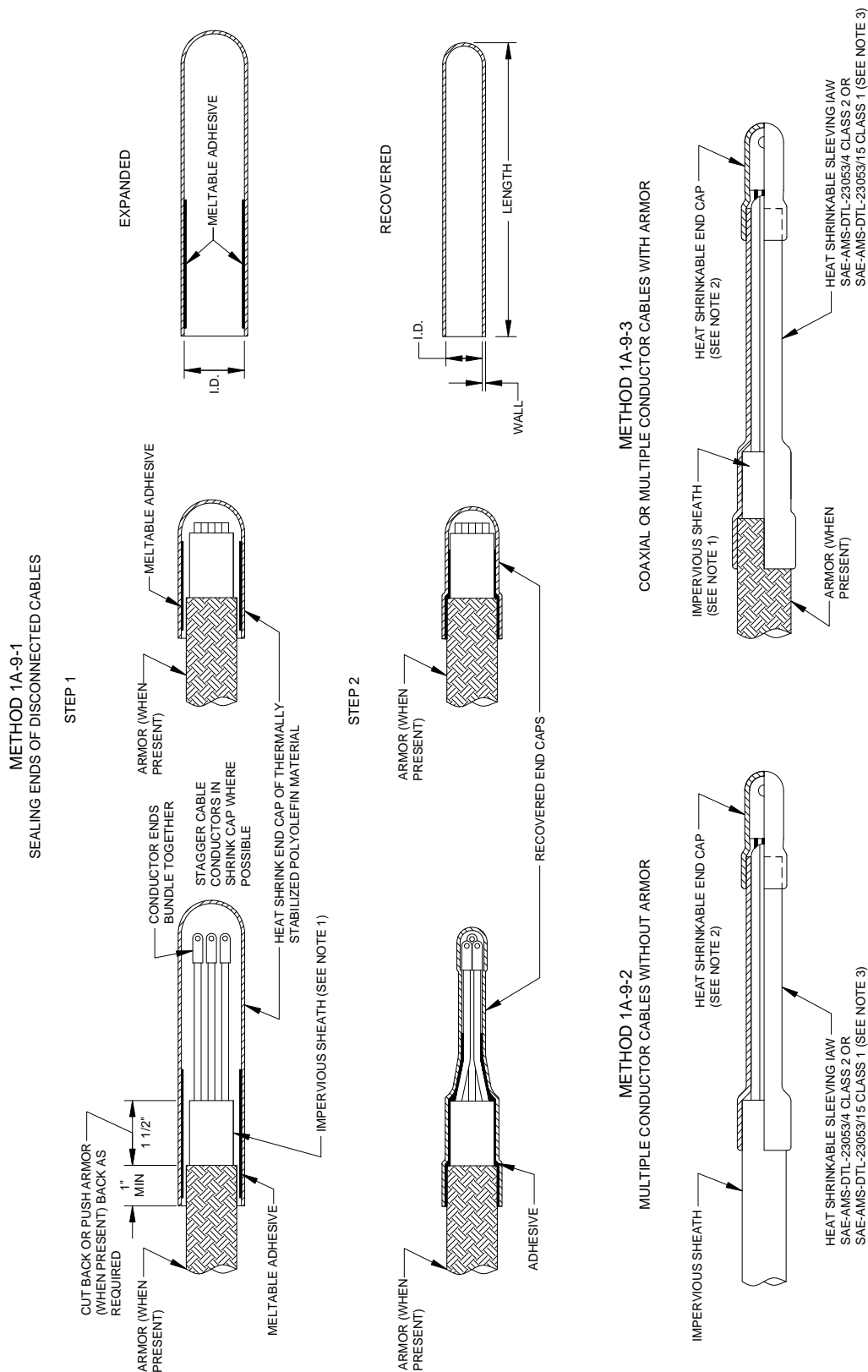


FIGURE 1A9. Cable end-sealing with heat-shrinkable tubing and end caps for disconnected, deactivated, and unused cables.

MIL-STD-2003-1A(SH)  
APPENDIX A

TABLE 1A9-I. End cap dimensions.

Cable size cir mils (MCM)	Part no. suggested	Expanded ID	Length min.	ID max.	Wall nom.
3-40	1A10-1	0.35	1.2	0.18	0.06
	1A10-2	0.81	2.4	0.37	0.08
50-150	1A10-3	1.00	2.7	0.45	0.09
200-500	1A10-4	1.55	3.6	0.71	0.10
650 and Greater	1A10-5	2.00	4.0	0.90	0.11
	1A10-6	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.

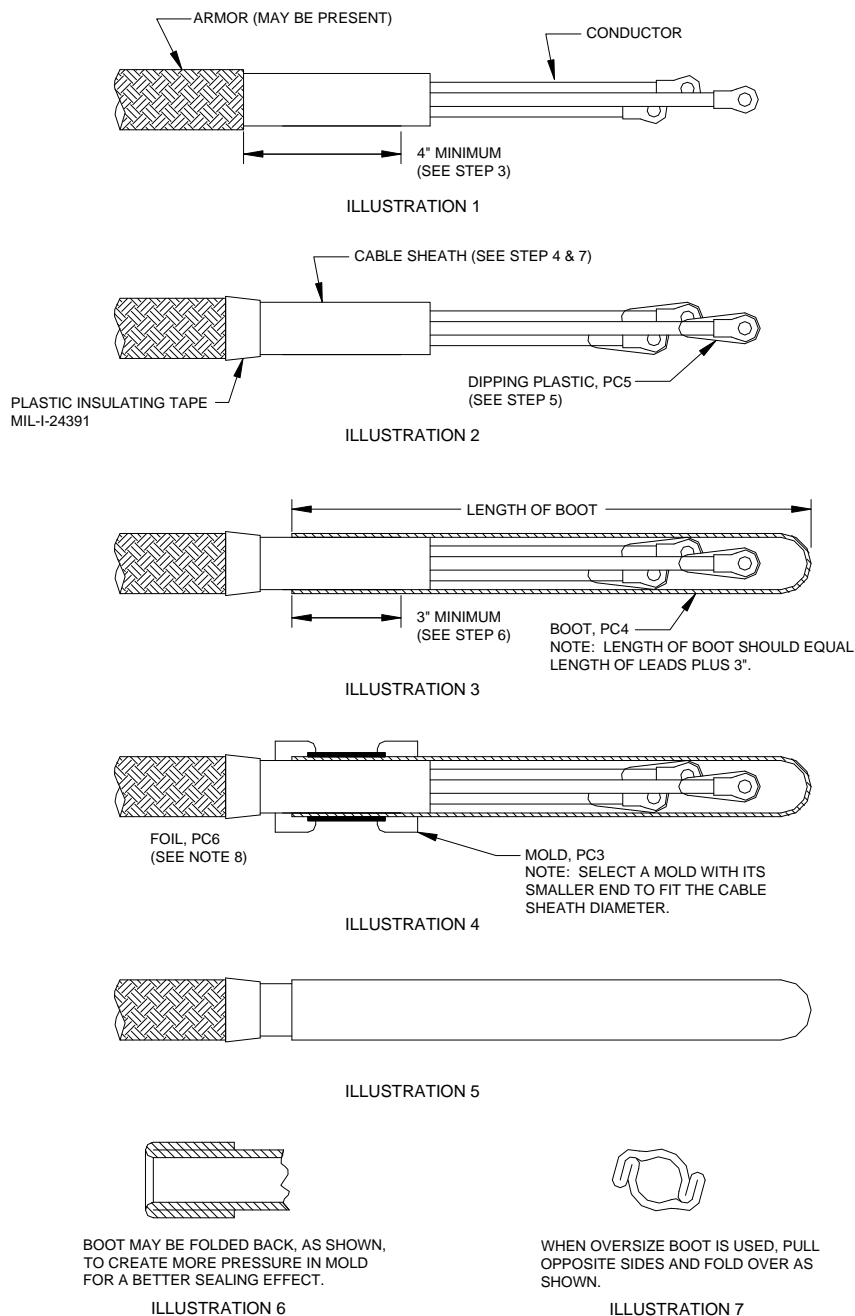
**Notes and installation instructions:**

1. Cable armor (when present) shall be cut back to expose impervious sheath for 1½". 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 insure 1" minimum overlap on armor (when present) as shown in note 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 - Continued.

# MIL-STD-2003-1A(SH) APPENDIX A

## METHOD 1A-10-1



### 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" 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.

MIL-STD-2003-1A(SH)  
APPENDIX A

**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" 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 the 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, it 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 6).

TABLE 1A10-I. List of mold and boot sizes.

Cable dia.	Mold			Boot				
	Dittmore & Freimouth Co. part no. or equivalent			Dittmore & Freimouth Co. part no. 2078-2001 or equivalent				
				12" lng	18" lng	24" lng	30" lng	36" lng
1/4"	2078-2008-2			2-12	2-18	2-24	2-30	2-36
3/8"			3	3-12	3-18	3-24	3-30	3-36
1/2"			4	4-12	4-18	4-24	4-30	4-36
5/8"			5	5-12	5-18	5-24	5-30	5-36
3/4"			6	6-12	6-18	6-24	6-30	6-36
7/8"			7	7-12	7-18	7-24	7-30	7-36
1"			8	8-12	8-18	8-24	8-30	8-36
1 1/8"			9	9-12	9-18	9-24	9-30	9-36
1 1/4"			10	10-12	10-18	10-24	10-30	10-36
1 3/8"			11	11-12	11-18	11-24	11-30	11-36
1 1/2"			12	12-12	12-18	12-24	12-30	12-36
1 5/8"			13	13-12	13-18	13-24	13-30	13-36
1 3/4"			14	14-12	14-18	14-24	14-30	14-36
1 7/8"			15	15-12	15-18	15-24	15-30	15-36
2"			16	16-12	16-18	16-24	16-30	16-36
Example: The part number for a 24" long boot for a cable of 1" diameter is 2078-2001-8-24.								

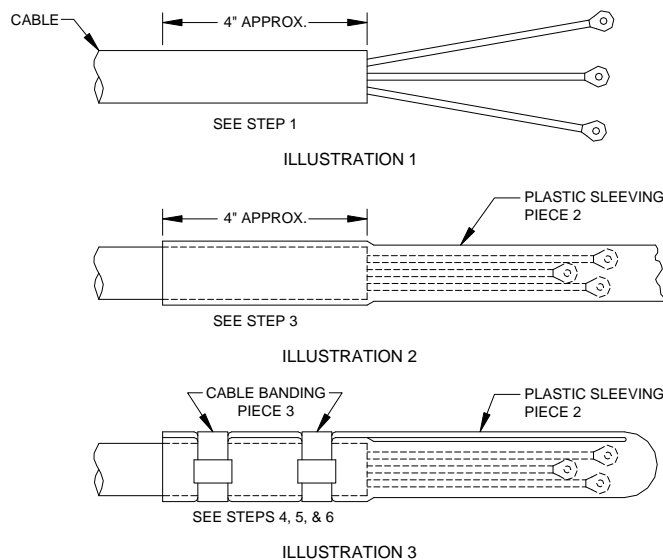
NOTE:

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.

MIL-STD-2003-1A(SH)  
APPENDIX A

METHOD 1A-11-1  
MULTIPLE CONDUCTOR CABLES  
WITH AND WITHOUT ARMOR



**Weather sealing steps for Method 1A-11-1:**

1. Push cable armor, when present, back about 6" (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" back on the cable (see illustration 1.)
2. Place a heat-shrinkable end cap of the proper size from table 1A10-I, over each of the conductor ends and shrink to conform. Heat-shrinkable sleeving in accordance with SAE-AMS-DTL-23053/4 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" 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.

MIL-STD-2003-1A(SH)  
APPENDIX A

METHOD 1A-11-2

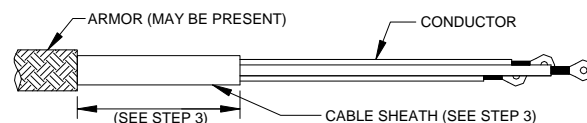


ILLUSTRATION 1

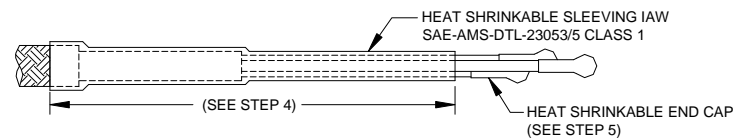


ILLUSTRATION 2

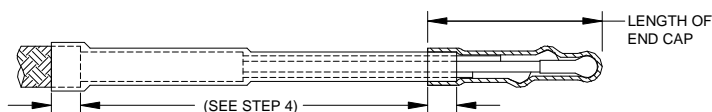


ILLUSTRATION 3

**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" 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" 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 1A10-I over each of the conductor ends, and shrink to conform. Heat-shrinkable sleeving in accordance with SAE-AMS-DTL-23053/4 Class 2 with crimped end may be used as an alternate conductor insulation, available from Raychem.
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-AMS-DTL-23053/5 Class 1.

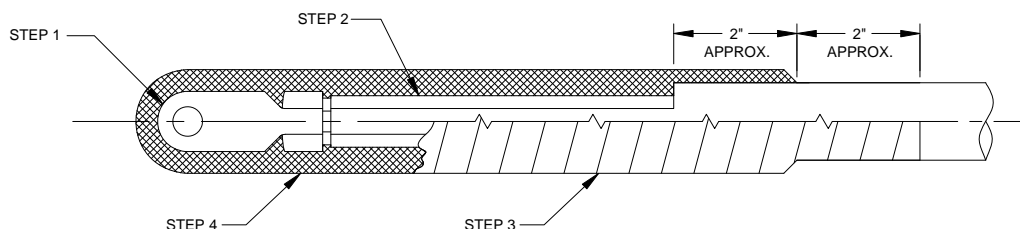
PC 3, Cable banding – CRES. See figure 4C22.

PC 4, Banding buckle – CRES.

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

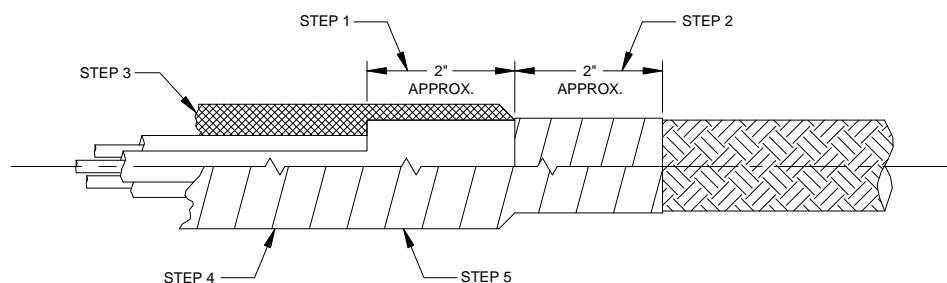
MIL-STD-2003-1A(SH)  
APPENDIX A

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



1. 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" over cable sheath.
3. Apply two servings (min.) half lapped of plastic electrical insulating adhesive tape, 1" wide, MIL-I-24391.
4. Coat entire seal with three coats of Neoprene cement.

METHOD 1A-12-2  
MULTIPLE CONDUCTOR CABLES WITH ARMOR



1. Remove armor a minimum of 2" from the end of jacket.
2. Seize armor end with one serving half lapped of plastic electrical insulating adhesive tape, 1" 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" 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" 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.

MIL-STD-2003-1A(SH)  
APPENDIX A

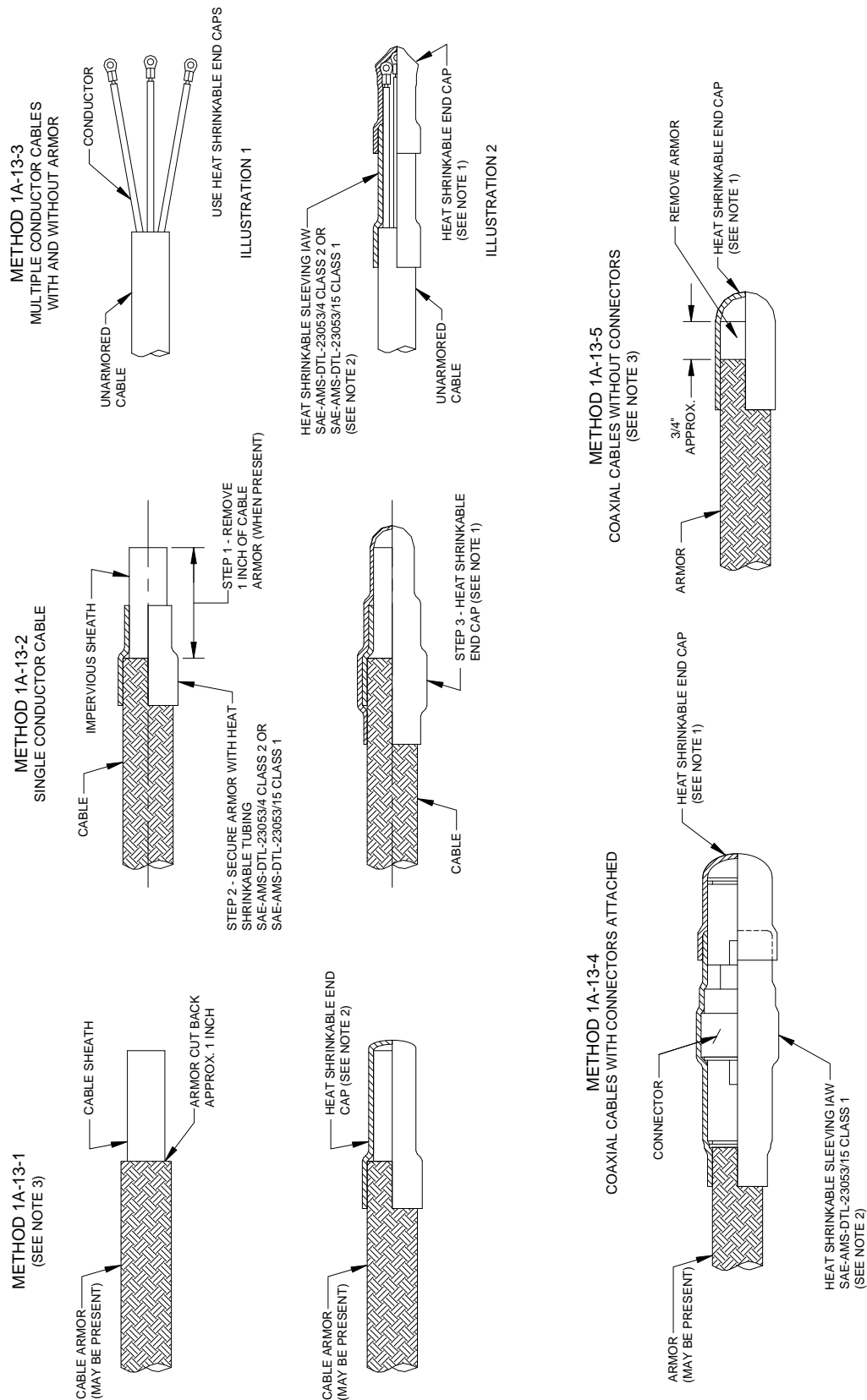


FIGURE 1A13. Cable end-sealing – disconnected and stored cable.

