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DEPARTMENT OF DEFENSE
STANDARD PRACTICE

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS (CABLES)

(PART 1 OF 7 PARTS)

AMSC N/A AREA GDRQ

FOREWORD

1. This Department of Defense Standard Practice 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. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Department of the Navy, Naval Sea Systems Command, ATTN: SEA 05Q, 1333 Isaac Hull Avenue Southeast, Stop 5160, Washington Navy Yard, DC 20376-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard practice provides detailed information and guidance to personnel concerned with the installation of fiber optic cable topologies (fiber optic cabling and associated components) on Naval surface ships and submarines. The methods specified herein are not identifiable to any specific ship class or type, but are intended to standardize and minimize variations in installation methods to enhance the compatibility of the installations on all Naval ships.

4. In order to provide flexibility in the use and update of the installation methods, this standard practice is issued in eight parts; the basic standard practice and seven numbered parts as follows:

Part 1 Cables
Part 2 Equipment
Part 3 Cable Penetrations
Part 4 Cableways
Part 5 Connectors and Interconnections
Part 6 Tests
Part 7 Pierside Connectivity Cable Assemblies and Interconnection Hardware

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1. SCOPE

1.1 Purpose. This standard provides detailed methods for fiber optic cable selection, handling, marking, and repair.

1.1.1 Applicability. These criteria apply to installations on specific ships when invoked by the governing ship specification or other contractual document. They are intended primarily for new construction; however, they are also applicable for conversion or alteration of existing ships. The rapidly changing state of the art in fiber optic technology makes it essential that some degree of flexibility be exercised in enforcing this document. Where there is a conflict between this document and the ship specification or contract, the ship specification or contract shall take precedence. Where ship design is such that the methods herein cannot be implemented, users shall submit new methods or modifications of existing methods for approval prior to implementation to: Department of the Navy, Naval Surface Warfare Center, Dahlgren Division, ATTN: Code B35, 17320 Dahlgren Road, Dahlgren, VA 22448-5100.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4 and 5 of this standard. This section does not include documents cited in other sections of this standards 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 documents cited in sections 3, 4 and 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 listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

FEDERAL SPECIFICATIONS

A-A-59731 - Fittings, Tube, Blown Optical Fiber.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-A-2877 - Aluminum Alloy Tape.

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

MIL-PRF-24623 - Splice, Fiber Optic Cable, General Specification for (Metric).

MIL-C-28876 - Connectors, Fiber Optic, Circular, Plug and Receptacle Style, Multiple Removable Termini, General Specification for.

MIL-PRF-49291 - Fiber, Optical, (Metric) General Specification for.

MIL-I-81765/1 - Insulating Components, Molded, Electrical, Heat Shrinkable, Polyolefin, Crosslinked, Semi-rigid and Flexible.

MIL-C-83522 - Connectors, Fiber Optic, Fixed Single Terminus, General Specification for.

MIL-PRF-85045 - Cables, Fiber Optic,(Metric) General Specification for.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-2042-2 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Equipment)(Part 2 of 6 Parts).

MIL-STD-2042-3 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Cable Penetrations)(Part 3 of 6 Parts).

MIL-STD-2042-4 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Cableways)(Part 4 of 6 Parts).

MIL-STD-2042-5 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Connectors and Interconnections)(Part 5 of 6 Parts).

MIL-STD-2042-6 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Tests)(Part 6 of 6 Parts).

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Documents Order Desk, 700 Robbins Ave, Building 4D, Philadelphia, PA, 19111-5094.)

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 the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z136.2 - Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.)

ELECTRONICS INDUSTRY ASSOCIATION/TELECOMMUNICATIONS INDUSTRY ASSOCIATION

EIA/TIA-440 - Fiber Optic Terminology.

(Application for copies should be addressed to Global Engineering Documents, 1990 M Street NW, Suite 400, Washington, DC 20036.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

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

(Application for copies should be addressed to Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001)

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

3. DEFINITIONS

3.1 General fiber optics terms. Definitions for general fiber optics terms used in this standard practice are in accordance with EIA/TIA-440. Definitions and acronyms for other terms as they are used in this standard practice are given in the following paragraphs.