MIL-STD-2003-1A(SH)  
APPENDIX A

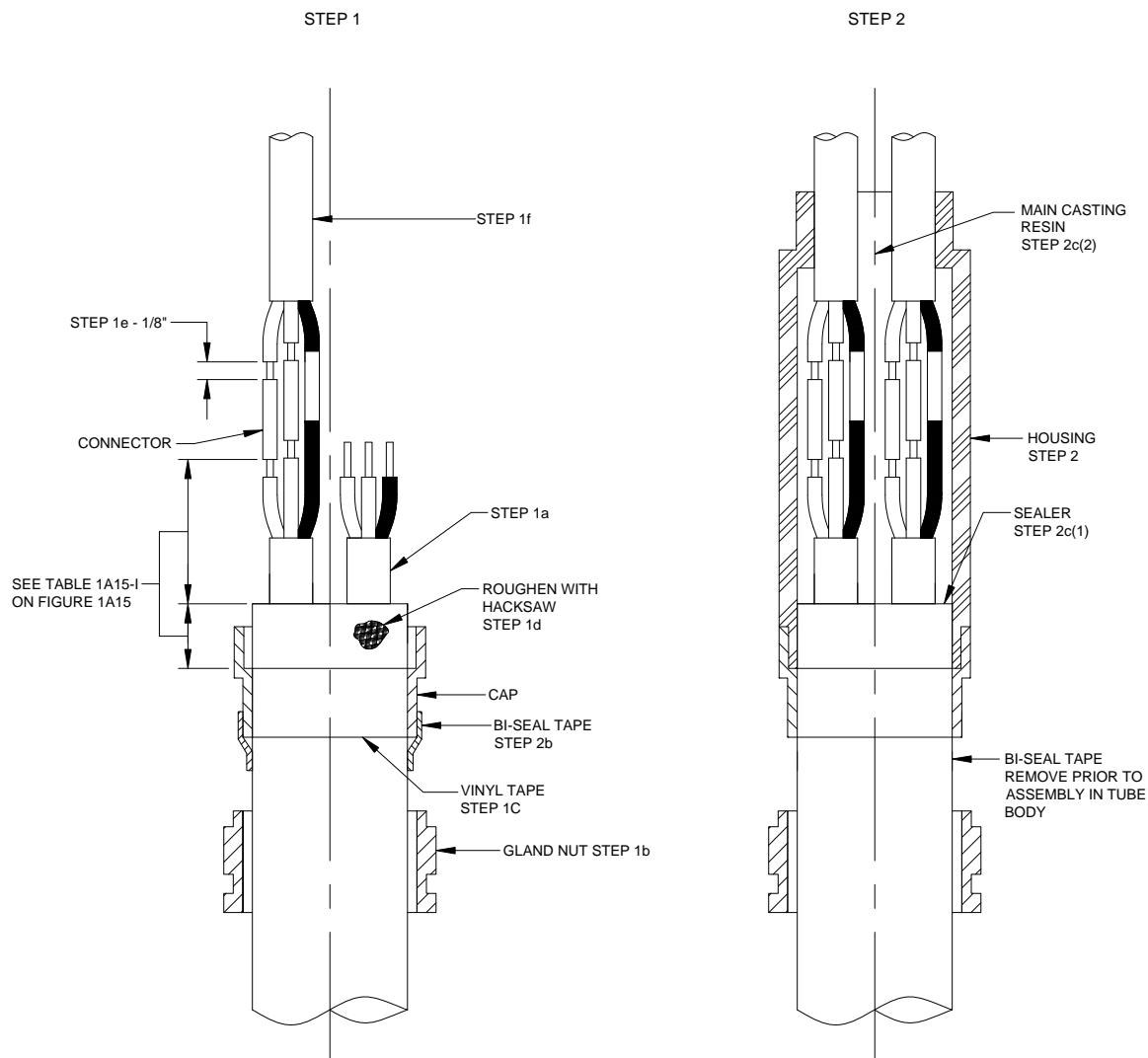
NOTES:

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" 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.

MIL-STD-2003-1A(SH)  
APPENDIX A

METHOD 1A-14-1



**Instructions:**

**Step 1:**

- Prepare cable end by exposing wires and cutting back armor, when present, as indicated.
- Slide gland nut and cap onto the cable.
- Cut back armor (when present) as indicated and secure with tape as required.
- Roughen up exposed area of cable sheath with a hacksaw blade.
- Crimp insulated connectors on the conductors leaving  $\frac{1}{8}$ " of the bare conductor exposed. On shielded conductors, cut and fray the shielding back, twist together and treat as a separate conductor as indicated.
- Crimp extension wires to the connectors in the same manner as indicated above, maintaining proper color coding and/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.

MIL-STD-2003-1A(SH)  
APPENDIX A

**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 #84 x 20 (main casting resin) mixture. 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 eight hours prior to installation in its stuffing tube.

**Mixing instructions:**

1. Materials.
  - a. Epoxy resin #84 x 20 – manufactured by Stanley Chemical Company, East Berlin, Connecticut or equal.
  - b. Activator #90 x 3 (diethylene thiamine) – manufactured by Stanley Chemical Company, East Berlin, Connecticut or equal.
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 #84 x 20 (main casting resin).
  - a. Add 100 parts by weight of epoxy resin #84 x 20 to 10 parts by weight of activator #90 x 3 and stir until thoroughly mixed. Pour this mixture into a clean paper cup (do not scrape the sides of the first cup when transferring the mixture) and allow to stand for 10 minutes. This will allow any air bubbles to rise to the top. Scrape the bubbles from the top and the mixture is ready for use.

**NOTES:**

1. Vinyl electrical tape should be ½" wide, stock number 9G5970-00-419-4290, conforming to MIL-I-24931.
2. Bi-seal self bonding tape, or equivalent, shall be ¾" wide, 10 mils thick as manufactured by Bishop Electric Corporation, 104 Revere Street, Canton, Massachusetts 02021-2911 or equal (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.

MIL-STD-2003-1A(SH)  
APPENDIX A

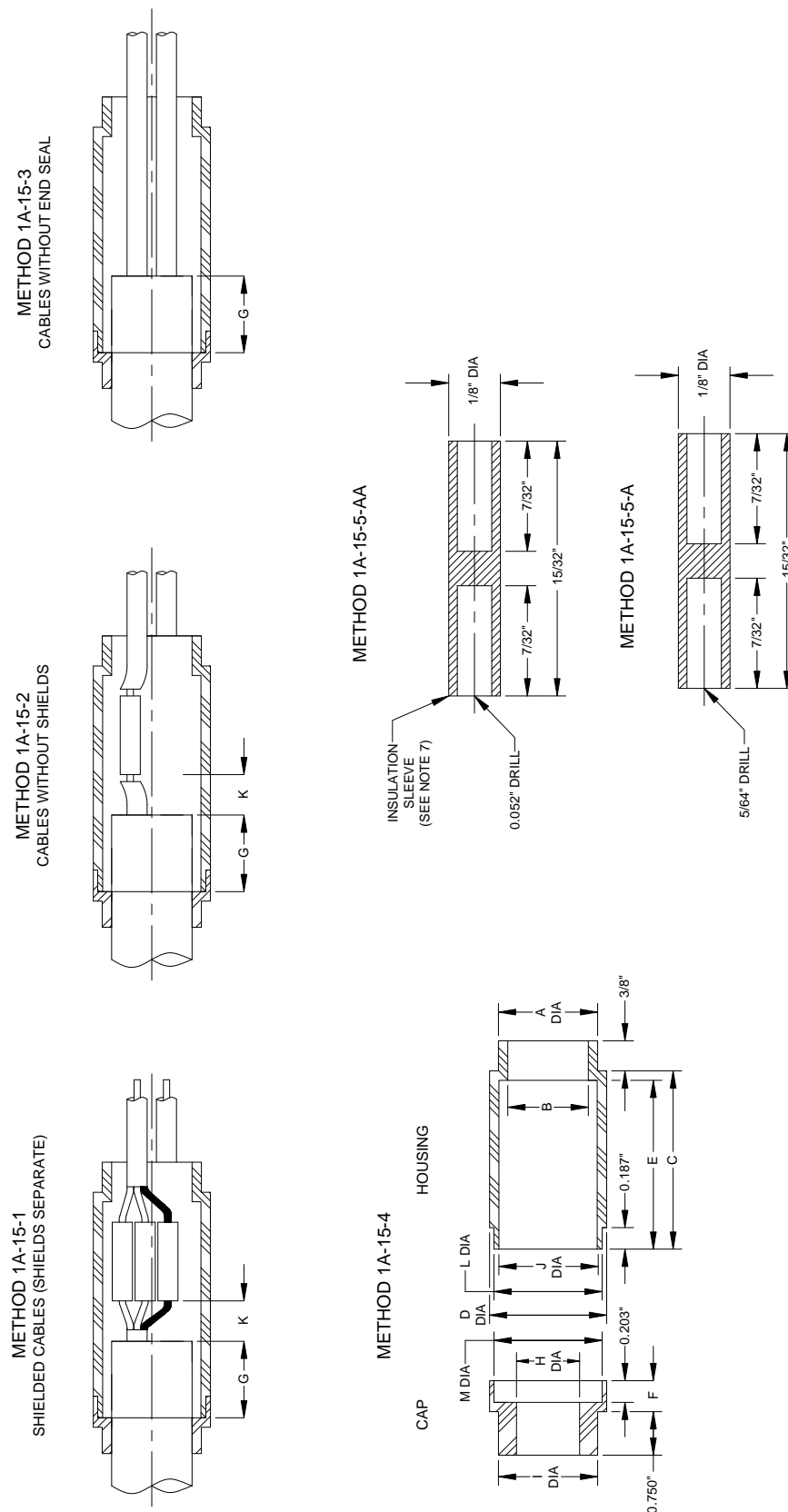


FIGURE 1A15. Cable end-sealing for inboard pressure-proof installations on submarines.

MIL-STD-2003-1A(SH)  
APPENDIX A

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-19-4-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-19-4-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-19-4-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-19-4-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-19-4-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-19-4-F	F	1.545	1.437	2.000	2.015	1.875	0.312	½	1.20	1.710	1.807	⅞	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 figure 3E1) 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-19-4) shall be a low halogen, low smoke, non-pvc, rigid material.
6. Material for connector (PC 1A-19-5) shall conform to MIL-T-16366. Insulation may be loose fitting plastic sleeving SAE-AMS-DTL-23053/5 Class 1. Note: Alternate commercial pre-insulated connectors having a solid center section (water dam) such as Burndy PSM 18-G5, PSM 16-G1, PS 10G, and PS 8CG1 for PCs 1A-9-5AA to C or amp drawing numbers 52575, 52578, 52577 are acceptable.
7. Ream "H" dimensions on cap PC 1A-19-4 to obtain a snug fit on O.D. of cable.
8. Tubes shall be in accordance with MIL-S-24235/7 and /8.

TABLE 1A15-II. Cable assignment.

Tube size	Cable	O.D.	Connector PC no.	Cap and housing assembly
A	LSDSG-3	0.40	1A-19-5A	1A-19-4A
B	LSTTRS-2	0.69	1A-19-5AA	1A-19-4B
B	LSTTRS-4	0.75	1A-19-5AA	1A-19-4B
C	LSTTRS-6	0.89	1A-19-5AA	1A-19-4C
D	LSTTRS-8	1.00	1A-19-5AA	1A-19-4D
E	LSTTRS-10	1.09	1A-19-5AA	1A-19-4E
E	LSTTRS-12	1.11	1A-19-5AA	1A-19-4E
F	LSTTRS-16	1.20	1A-19-5AA	1A-19-4F

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

MIL-STD-2003-1A(SH)  
APPENDIX A

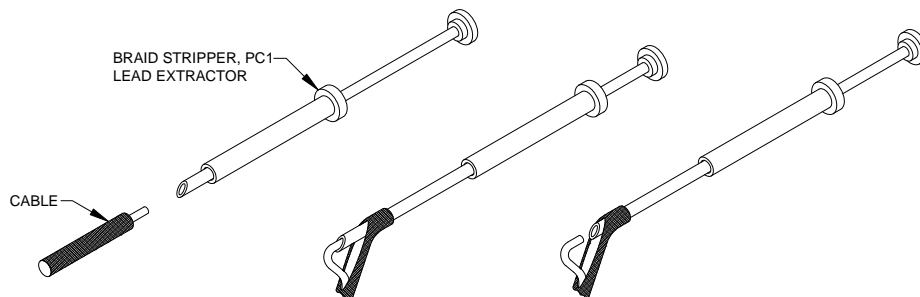
METHOD 1A-16-1

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.

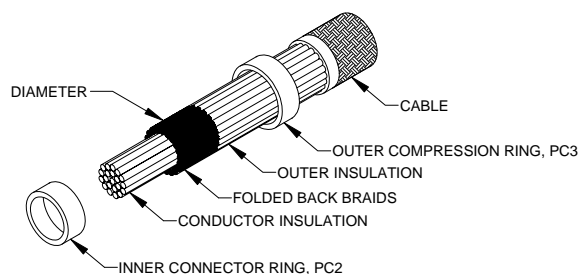
MIL-STD-2003-1A(SH)  
APPENDIX A

METHOD OF SEPARATING THE BRAID FROM  
SHIELDED WIRE CONDUCTORS



- Slide the pointed tube between the cable insulation and the metal braid.
- 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.
- Insert plunger and push core back through the hole in the braid as illustrated.

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



**Step 1 – Preparation of shielded conductors:**

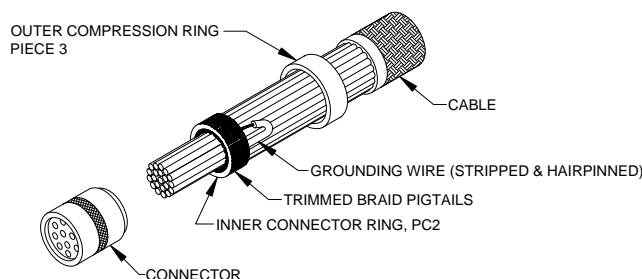
The inner conductor is pushed through the braid and the braid folded back. This may be done with a blunt instrument or with lead extraction tool shown above. Flatten the braid pigtail by hand, and fold back against the cable bundle.

**Step 2 – Selection of ring size:**

The inner collector ring PC 2, outer compression ring PC 3, and the compression die PC 4 sizes are 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.

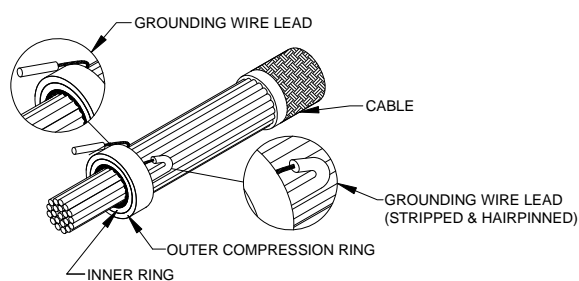
FIGURE 1A17. Grounding of shields of multiple conductor cables.

MIL-STD-2003-1A(SH)  
APPENDIX A



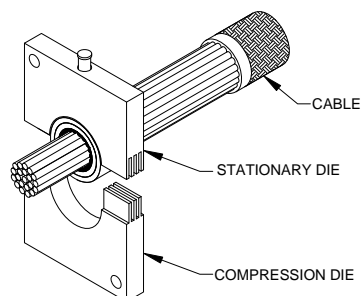
**Step 3 – Assembling of rings:**

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.



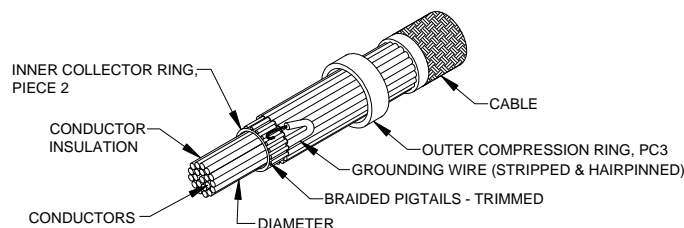
**Step 5 – Compression:**

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.

MIL-STD-2003-1A(SH)  
APPENDIX A

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



**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 nearest to the diameter of the conductor bundle under braid pigtails. Compression ring PC 3 and compression die PC 4 are to 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.

**Material:**

The following material shall be Thomas & Betts Co., Shield-Kon Shielded Cable Connectors, or equivalent:

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.

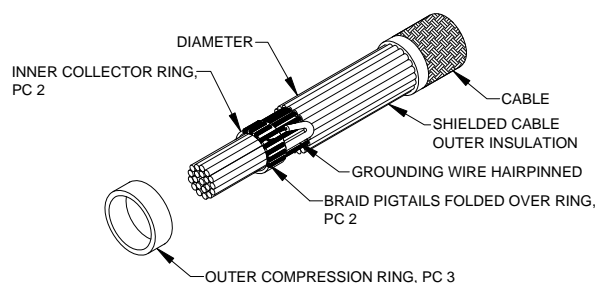
**NOTES:**

1. Tests for grounding ring connectors and figure 1A18 note 1 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.

MIL-STD-2003-1A(SH)  
APPENDIX A

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



**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 nearest to the diameter of the conductor bundle over braids before pigtailing. Compression ring PC 3 and compression die PC 4 are to be selected with matching color code.

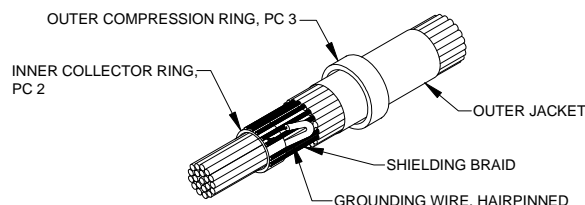
**Step 3 – Assembly of rings:**

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.

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



**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:**

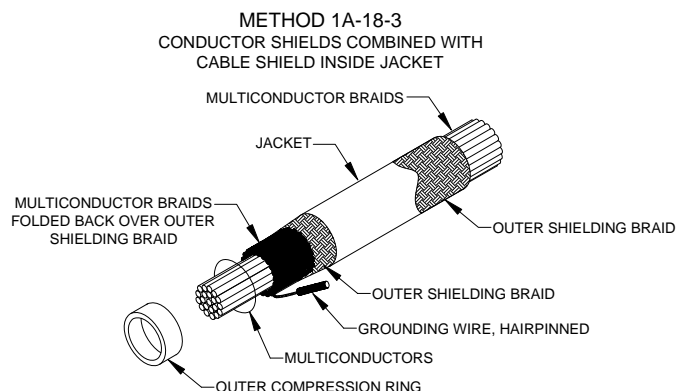
Slide outer ring over braid bundle. Trim braid to approximately 1½" from jacket and fan slightly. Slide inner ring over bundled conductors and under braids. Grounding lead may be inserted between braid and outer ring as outer ring is assembled over braided shield. Carefully locate the outer ring in the 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.

MIL-STD-2003-1A(SH)  
APPENDIX A



### **Method 1A-18-3**

#### **Step 1 – Preparation of shielded conductors:**

Trim braid to approximately 1½" 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:**

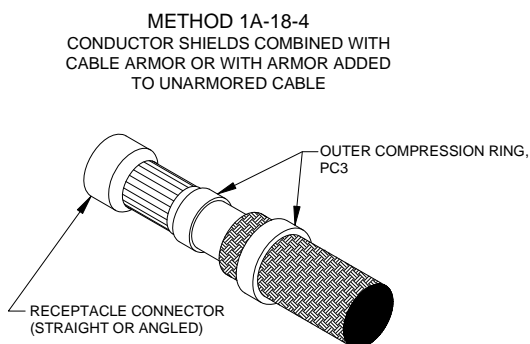
Select the rings in accordance with the double-fold Method 1A-17-1, step 2, figure 1A17.

#### **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.



### **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, 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 must 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.

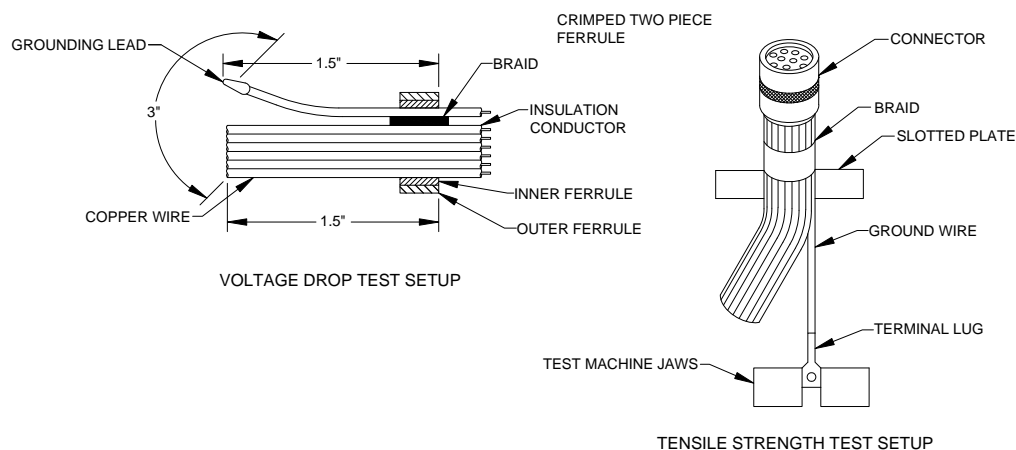
#### **Step 3 – Compression:**

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.

MIL-STD-2003-1A(SH)  
APPENDIX A

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



**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.

MIL-STD-2003-1A(SH)  
APPENDIX A

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		1/8" 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.

# MIL-STD-2003-1A(SH) APPENDIX A

## METHOD 1A-19-1

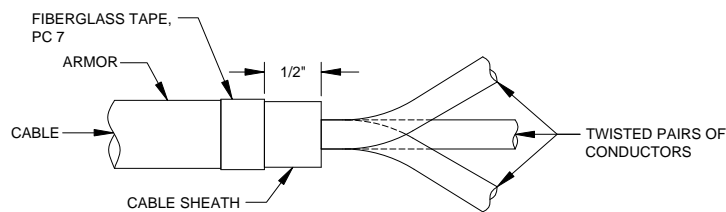


ILLUSTRATION 1  
END PREPARATION OF CABLE SHEATH

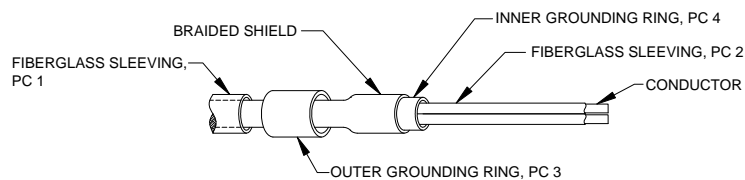


ILLUSTRATION 2  
PREPARATION OF CONDUCTORS

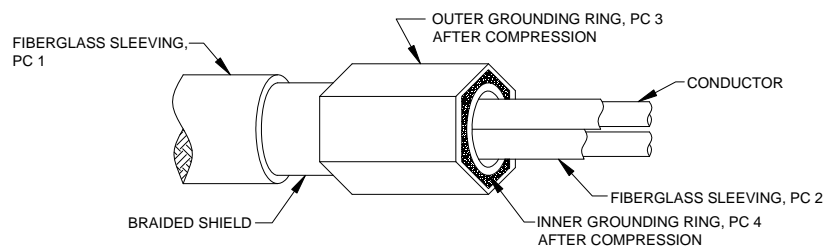


ILLUSTRATION 3  
PREPARING BRAIDED SHIELD TERMINATION  
WHEN GROUNDING IS NOT REQUIRED

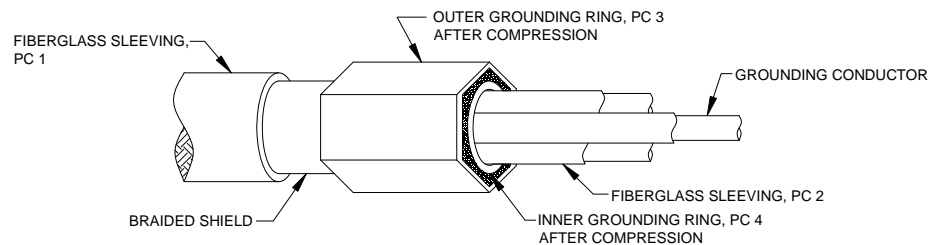


ILLUSTRATION 3A  
PREPARING BRAIDED SHIELD WHEN  
GROUNDING IS REQUIRED

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

MIL-STD-2003-1A(SH)  
APPENDIX A**End preparation of position indicator (PI) type cables****Step 1 (see illustration 1):**

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  $\frac{1}{2}$ " 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 will be determined by distance from butt of cable to  $\frac{1}{2}$ " 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 and Betts Co. tool or equal.

**Alternate Step 3 (see illustration 4):**

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  $\frac{1}{4}$ " 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.

**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 is to 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.

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

# MIL-STD-2003-1A(SH) APPENDIX A

## METHOD 1A-19-1

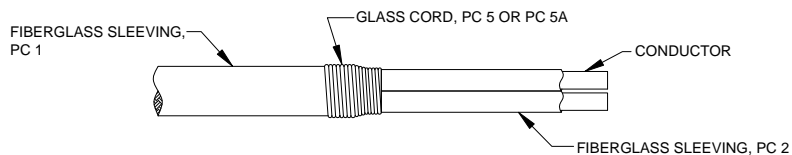


ILLUSTRATION 4  
END PREPARATION OF BRAIDED SHIELD  
(GROUNDING CONDUCTOR NOT SHOWN)

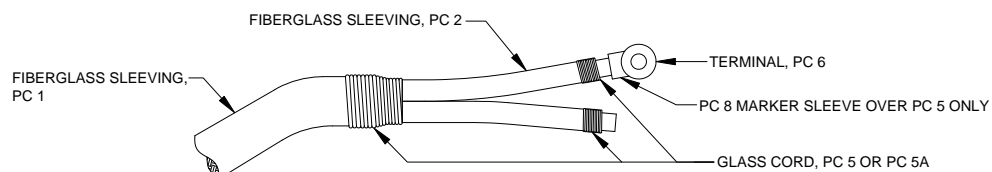


ILLUSTRATION 5  
END PREPARATION OF CONDUCTOR  
(GROUNDING CONDUCTOR NOT SHOWN)

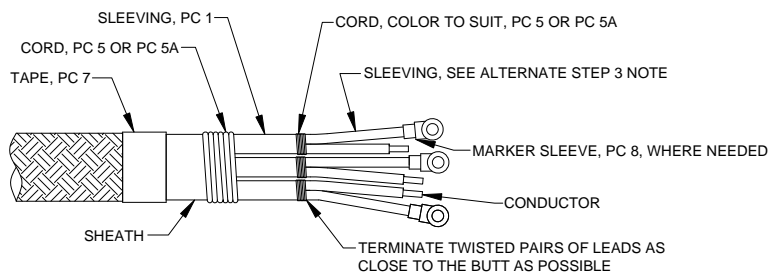


ILLUSTRATION 6  
PREPARING BRAIDED SHIELD TERMINATION  
WHEN GROUNDING IS NOT REQUIRED

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

MIL-STD-2003-1A(SH)  
APPENDIX A

TABLE 1A19-II. List of materials.

PC no.	Description	Matl spec	Matl reqt	NSN or MFG PT no.	Remarks
1	Fiberglass sleeving, single wall, natural color, size 3 (or size to suit)	MIL-I-3190/6	Class 200 Type D, catalog C	Bently 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	Bently 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	Bently Harris Mfg Co. catalog no. 0211001M or equal	Silicone oil impregnated in lieu of silicone rubber coated
3	Outer grounding ring	-	-	Thomas And Betts Co. Style GSC or equal	Pre-insulated type unirings shall not be installed where the temperature may exceed 250 °F
4	Inner grounding ring	-	-	Thomas and Betts Co. 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.

MIL-STD-2003-1A(SH)  
APPENDIX A

**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 equivalent (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 equivalent (approved) high temperature method.

**NOTES:**

1. Synthetic resin tubing SAE-AMS-DTL-23053/5 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.
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/E1A J-STD-006) and Type Sn60-W-R-P3 (IPC/E1A 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 must 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-AMS-DTL-23053/5 Class 1 may be used in lieu of PCs 1, 2, and 8. When using sleeving in accordance with SAE-AMS-DTL-23053/5 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.

MIL-STD-2003-1A(SH)  
APPENDIX B

GROUP 1B - CABLE ENTRY TO EQUIPMENT

B.1 SCOPE

B.1.1 Scope. This appendix describes the procedures and methods for cable entry to equipment.

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.

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-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-M-24519	-	Molding Plastics, Electrical, Thermoplastic
MIL-DTL-24640	-	Cable, Light-Weight, Electric, for Shipboard Use, General Specification for
MIL-DTL-24643	-	Cables and Cords, Electrical, Low Smoke, for Shipboard Use, General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-1310	-	Standard Practice for Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety
MIL-STD-2003-3	-	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Penetrations)

MIL-STD-2003-1A(SH)  
APPENDIX B

- |                |   |   |
|----------------|---|---|
| MIL-STD-2003-4 | - | Electric Plant Installation Standard Methods For Surface Ships and Submarines (Cableways) |
| MS90387        | - | Tool, Hand, Adjustable for Plastic and Metal Tiedown Straps                               |

(Copies of these documents are available online at <http://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

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 D2400  | - | Standard Specification for Varnished Glass-Polyester Cloth Used for Electrical Insulation             |
| 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 F1836M | - | Standard Specification for Stuffing Tubes, Nylon, and Packing Assemblies (Metric)                     |

(Copies of these documents are available from ASTM International, 100 Barr Harbor Dr., P.O. Box C700, West Conshohocken, PA 19428-2959 or online at [www.astm.org](http://www.astm.org).)

SAE INTERNATIONAL

- |                      |   |  |
|----------------------|---|--|
| SAE-AMS-DTL-23053/4  | - | Insulation Sleeving, Electrical, Heat-Shrinkable, Polyolefin, Dual-Wall, Outer Wall Crosslinked                    |
| SAE-AMS-DTL-23053/15 | - | Insulation Sleeving, Electrical, Heat-Shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked |
| SAE-AS23190          | - | Straps, Clamps, and Mounting Hardware, Plastic and Metal for Cable Harness Tying and Support                       |
| 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        |

(Copies of these documents are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or online at [www.sae.org](http://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.

MIL-STD-2003-1A(SH)  
APPENDIX B

### B.3 REQUIRED EQUIPMENT AND MATERIALS

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

### B.4 NOTES AND PROCEDURES

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

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

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

<b>Figure number</b>	<b>Cable entry into equipment enclosures</b>	<b>Page</b>
1B1	Cable entrance to switchboards	58
1B2	Cable entrance to transformers	60
1B3	Cable entrance to non-watertight equipment	61
1B4	Cable entrance to watertight equipment	63
1B5	Strapping and supporting wire bundles in electrical equipment	65
1B6	Lacing and wrapping wire bundles in electrical and electronic equipment	67
1B7	Stuffing tubes installed on equipment exposed to high temperature	69
1B8	Installation of cables on sound isolated motors	70
1B9	Inboard stuffing tubes for submarines	72
1B10	Cable termination for motors and transformers (surface ships and submarines)	73
1B11	Insulating bus terminals and bus bars on submarines	75
1B12	Installation of thermocouple cable entering equipment	77
1B13	Heat-shrink cable entry applicable to watertight and non-watertight enclosures	79
1B14	Cable entrance to non-watertight enclosures – use of drip loop and plastic sealer	82

MIL-STD-2003-1A(SH)  
APPENDIX B

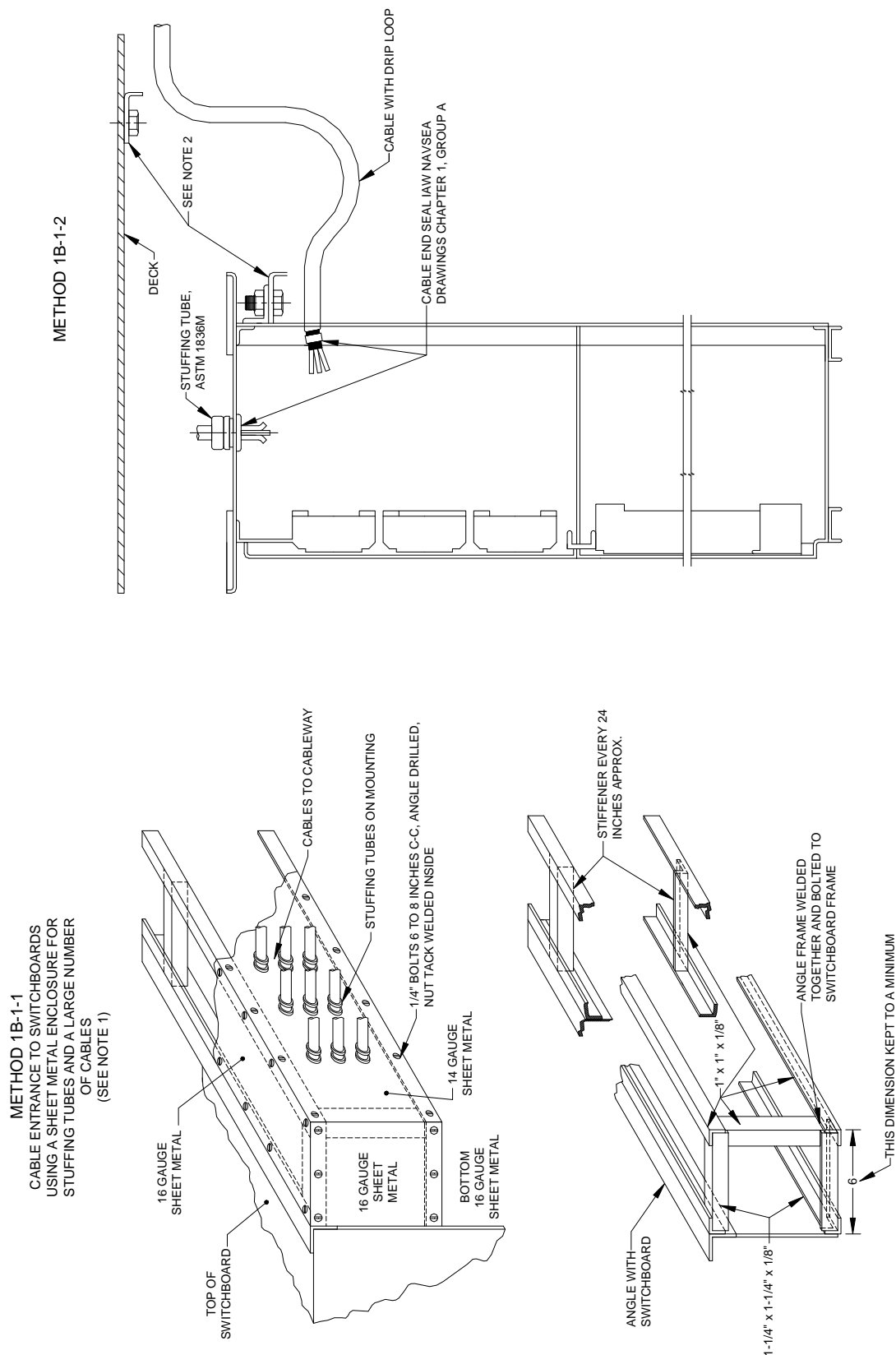
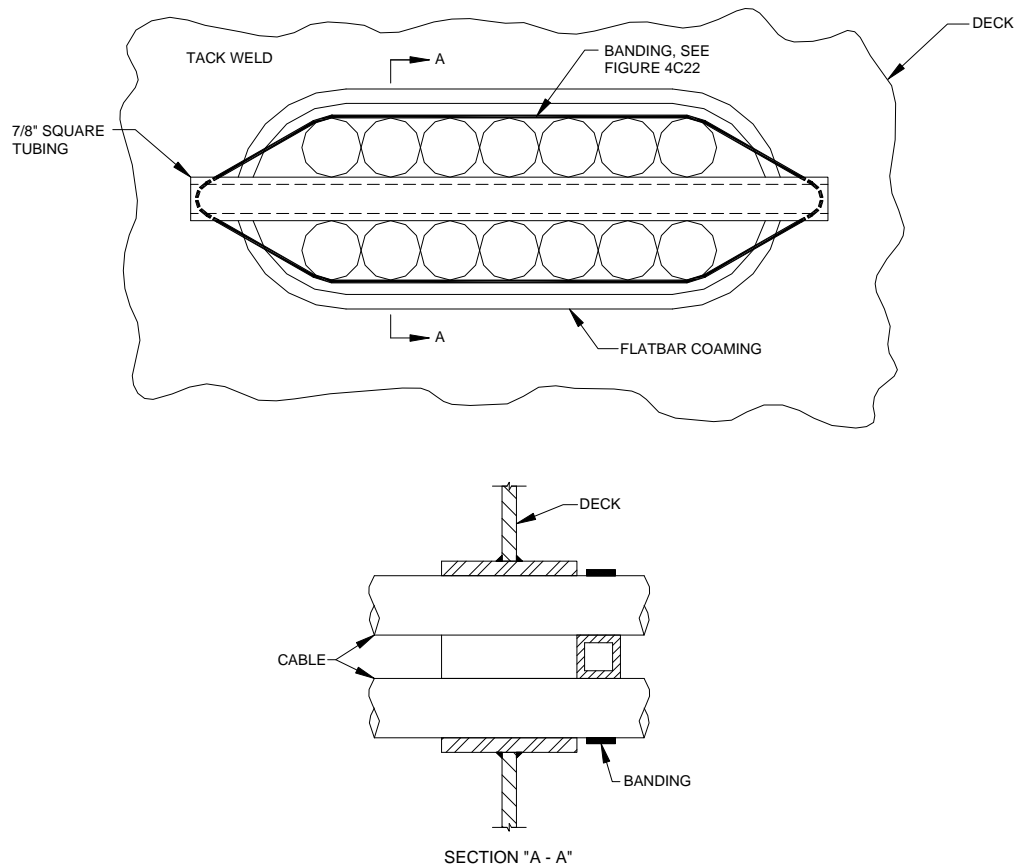


FIGURE 1B1. Cable entrance to switchboards.

MIL-STD-2003-1A(SH)  
APPENDIX B

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



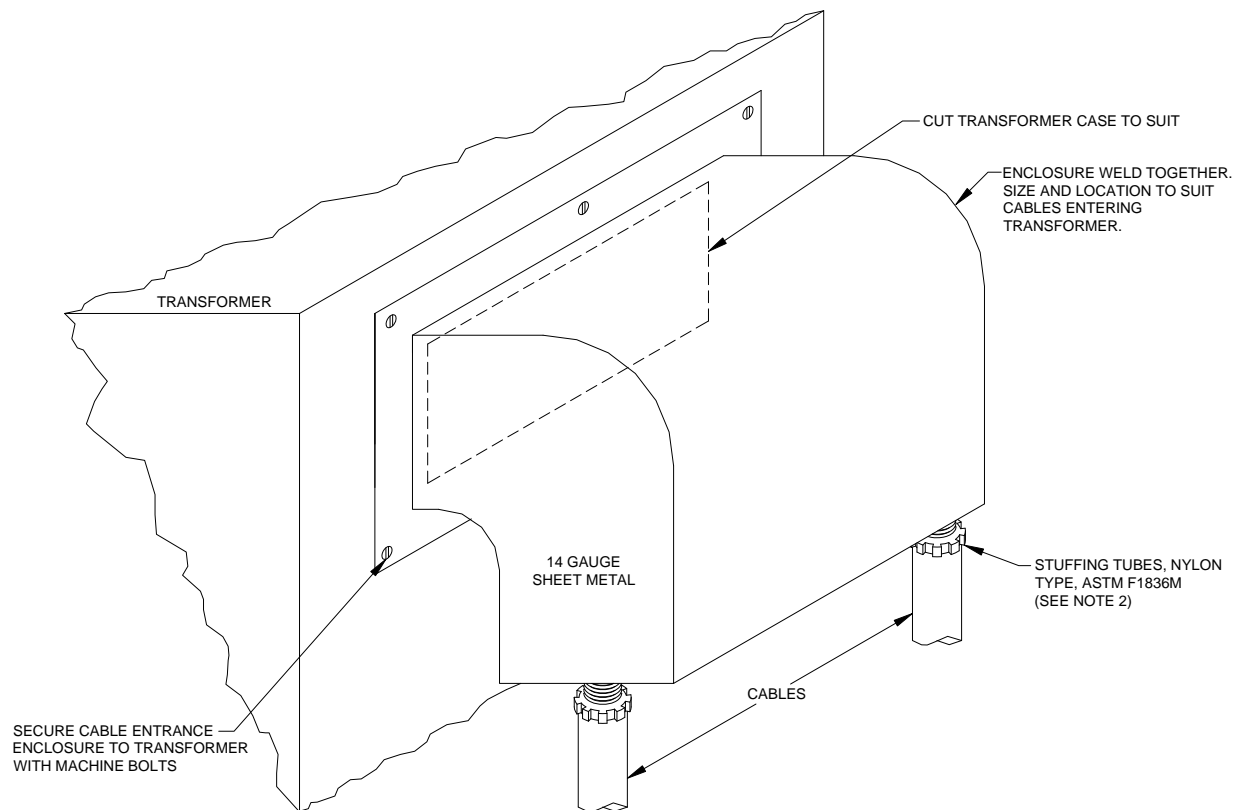
NOTES:

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.

FIGURE 1B1. Cable entrance to switchboards - Continued.

MIL-STD-2003-1A(SH)  
APPENDIX B

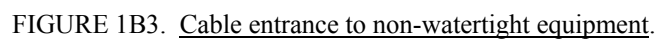
METHOD 1B-2-1  
CABLE ENTRANCE TO TRANSFORMERS  
USING A SHEET METAL ENCLOSURE WITH  
STUFFING TUBES OR CABLE CLAMPS IN LIEU  
OF ANGLE TUBES



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.

FIGURE 1B2. Cable entrance to transformers.



MIL-STD-2003-1A(SH)  
APPENDIX B

TABLE 1B3-I. Connectors for small size cables.

Cable O.D.	$\frac{5}{16}$ to $\frac{1}{32}$	$\frac{1}{2}$ to $\frac{3}{4}$
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.

Cable O.D.	$\frac{3}{4}$ to $\frac{7}{8}$	$\frac{7}{8}$ to $1\frac{1}{16}$	$1\frac{1}{16}$ to $1\frac{3}{8}$	$1\frac{3}{8}$ to $1\frac{1}{2}$
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	1 $\frac{1}{4}$	1 $\frac{1}{2}$	2

NOTES:

1. Straight box connectors shall be equivalent to Type-1 (two 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  $\frac{1}{8}$ " 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) to provide a drip-proof cable entrance. 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  $\frac{1}{2}$ " to  $\frac{3}{4}$ ", short elbow (Gedney # 8-475 or equal) and  $\frac{3}{4}$ " 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 must be taken not to over-torque the connector screws to prevent damage to the conductors.

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

MIL-STD-2003-1A(SH)  
APPENDIX B

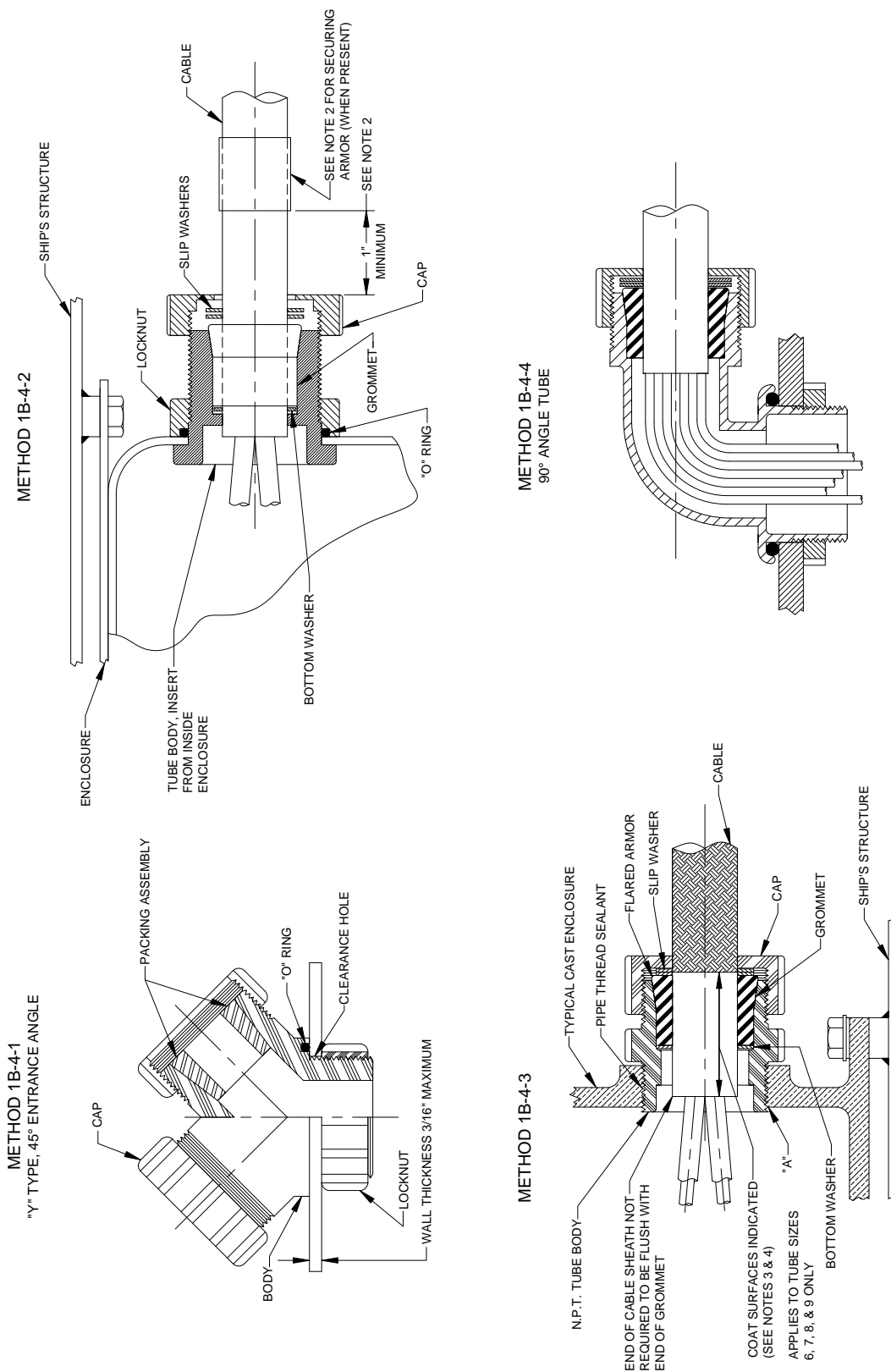


FIGURE 1B4. Cable entrance to watertight equipment.

MIL-STD-2003-1A(SH)  
APPENDIX B

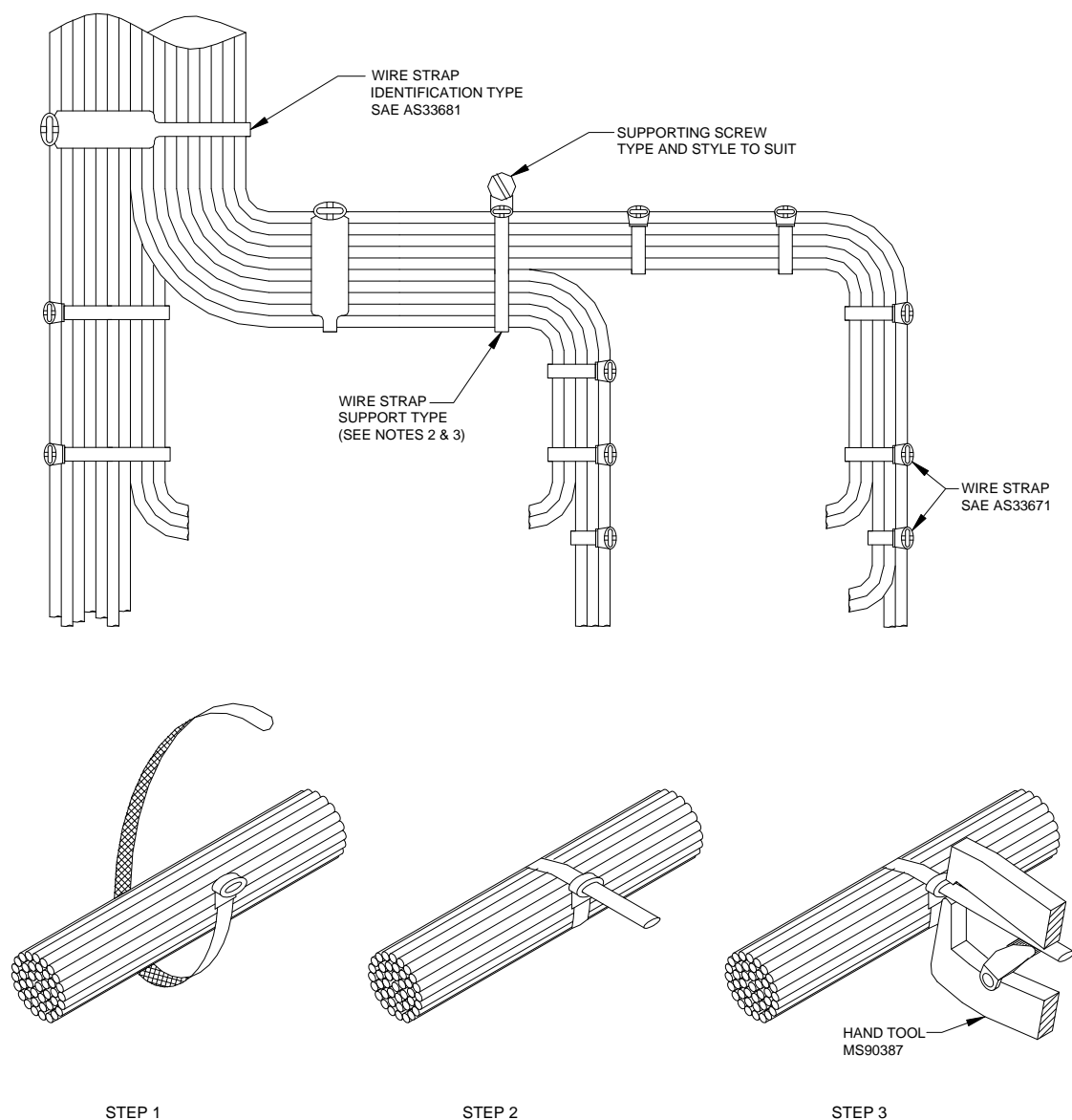
NOTES:

1. See figures 3C1, 3C2, and 3C3 for details on nylon stuffing tubes and installation requirements as well as tube cable assignment.
2. Secure armor (when present) on cable a minimum of 1" from plastic tube face with a shrink fit plastic sleeve. Metal squeeze rings similar to Burndy-Hyring, or equal, may be used.
3. Apply one coat of Gates Engineering Company bonding agent N-29 (accelerated with N-39) or equal 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 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.

MIL-STD-2003-1A(SH)  
APPENDIX B

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.

MIL-STD-2003-1A(SH)  
APPENDIX B

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  $2\frac{1}{2}$  times the diameter of the bundle. Maximum distance between support type straps shall be 10".
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.
6. Plastic cable straps shall not be used in cableways to secure or support cables.

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

MIL-STD-2003-1A(SH)  
APPENDIX B

METHOD 1B-6-1  
LACING PROCEDURE

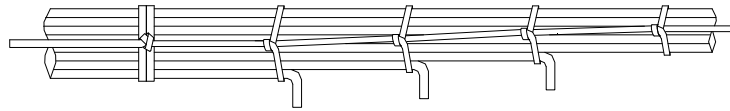


ILLUSTRATION 1

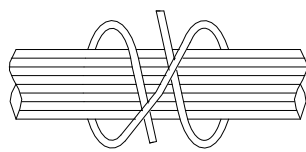


ILLUSTRATION 2

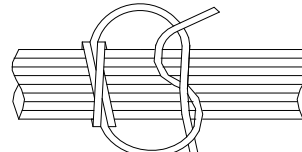


ILLUSTRATION 3

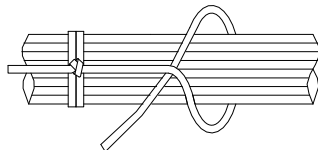


ILLUSTRATION 4

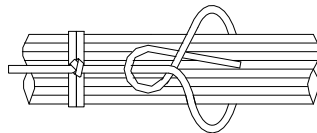


ILLUSTRATION 5

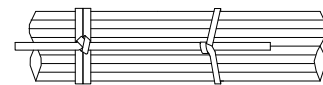


ILLUSTRATION 6

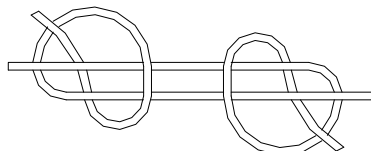


ILLUSTRATION 7

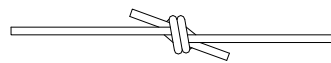
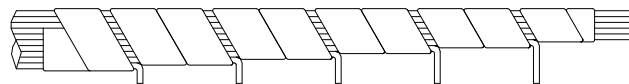


ILLUSTRATION 8

METHOD 1B-6-2  
WRAPPING 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.

MIL-STD-2003-1A(SH)  
APPENDIX B

**Lacing procedure (continued):**

3. The spacing between lockstitches on wire bundle sections  $\frac{5}{8}$ " or smaller in diameter shall be  $\frac{1}{2}$ " to  $\frac{3}{4}$ ". On wire bundle sections larger than  $\frac{5}{8}$ " in diameter, the spacing shall be  $\frac{1}{2}$ " to 1". In addition, on sections larger than  $\frac{5}{8}$ " 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 two-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" of wrapping. Then wrap straightened portion around the bundle of conductors. Straighten another 2-4" 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.

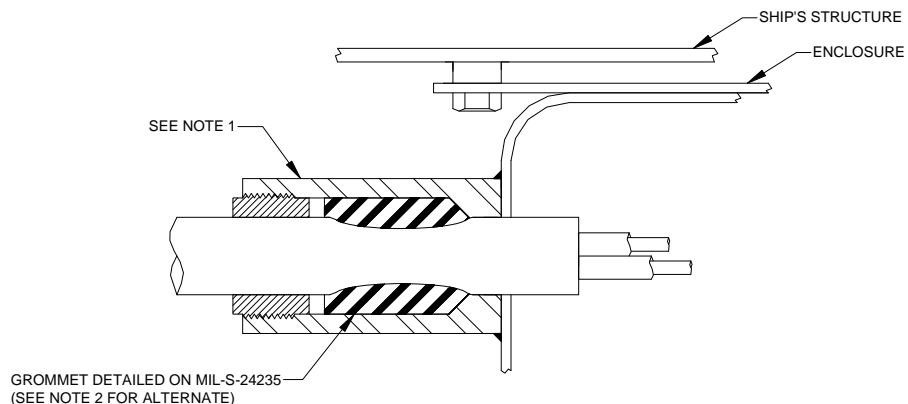
**NOTES:**

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 such as nylon "amp-spirap" or equal. 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 a Neoprene cement (commercial) to the ends of the cord or tape.

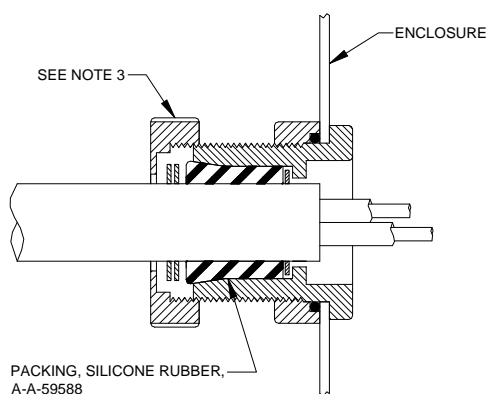
FIGURE 1B6. Lacing and wrapping wire bundles in electrical and electronic equipment - Continued.

MIL-STD-2003-1A(SH)  
APPENDIX B

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:
  - a. Half of the double gland stuffing tube, shown on figure 3A10.
  - b. Tube body, shown on figure 3A14.
  - c. Stuffing tube, shown on figure 3B7.
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.

MIL-STD-2003-1A(SH)  
APPENDIX B

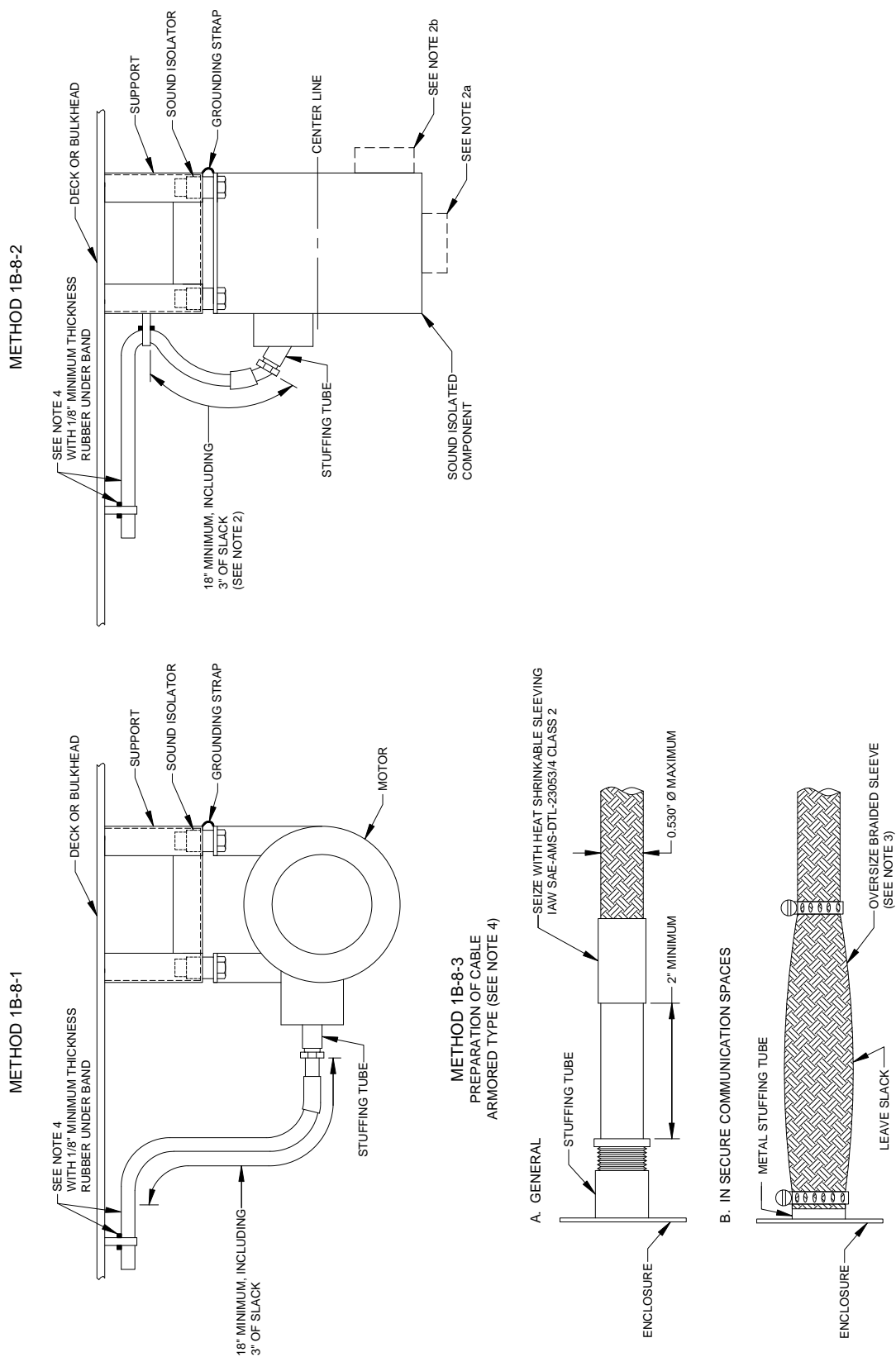


FIGURE 1B8. Installation of cables on sound isolated motors.

MIL-STD-2003-1A(SH)  
APPENDIX B

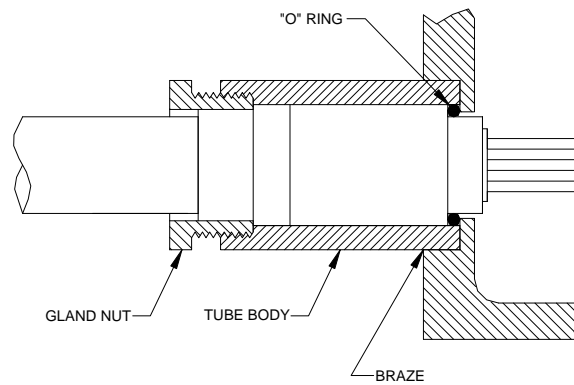
NOTES:

1. Position cable loop so that it will not touch structures or adjacent equipment.
2. Amount of slack (greater than 3" min.) 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 NAVSHIPS 0900-004-7001 (Ships Noise Control), stripping of armor is applicable only to cables of 0.530 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.

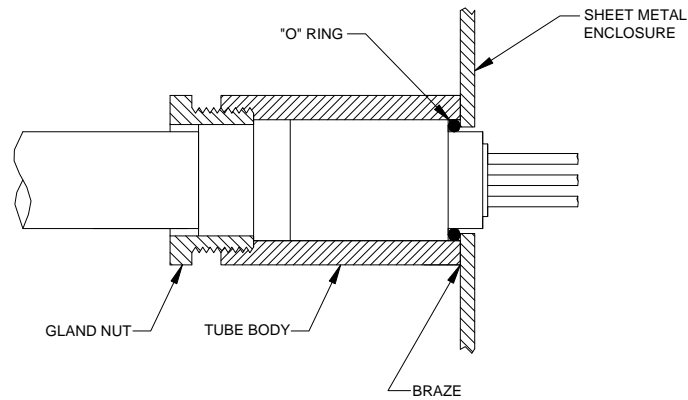
FIGURE 1B8. Installation of cables on sound isolated motors - Continued.

MIL-STD-2003-1A(SH)  
APPENDIX B

METHOD 1B-9-1



METHOD 1B-9-2



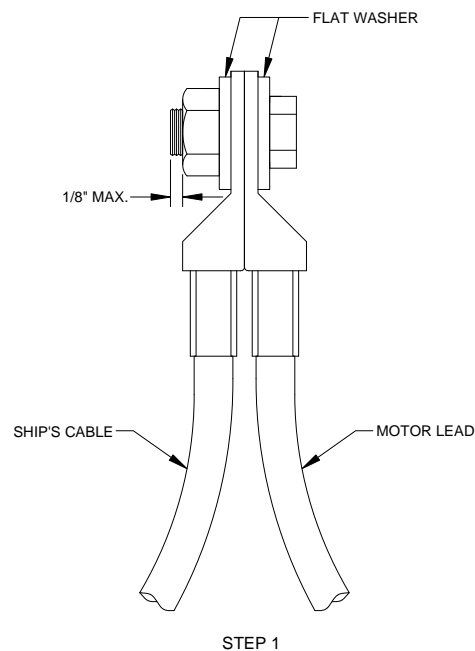
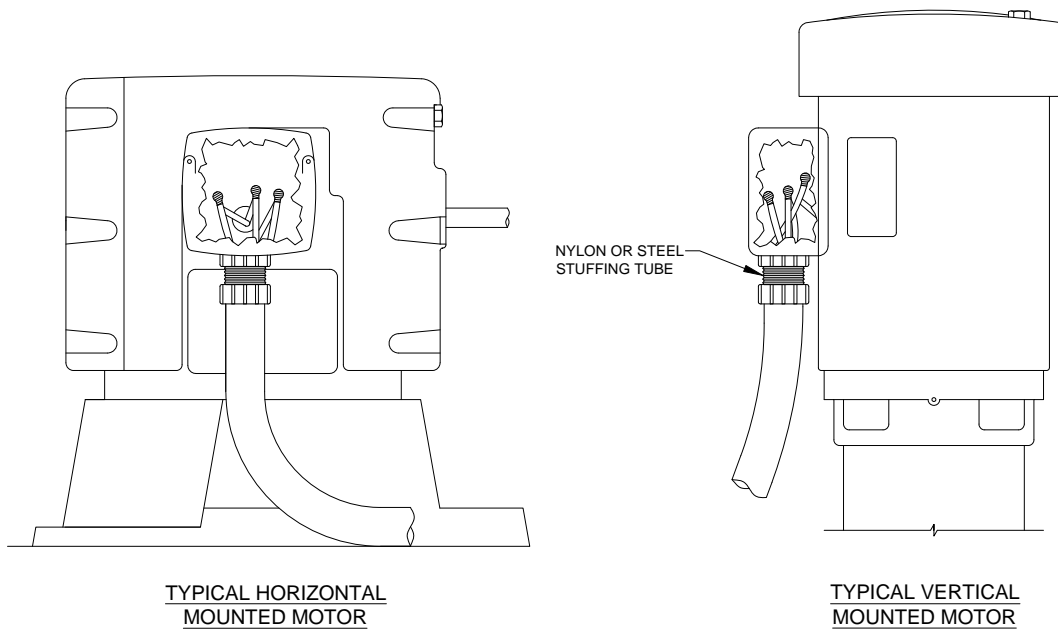
NOTES:

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

FIGURE 1B9. Inboard stuffing tubes for submarines.

MIL-STD-2003-1A(SH)  
APPENDIX B

METHOD 1B-10-1



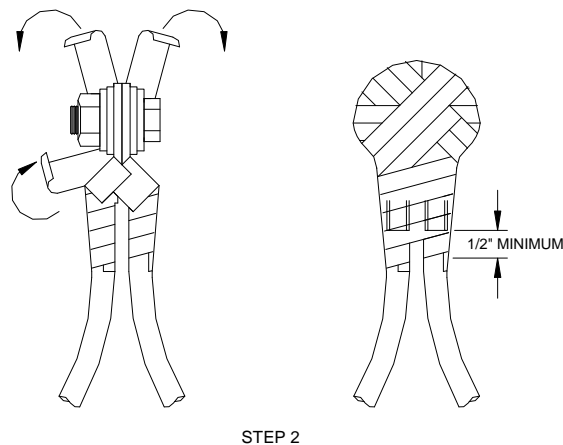
**Step 1:**

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

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

MIL-STD-2003-1A(SH)  
APPENDIX B

METHOD 1B-10-1



STEP 2

**Step 2:**

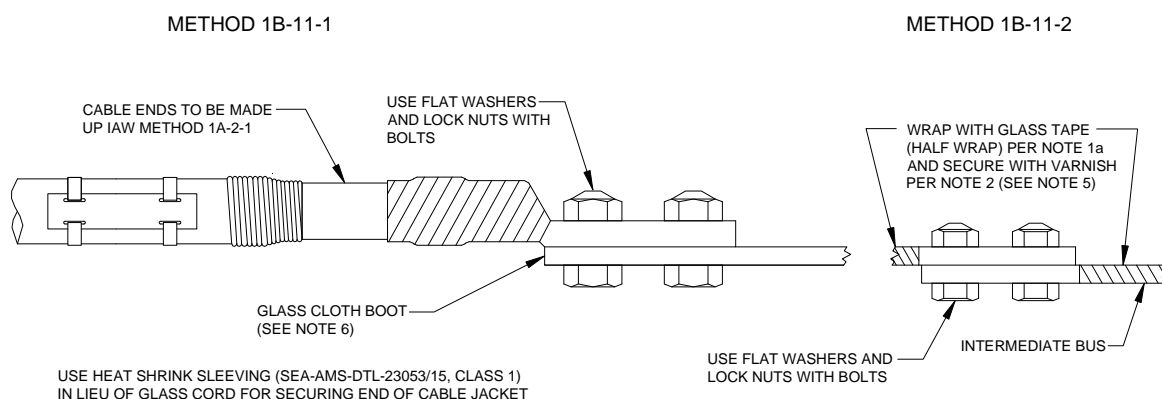
Apply tape as required in notes 1 and 2.

**NOTES:**

1. For 9000 circular mills and smaller:
  - 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 layers of electrical filler tape (NSN 5970-00-184-2002) in accordance with ASTM D4388.
  - c. Apply a minimum of two half-lap layers of plastic electrical tape in accordance with local requirements.
2. For cables over 9000 circular mills:
  - 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 (NSN 5970-00-184-2002) in accordance with ASTM D4388.
  - c. Apply a minimum of two half-lap layers of plastic electrical tape in accordance with local requirements.
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.)

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

MIL-STD-2003-1A(SH)  
APPENDIX B



**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" of each other or within 3" 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" 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 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 6 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" of each other, or disconnects closer than 3" 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".

FIGURE 1B11. Insulating bus terminals and bus bars on submarines.

MIL-STD-2003-1A(SH)  
APPENDIX B

**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-AMS-DTL-23053/15, 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.

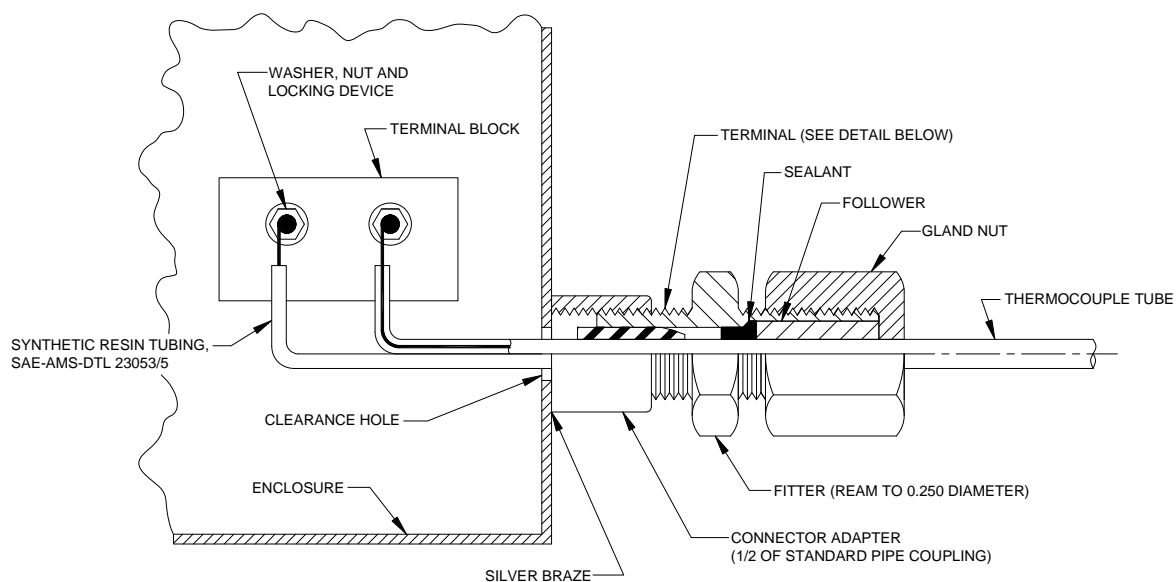
**NOTES:**

1. Tapes used shall be the following:
  - a. Glass tape - MIL-Y-1140, Class C, 1½" wide, 0.007" to 0.010" thick.
  - b. Mica tape - G.E. Co. Type No. 1604, reinforced mica tape seven mils thick, 1" wide or equivalent.
2. Insulating varnish in accordance with MIL-I-24092.
3. See figure 2C9 for battery bus inter-cell insulation.
4. In lieu of taping, a coating of approved plastisol insulation applied to a thickness of 0.125" may be used as an alternate, or tubing in accordance with Method 1B-11-2.
5. Varnish, paint, or plastisol 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 shall comply with ASTM D2400 and ASTM D2754, Form "C", Grade "O", 0.010" thick.
6. The edges of all bus bars to be taped shall be rounded with a radius equal to ½ their thickness.

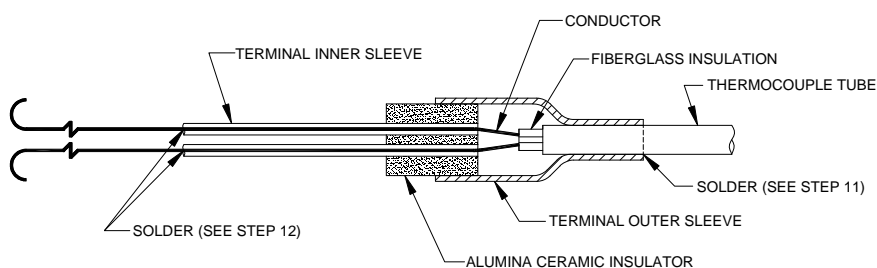
FIGURE 1B11. Insulating bus terminals and bus bars on submarines - Continued.

MIL-STD-2003-1A(SH)  
APPENDIX B

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" 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  $\frac{1}{4}$ " from end of tube.
3. Clean the tube back a maximum of 1" 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, must 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.

MIL-STD-2003-1A(SH)  
APPENDIX B**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 brazer 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-AMS-DTL-23053/5 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 must be over 0.2 megohms. The end hole shall be made watertight by filling with a silver base brazing alloy QQ-B-854 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.



MIL-STD-2003-1A(SH)  
APPENDIX B

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 must 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  $\frac{1}{4}$ " to  $\frac{3}{8}$ " of the armor (when present) must 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 Method 3C-2-1 of MIL-STD-2003-3.
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  $\frac{3}{16}$ " thick.

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

MIL-STD-2003-1A(SH)  
APPENDIX B

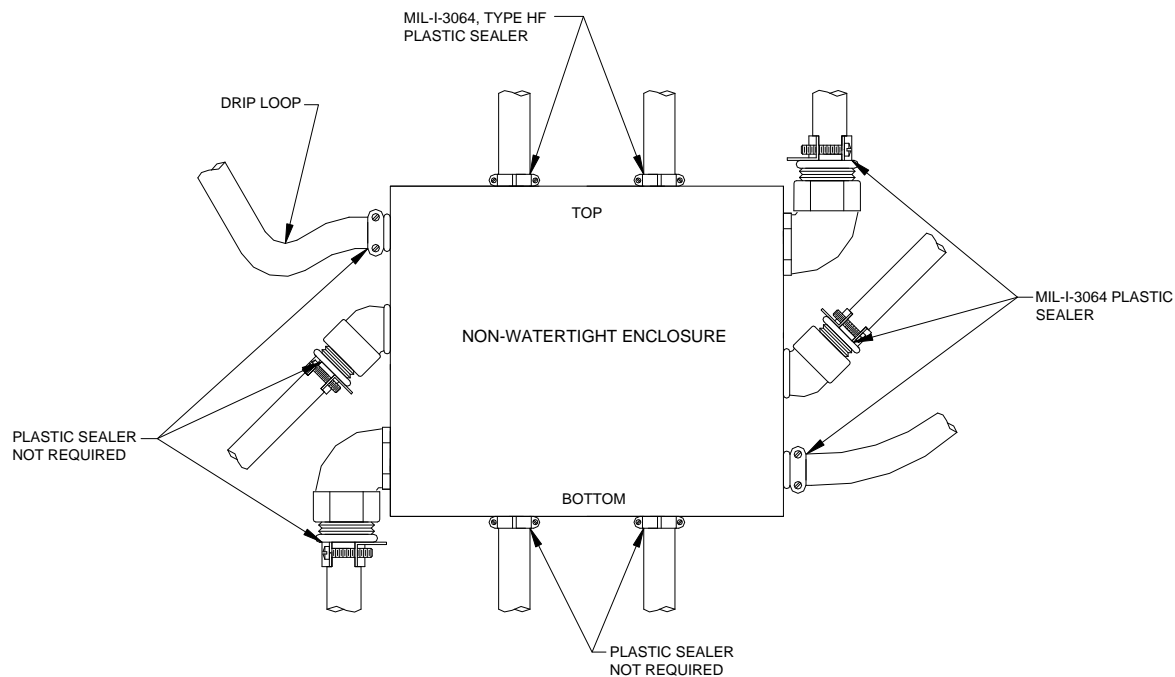
**Installation notes (continued):**

11. Grounding, if required, will 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 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 must be in accordance with A-A-3097.
15. Seals must 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.

MIL-STD-2003-1A(SH)  
APPENDIX B

METHOD 1B-14-1



NOTES:

1. See figure 1B3 for box connector and plastic sealer requirements.
2. When installing cables in a non-watertight enclosure, the preferred method of cable entry is to bring the cable into the bottom or lower side of the enclosure.
3. When cables are installed in the top or side of enclosures, the cable must have a drip loop or MIL-I-3064 plastic sealer installed to ensure that the enclosure is drip-proof.
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.

MIL-STD-2003-1A(SH)  
APPENDIX C

GROUP 1C - PROTECTION OF TOPSIDE CONNECTORS

C.1 SCOPE

C.1.1 Scope. This appendix describes the procedures for protection of topside connectors.

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.

DEPARTMENT OF DEFENSE SPECIFICATIONS

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

(Copies of this document are available online at <http://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

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-AMS-DTL-23053/5 - Insulation Sleeving, Electrical, Heat-shrinkable, Polyolefin, Flexible, Crosslinked

(Copies of this document are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or online at [www.sae.org](http://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 section, all dimensions are in inches unless otherwise noted.

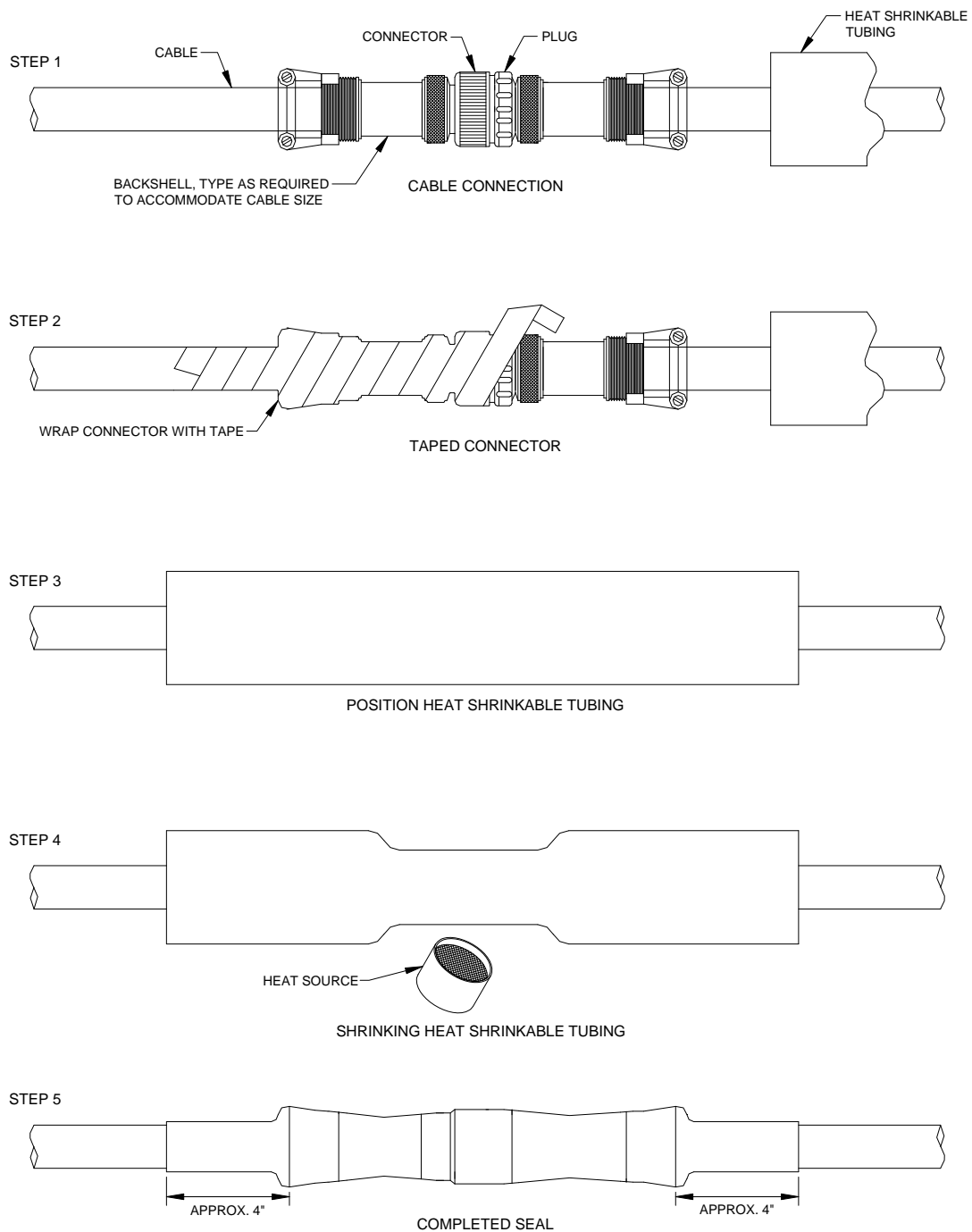
C.4.2 Figures. Table 1CI provides information for the figures in this group.

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

Figure number	Protection of topside connectors	Page
1C1	Protection of connectors topside	84

MIL-STD-2003-1A(SH)  
APPENDIX C

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.

MIL-STD-2003-1A(SH)  
APPENDIX C

## 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" longer than mated connectors) on one of the cables. Connect the connectors together. Abrade the cable jacket circumferentially and clean with appropriate solvent (Methyl Ethyl Ketone (Mek) or equivalent).
  - 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-AMS-DTL-23053/5 Class 1 or Class 3 (without sealant).

FIGURE 1C1. Protection of connectors topside - Continued.

MIL-STD-2003-1A(SH)  
APPENDIX D

GROUP 1D - REPAIR OF DAMAGED CABLE

## D.1 SCOPE

D.1.1 Scope. This appendix describes the procedures for the repair of damaged cables.

## 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)

(Copies of this document are available online at <http://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

A.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 & Submarine Electronic/Electrical Installation Methods

(Copies of these documents are available from Commander, Portsmouth Naval Shipyard, ATTN: Code 280.1, Kittery, ME 03904.)

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-AMS-DTL-23053/15 - Insulation Sleeving, Electrical, Heat-shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked

(Copies of this document are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or online at [www.sae.org](http://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 section, all dimensions are in inches unless otherwise noted.

MIL-STD-2003-1A(SH)  
APPENDIX D

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

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

<b>Figure number</b>	<b>Repair of damaged cables</b>	<b>Page</b>
1D1	Repair of damaged cables, insulation, and armor	88
1D2	Repair of jet aircraft servicing and starting cables	90
1D3	Repair of cables, power, control, telephone, and electronic	92
1D4	Cable jacket repair sleeve, installation	94
1D5	Cable jacket repair sleeve, installation	96
1D6	Cable jacket repair sleeve, installation	98

MIL-STD-2003-1A(SH)  
APPENDIX D

METHOD 1D-1-1

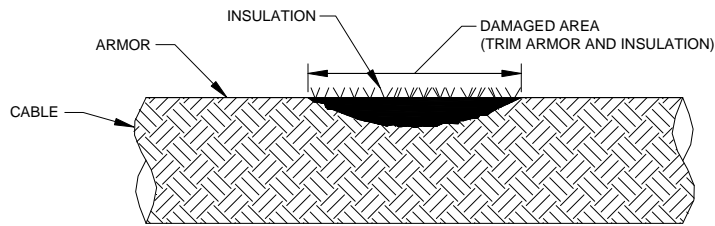


ILLUSTRATION 1

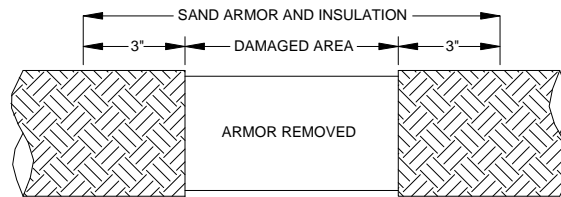


ILLUSTRATION 2  
REMOVE ARMOR FROM AREA TO BE REPAIRED

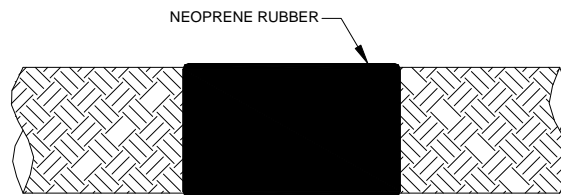


ILLUSTRATION 3

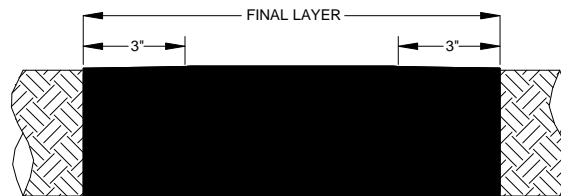


ILLUSTRATION 4

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

**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" each side of the damaged area. See illustration 2.

**Step 3:**

Clean area with Xylol or equivalent solvent.

**Step 4:**

Apply successive layers of GACO Type N29 adhesive and  $\frac{1}{16}$ " thick Neoprene rubber to obtain a resultant thickness greater than that of the damaged material. See illustration 3.

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

MIL-STD-2003-1A(SH)  
APPENDIX D

**Step 5:**

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

**Step 6:**

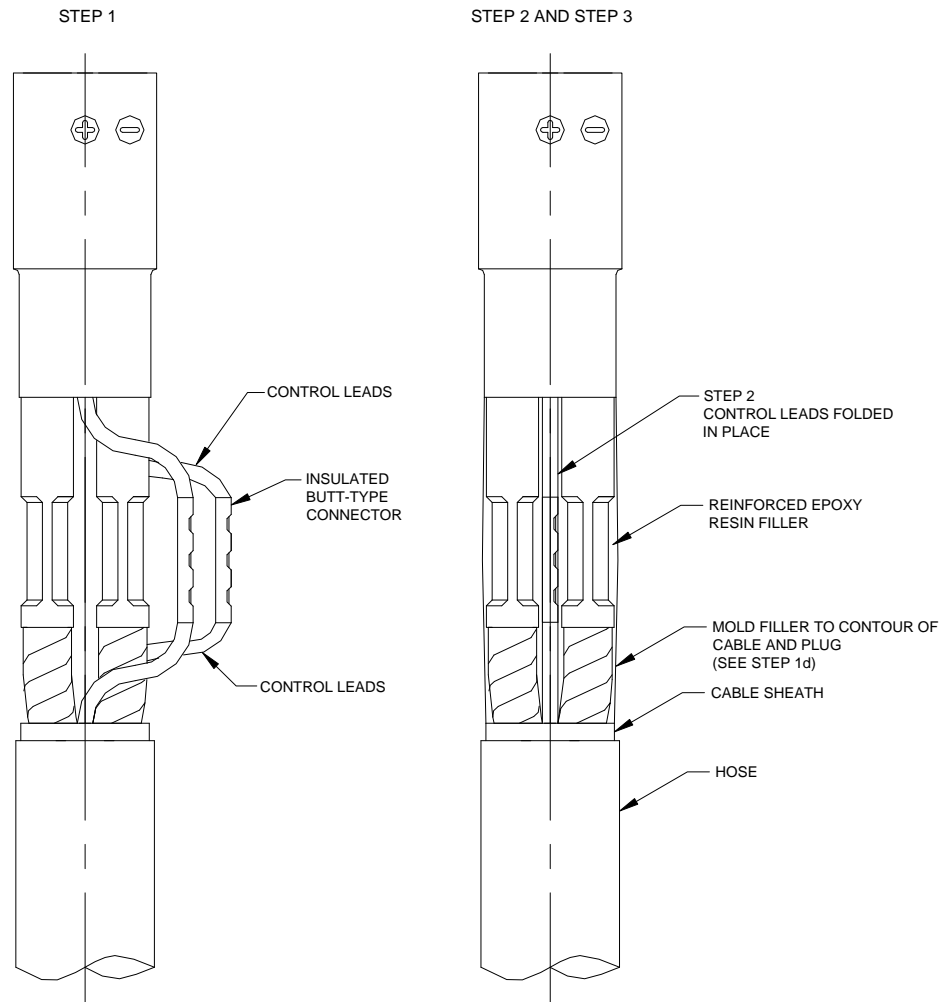
Apply a sufficient amount of GACO Type N29 adhesive coating, or equal, to cover the repair and saturate the adjacent exposed armor.

NOTE: An alternate method for repairing damaged armor utilizing self-adhesive aluminum tape in accordance with Surface & Submarine Electronic/Electrical Installation Methods, Drawing No. 803-5725675 is acceptable.

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

MIL-STD-2003-1A(SH)  
APPENDIX D

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:

- Obtain and have ready an expendable container and spatula or putty knife for mixing the epoxy resin and milled fiber.
- Mix together the resin and hardener contained in one 2 $\frac{3}{4}$ -ounce size package of epoxy resin A-A-59296, Type I (FSN 9G5970-752-5430) in accordance with MRF's instructions. NOTE: Resin will set up hard in 10 to 15 minutes.
- Pour the epoxy resin mixture (b above) onto about  $\frac{2}{3}$  cup of milled fiber and mix to the consistency of soft putty.

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

MIL-STD-2003-1A(SH)  
APPENDIX D

**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  $\frac{1}{8}$ " strands of kationic binder. Possible source are manufacturers and processors of fiber glass.

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

MIL-STD-2003-1A(SH)  
APPENDIX D

Method 1D-3-1



Illustration 1



Illustration 5



Illustration 2



Illustration 6



Illustration 3



Illustration 7



Illustration 4

NOTES:

1. The procedure outlined is suitable for repairing cables having polyethylene cable jacket or insulation by using casting moulds 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 table 1E3-III of figure 1E3 and notes 10e, 10e1, and 11-13 and figure 1E1 for material specifications.
2. Roughen outer jacket of cable with emery cloth. Be sure to roughen complete area that will be covered with mould. 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,  $\frac{1}{2}$ " 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.

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

MIL-STD-2003-1A(SH)  
APPENDIX D

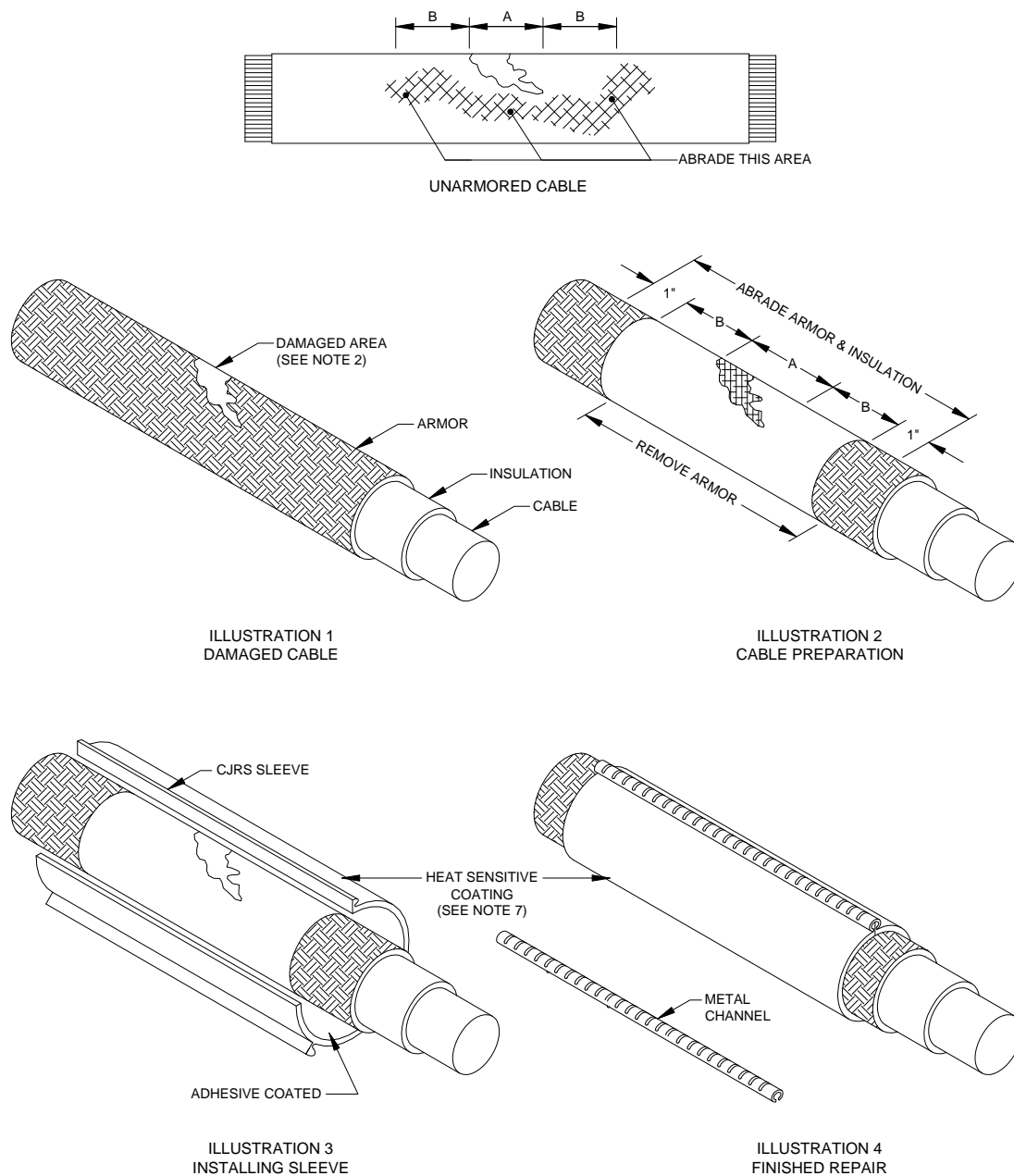
NOTES (continued):

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.

MIL-STD-2003-1A(SH)  
APPENDIX D

METHOD 1D-4-1



**Notes and installation instructions:**

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

FIGURE 1D4. Cable jacket repair sleeve, installation.

MIL-STD-2003-1A(SH)  
APPENDIX D

NOTES (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" 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-AMS-DTL-23053/15, 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.

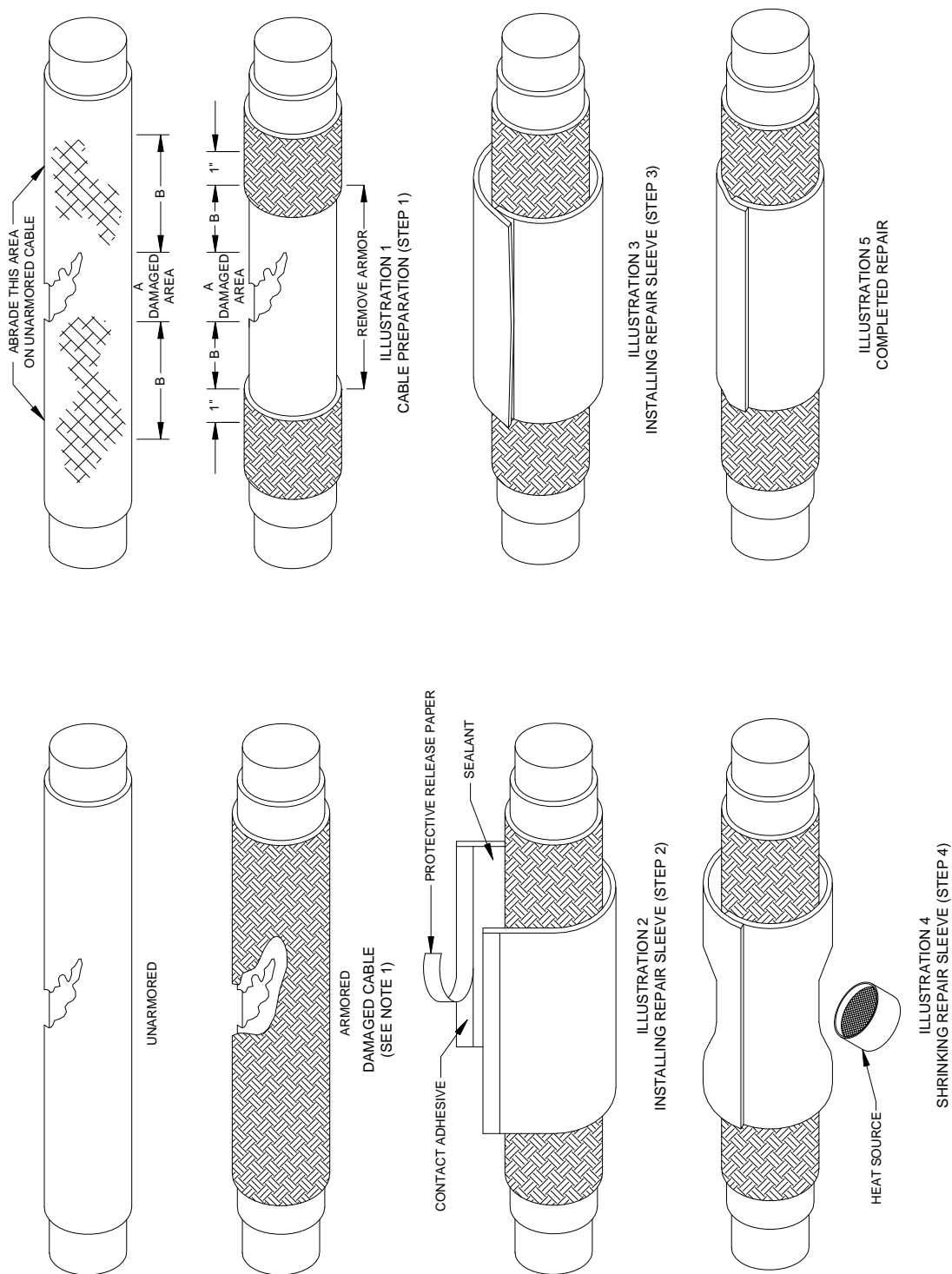
TABLE 1D4-I. Dimensions in inches.

Part number for cable diameter range	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	
1D41-A	3	0.30 to 0.60	A+2B	A+2B+2	1.8	0.94	0.080±0.010
1D41-B	3	0.61 to 1.00	A+2B	A+2B+2	3.14	1.91	0.080±0.010
1D41-C	3	1.01 to 1.60	A+2B	A+2B+2	5.03	3.17	0.080±0.010
1D41-D	4	1.61 to 2.30	A+2B	A+2B+2	7.22	5.06	0.080±0.010
1D41-E	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.

MIL-STD-2003-1A(SH)  
APPENDIX D

METHOD 1D-5-1



NOTES:

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

FIGURE 1D5. Cable jacket repair sleeve installation.

MIL-STD-2003-1A(SH)  
APPENDIX D

NOTES (continued):

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

**Step 1:**

Trim damaged insulation and/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 (MEK or equivalent).

**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-AMS-DTL-23053/15 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".
4. This repair to be accomplished only on installed cables.

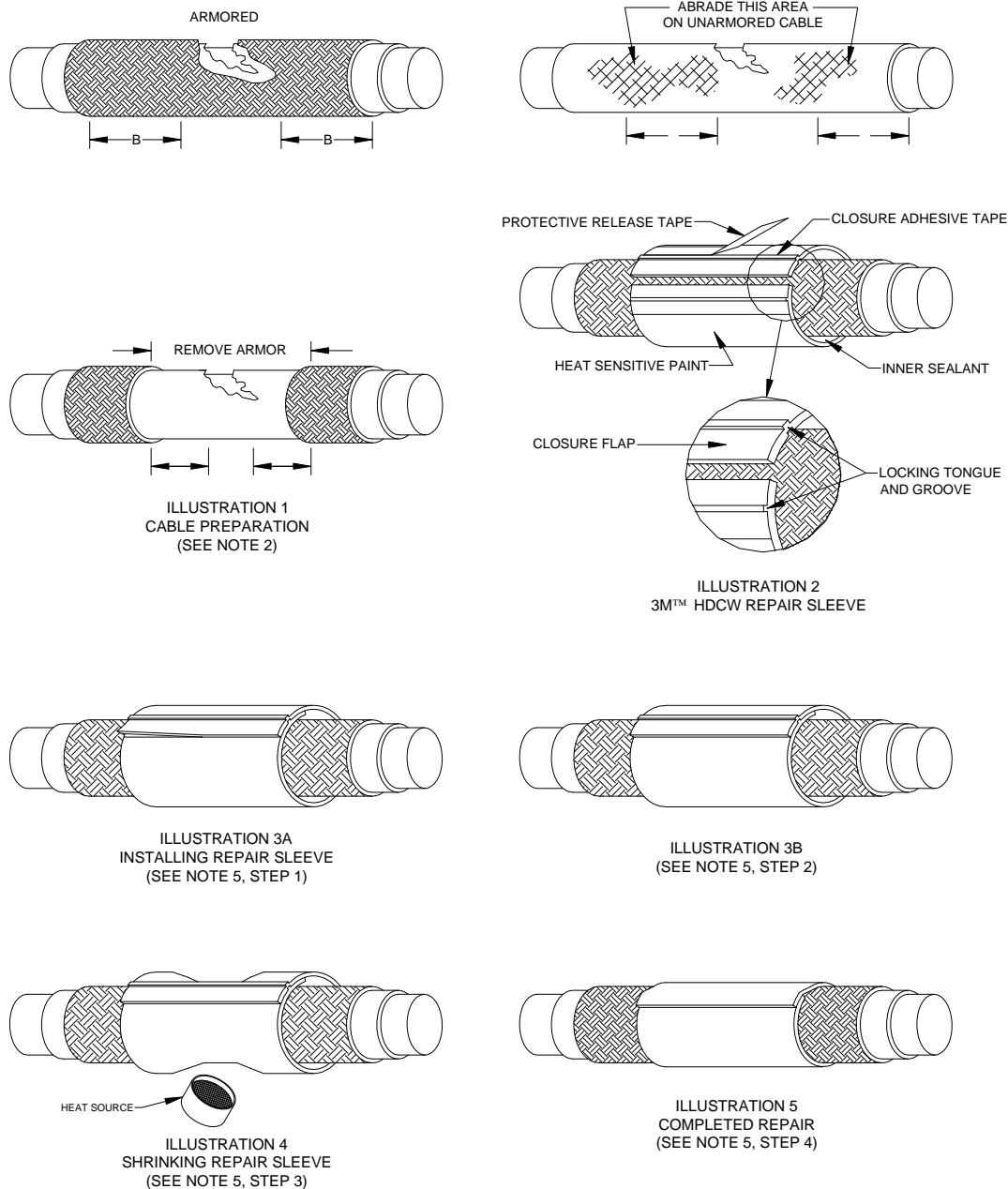
TABLE 1D5-I. Dimensions in inches.

Part number for cable diameter range	B	Use on cable diameter range	Sleeve length minimum for		ID		Wall thickness after shrinking
			Unarmored cable	Armored cable	Minimum expanded	Maximum recovered	
1D51-A	3	0.50 to 1.10	A+2B	A+2B+2	1.25	0.50	0.080±0.010
1D51-B	3	0.80 to 1.80	A+2B	A+2B+2	2.00	0.75	0.080±0.010
1D51-C	4	1.20 to 3.30	A+2B	A+2B+2	3.60	1.10	0.080±0.010
1D51-D	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.

MIL-STD-2003-1A(SH)  
APPENDIX D

METHOD 1D-6-1



**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" wide aluminum heat shield tape, such as 3M™ 49 tape or equivalent, 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" is underneath the sleeve with 3" extending beyond the sleeve ends. Dress the aluminum tape eliminating all sharp edges.
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.

FIGURE 1D6. Cable jacket repair sleeve installation.

MIL-STD-2003-1A(SH)  
APPENDIX D

NOTES:

1. The procedure outlined is suitable for repairing armor and/or sheath damage only, with conductors and water-sealing compounds being intact as an alternative to figures 1D1 and 1D4.
2. Trim damaged insulation and/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 (MEK or equivalent).
4. Select proper repair sleeve and cut to proper length as shown in table 1D6-I.
5. Repair procedure:

**Step 1:**

Center the HDCW 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 HDCW 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 HDCW 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-AMS-DTL-23053/15. 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.

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

Part number for cable diameter range	B	Use on cable diameter range	Sleeve length minimum for		ID		Wall thickness after shrinking
			Unarmored cable	Armored cable	Minimum expanded	Maximum recovered	
1D61-A	3	0.50 to 1.10	A+2B	A+2B+2	1.50	0.50	0.120±0.010
1D61-B	3	0.60 to 1.80	A+2B	A+2B+2	2.10	0.60	0.120±0.010
1D61-C	4	1.20 to 3.60	A+2B	A+2B+2	4.00	1.20	0.120±0.010
1D61-D	5	1.60 to 4.95	A+2B	A+2B+2	5025	1.60	0.120±0.010

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

MIL-STD-2003-1A(SH)  
APPENDIX E

GROUP 1E – CABLE SPLICING

E.1 SCOPE

E.1.1 Scope. This appendix describes procedures for splicing of Navy shipboard cables.

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
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-DTL-24640	-	Cable, Light-Weight, Electric, for Shipboard Use, General Specification for
MIL-DTL-24643	-	Cables and Cords, Electrical, Low Smoke, for Shipboard Use, General Specification for
MIL-DTL-24643/33	-	Cable, Electrical, Type LS2SWU

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-2003-5	-	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Connectors)
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(Copies of these documents are available online at <http://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

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 D1931	-	Standard Specification for Fully Cured Silicone Rubber-Coated Glass Fabric and Tapes for Electrical Insulation
ASTM F1835	-	Standard Guide for Cable Splicing Installations

(Copies of these documents are available from ASTM International, 100 Barr Harbor Dr., P.O. Box C700, West Conshohocken, PA 19428-2959 or online at [www.astm.org](http://www.astm.org).)

MIL-STD-2003-1A(SH)  
APPENDIX E

SAE INTERNATIONAL

SAE-AMS-DTL-23053/15 - Insulation Sleeving, Electrical, Heat-shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked

(Copies of this document are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or online at [www.sae.org](http://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 section, all dimensions are in inches unless otherwise noted.

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

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

<b>Figure number</b>	<b>Navy shipboard cable splicing methods</b>	<b>Page</b>
1E1	Splicing cable – power, control, telephone, and electronic with heat-shrink tubing	102
1E2	Splicing cable – power, control, telephone, and electronic with heat-shrink tubing	104
1E3	Splicing cable – power, control, telephone, and electronic using heat-shrink tubing	108
1E4	Splicing high temperature cable	110

MIL-STD-2003-1A(SH)  
APPENDIX E

**Method 1E-1A:**

1. MIL-DTL-915, MIL-DTL-24640, and MIL-DTL-24643 cable may be spliced except for the following:
  - 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. D.C. bus tie cable on submarines
  - g. Reactor plant system cable unless approved by NAVSEA on a case by case basis
  - h. Non-nuclear cable in reactor compartments unless approved by NAVSEA
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 illustrations 1, 2, 3, 4, 5, and 6. 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 axis of the conductor 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 illustrations 2, 3, 4, 5, and 6. 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-AMS-DTL-23053/15 and shall conform to the dimensional requirements of illustration 6 and tables 1E2-III and 1E2-IV.
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, it will be necessary to use a melttable sealant which is compatible with thick-wall heat-shrink tubing and meets the requirements of figure 1A6. For approved manufacturers, contact NAVSEA 05Z3.
15. MIL-T-16366 CCBC connectors suitable for each conductor size are shown in table 1E3-I on figure 1E3. The conductor must be long enough to reach the full depth of the connector and the conductor insulation shall be flush with the butt of the connector.
16. Circuit integrity cables must have the crimped CCBC connectors completely wrapped with A-A-59770 glass tape.
17. Armor over splices of armored cable can be omitted except when armor is mandatory. A jumper cable can be installed at the splice to maintain electrical continuity if required.
18. Shields over splices of shielded conductors in cables are mandatory. See MIL-STD-2003-5 (figures 5A19-23) for conductor shield termination methods.
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.

MIL-STD-2003-1A(SH)  
APPENDIX E**Method 1E-1A (continued):**

## 20. Installation procedure:

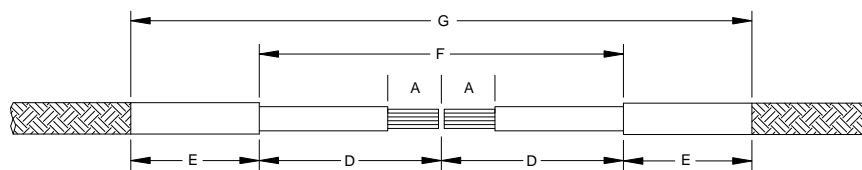
- a. Slide expanded heat-shrinkable part over item to be covered.
- b. Shrink tubing by applying heat using a hot air blower or other heat source. Tubing starts to shrink at 250-275 °F (121.1-135 °C). Higher temperature rating of heat gun is sometimes required to offset heat-shrink effect of conductor, connector, shielding, etc.
- c. 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.
- d. 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.
- e. Use tables 1E2-I through 1E2-IV and illustration 6 as guides to diameters and length of tubing required for splicing common sizes of cable.

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

MIL-STD-2003-1A(SH)  
APPENDIX E

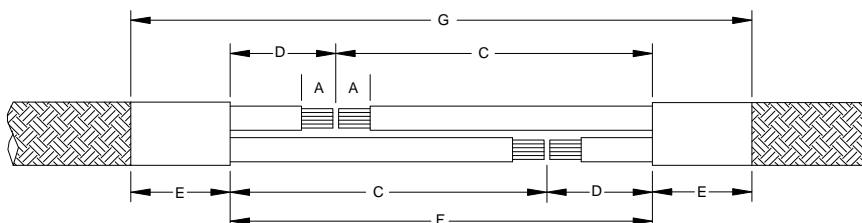
METHOD 1E-2-1

ILLUSTRATION 1  
SPLICING DIMENSIONS FOR SINGLE CONDUCTOR CABLE



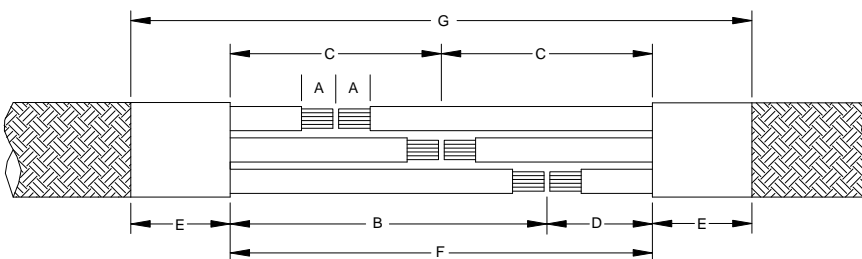
BARE COPPER ON CONDUCTOR EQUALS "A"  
(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE DIMENSIONS)

ILLUSTRATION 2  
SPLICING DIMENSIONS FOR TWO-CONDUCTOR CABLE



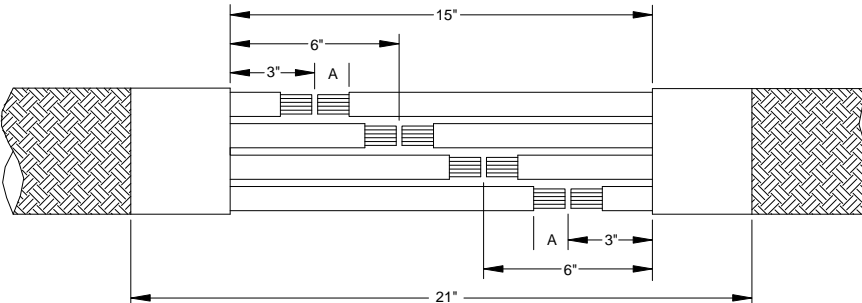
BARE COPPER ON EACH CONDUCTOR EQUALS "A"  
(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE DIMENSIONS)

ILLUSTRATION 3  
SPLICING DIMENSIONS FOR THREE-CONDUCTOR CABLE



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

ILLUSTRATION 4  
SPLICING DIMENSIONS FOR FOUR-CONDUCTOR CABLE



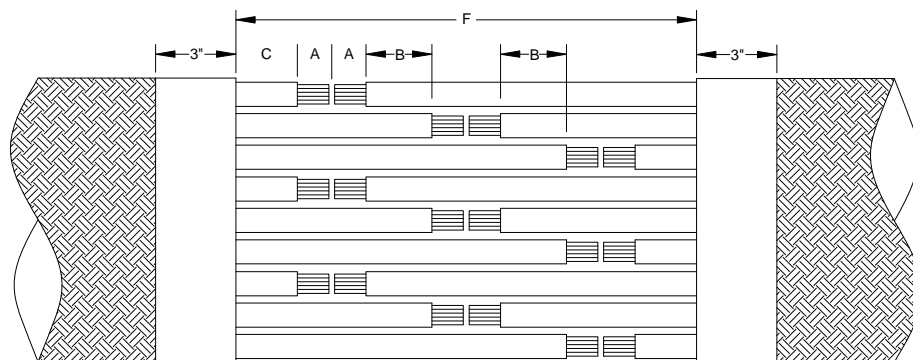
BARE COPPER ON EACH CONDUCTOR EQUALS "A"  
(SEE TABLE 1E2-I AND TABLE 1E2-II FOR SPLICE DIMENSIONS)

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

MIL-STD-2003-1A(SH)  
APPENDIX E

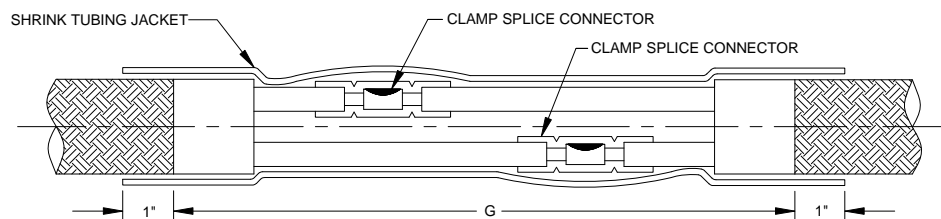
METHOD 1E-2-1

ILLUSTRATION 5  
SPlicing 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 DIMENSIONS AND SHRINK TUBING INSTALLATION FOR  
POWER CABLES AND SINGLE CONDUCTOR DEGAUSSING CABLE



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

NOTES:

1. See tables 1E2-I and 1E2-II for splice dimensions.
2. For guidance, see ASTM F1835; Standard Guide for Cable Splicing Applications.

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

MIL-STD-2003-1A(SH)  
APPENDIX E

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	22
9 to 4	*	11	7	3	3	6	10	14	16	12	16	20	26
3 to 1/0	*	13	8	3	4	8	11	16	23	14	19	24	32
2/0 to 250	*	15	10	5	4	10	15	20	25	18	23	28	36
300 to 500	*	19½	13	6½	4	13	19½	26	-	21	27½	34	-
650 to 2000	*	-	-	10	4	20	-	-	-	28	-	-	-
* Dimension “A” equals half the connector length plus ⅛".													

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

Number of conductors	Dimensions **
	F
1-10	5
10-20	8
20-30	10
30-40	12
40-50	14
50-60	16
60-70	18
70-80	20
80-90	24
(For multi-conductor cable only): ** Dimension "A" equals ½ connector length plus ⅛" Dimension "B" equals 4A – distance from any adjacent butt splice Dimension "C" equals 4A – distance from sheath, either side Dimension "F" equals the length of stripped back cable for wire size 1620 CMA to 4110 CMA unshielded	

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

MIL-STD-2003-1A(SH)  
APPENDIX E

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

<b>Range of cable diameter</b>	<b>Jacket size length</b>	<b>Expanded I.D.</b>
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"

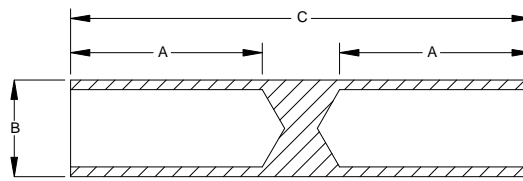
TABLE 1E2-IV. Shrink tubing dimensions. (see illustration 6)

<b>Expanded I.D.</b>	<b>Fully recovered</b>	
	<b>I.D.</b>	<b>Wall thickness</b>
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.

MIL-STD-2003-1A(SH)  
APPENDIX E

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.

MIL-STD-2003-1A(SH)  
APPENDIX E

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)
	Cable size designation	Size (Cmil)	Diameter over copper nominal (inches)	Standard cable size designation (AWG)	Size (Cmil)	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
	1(7)	1,119	0.038	20	1,020	0.036	¼	0.150	⅝	16
	1(10)	1,005	0.038	20	1,020	0.038	¼	0.150	⅝	15
	1½(16)	1,608	0.049	18	1,620	0.049	¼	0.150	⅝	23
	1½(41)	1,630	0.049	18	1,620	0.049	¼	0.150	⅝	24
	2(7)	1,775	0.048	18	1,620	0.046	¼	0.150	⅝	24
2½-4	2½(19)	2,426	0.057	16	2,580	0.061	¼	0.150	⅝	36
	2½(28)	2,613	0.061	16	2,580	0.061	¼	0.150	⅝	41
	3(7)	2,828	0.060	16	2,580	0.058	¼	0.150	⅝	43
	4(41)	4,121	0.077	15	4,110	0.078	¼	0.150	⅝	70
6-9	6(7)	6,512	0.092	12	6,530	0.092	⅝ <sub>16</sub>	0.212	¾	105
	9(7)	9,016	0.108	10	10,380	0.116	⅝ <sub>16</sub>	0.212	¾	140
14	14(7)	14,340	0.136	9	13,090	0.130	13 <sub>16</sub> <sub>16</sub>	¼	1¾	190
23	23(7)	22,800	0.171	7	20,820	0.164	13 <sub>16</sub> <sub>16</sub>	⅝ <sub>16</sub>	1¾	250
30	30(19)	30,860	0.202	5	33,090	0.221	1⅝	⅝ <sub>16</sub>	2¾	290
40	40(19)	38,910	0.226	4	41,740	0.239	1⅝	⅝ <sub>16</sub>	2¾	340
50	50(19)	49,080	0.254	3	52,620	0.260	1¾	¾	2⅝	390
60	60(37)	60,090	0.282	2	66,360	0.300	1¾	7 <sub>16</sub>	2⅝	440
75	75(37)	75,780	0.317	1	83,690	0.332	1¾	½	2⅞	500
100	100(61)	99,060	0.363	1/0	105,600	0.373	1¾	½	2⅞	600
125	125(61)	124,900	0.407	2/0	133,100	0.419	1½	9 <sub>16</sub>	3⅝	675
150	150(61)	157,600	0.457	3/0	167,800	0.470	1½	⅝	3⅝	750
200	200(61)	198,700	0.514	4/0	211,600	0.528	1⅝	11 <sub>16</sub>	3¾	900
250	250(61)	250,500	0.577	250MCM	250,000	0.576	1⅝	¾	3¾	1,000
300	300(91)	296,400	0.628	300MCM	300,000	0.630	2	13 <sub>16</sub>	4⅝	1,120
350	350(91)	349,800	0.682	350MCM	350,000	0.682	2	7 <sub>8</sub>	4⅝	1,125
400	400(127)	413,600	0.742	-	413,600	0.742	2⅝	⅝ <sub>16</sub>	4¾	1,325
650	650(127)	657,600	0.936	650MCM	650,000	0.930	2 13 <sub>16</sub>	1¾	5¾	1,750
800	800(127)	829,300	1.050	800MCM	800,000	1.031	2 15 <sub>16</sub>	1¾	6	2,000
1000	1000(127)	1,046,000	1.080	1000MCM	1,000,000	1.152	3	1½	6⅝	-
1600	1600(127)	1,662,000	1.485	1600MCM	1,600,000	1.459	3 3 <sub>16</sub>	1 15 <sub>16</sub>	6¾	3,000

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

MIL-STD-2003-1A(SH)  
APPENDIX E

**Material information:**

A-A-59163, A-A-59770, and ASTM D1931

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

Unsupported rubber tape with silicone pressure sensitive adhesive, Minnesota Mining and Mfg. Company No., 70 or equal.

**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" 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 Navy universal crimping tool up to size 9, and use manufacturer's recommended tool on size 14. 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 97 on figure 1E5.

5. The splice in the Type LSPS cable is assembled by cutting matching conductors so that the conductor splices will be approximately 2" from the crotch and 3" 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" more than half of the connector length. Insert the conductor to the stop in the connector and crimp. Apply three layers, ½ lapped, of self-bonding silicone rubber bias weave glass tape over the connector approximately 1" from each end of the connector. Then apply one layer of tape, ½ 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.

MIL-STD-2003-1A(SH)  
APPENDIX E

**Method 1E-4-1 (continued):**

7. Apply one layer, ½ 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" on the ends of the cable sheath. Apply two layers, ½ lapped, of unsupported pressure sensitive silicone rubber tape over the vulcanized silicone rubber compound and approximately 2" on the ends of the cable sheath. See illustration 101 on figure 1E5.
9. Apply two layers, ½ lapped, of self-bonding silicone rubber bias weave glass tape between the armor ends. See illustration 107 on figure 1E5.
10. Slide armor sleeve over splice area and secure ends with stainless steel "bandit" 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" 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 Navy universal crimping tool. 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" overlap. Stagger the splices between conductors of the same pair approximately 1". 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" 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.

MIL-STD-2003-1A(SH)  
APPENDIX E

**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" 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	$\frac{1}{2}$

NOTE: Use Navy universal crimping tool. 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. 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. 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.

5. The splice in the Type LSPI cable is assembled by starting with a matching shielded pair of conductors and marking the shielded pair  $2\frac{1}{2}$ " in each direction from the center of the splice area so there will be an overlap of 5" when the excess is removed. Remove  $4\frac{1}{2}$ " 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  $\frac{3}{4}$ " 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" 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" and 3", respectively, from the shield wire on one pair and 3" and 1", respectively, on the matching pair. Remove a  $\frac{1}{4}$ " 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" 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.

FIGURE 1E4. Splicing high temperature cable - Continued.

MIL-STD-2003-1A(SH)  
APPENDIX E

**Method 1E-4-3 (continued):**

6. Repeat the above steps with each pair of conductors, staggering each splice  $\frac{1}{2}$ ". 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.

MIL-STD-2003-1A(SH)  
APPENDIX E

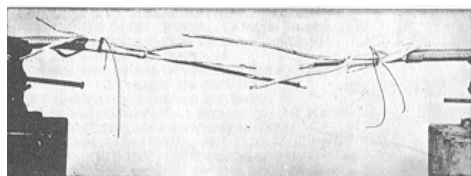


Illustration 97

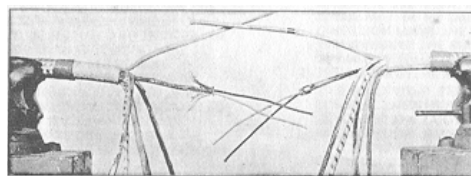


Illustration 104

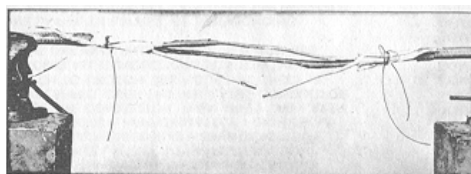


Illustration 98



Illustration 105

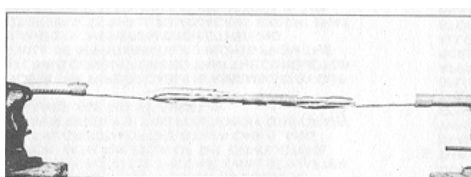


Illustration 99



Illustration 106

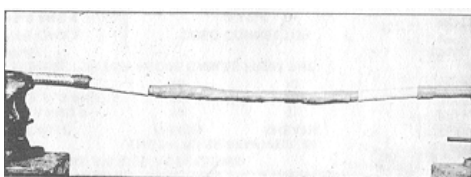


Illustration 100

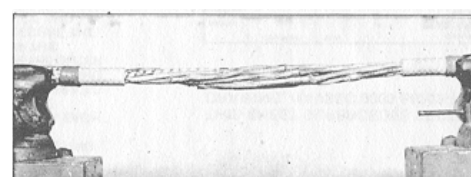


Illustration 107

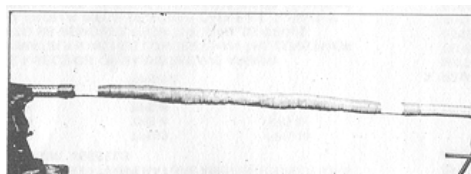


Illustration 101

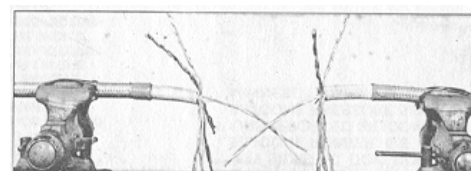


Illustration 108

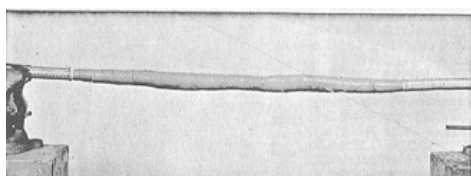


Illustration 102

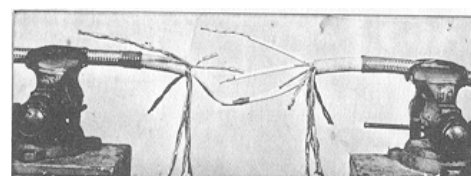


Illustration 109

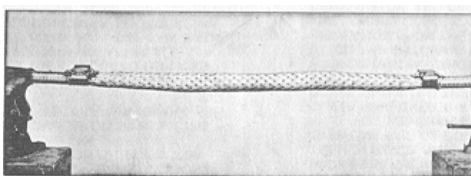


Illustration 103

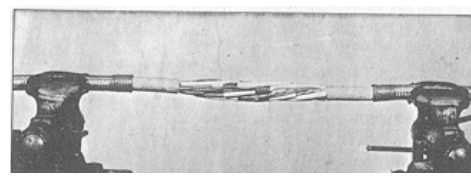


Illustration 110

FIGURE 1E5. Splicing high temperature cables.

MIL-STD-2003-1A(SH)

Preparing activity:  
Navy – SH  
(Project SESS-2008-002)

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 <http://assist.daps.dla.mil>.