3.2 Acronyms. The following acronyms are used in this standard practice:

BOF Blown Optical Fiber
FOCP Fiber Optic Cable Plant
FOCT Fiber Optic Cable Topology
FOICB Fiber Optic Interconnection Box
TRB Tube Routing Box

3.3 Allocated and not used fiber. A fiber that is designated for use for a particular system, but is not being used to transmit information. Allocated and not used fibers include fibers allocated as system spare fibers, system growth fibers, and system redundant fibers.

3.4 Allocated and used fiber. A fiber that is designated and required for use for a particular system, and is being used to transmit information. Allocated and used fibers include fibers used for normal channels, fibers for alternate channels, and fibers for non-redundant channels.

3.5 Alternate channel. The allocated and used active backup link for a normal channel.

3.6 Authorized approval. Written approval from the cognizant Government activity.

3.7 BOF bundle. A group of optical fibers within a special jacket that allows the entire bundle to be blown into a BOF tube.

3.8 BOF fiber. An optical fiber with a special coating that allows the fiber to be blown into a BOF tube.

3.9 BOF tube. A tube within a BOF cable through which optical fibers or optical fiber bundles are blown.

3.10 BOF tube coupler. A device used to join two BOF tubes together.

3.11 BOF tube routing box (TRB). An enclosure for holding BOF cables (trunk and local), BOF tubes (trunk and local), and tube couplers to interconnect BOF tubes.

3.12 Cable repair. Restoration/repair of only the outermost cable jacket.

3.13 Cable splicing.

3.13.1 Conventional cable splicing. Repair of a damaged conventional optical fiber cable by reconnecting severed fibers and providing an environmental enclosure at the spliced region.

3.13.2 BOF cable splicing. The joining of two BOF cable ends by connecting the tube ends together using tube couplers and providing an environmental enclosure at the spliced region.

3.14 End user equipment. Any cabinet, case, panel, or device that contains components that are either the origin or destination of an optical signal.

3.15 Fiber optic cable plant (FOCP). A subset of the FOCT that excludes local cables and their associated components. A conventional FOCP includes FOICBs, trunk cables and their associated connectors and splices. A BOF FOCP consists of

FOICBs, TRBs, tube couplers, BOF trunk cables, BOF fibers, BOF bundles, tube furcation units and associated connectors and splices.

3.16 Fiber optic cable topology (FOCT). An integrated optical fiber distribution system that provides the optical interconnection between end user equipments. A conventional FOCT includes the conventional FOCP components and outlet boxes, conventional local cables and their associated connectors and splices. A BOF FOCT includes the BOF FOCP components, BOF cable furcations, local conventional cables, local BOF cables, and associated connectors and splices.

3.17 Fiber optic interconnection box (FOICB). An enclosure for holding optical fiber cable (BOF and conventional), BOF tubes, tube furcation units, and optical fiber connectors, splices and adapters.

3.18 FOCP Growth fiber. An unallocated fiber intended for later use by fiber optic systems installed after initial ship construction.

3.19 Installing activity. An installing activity is any military or commercial organization involved with the installation of FOCTs aboard Naval ships.

3.20 Local cable.

3.20.1 Local conventional cable. A conventional optical fiber cable that runs between an end user equipment and an FOICB (or outlet box), or between an FOICB and an outlet box.

3.20.2 Local BOF cable. A BOF cable that runs between end user equipment and a TRB, or between a TRB and an outlet box.

3.21 Minimum bend diameter. The diameter at which a conventional optical fiber cable, OFCC (see 3.26), loose tube furcation unit, or BOF bundle (see 3.7) can be bent without degrading optical performance, or the diameter at which a BOF cable or BOF tube (see 3.10) can be bent without kinking a BOF tube. The short-term bend diameter applies during handling and installing; the long-term bend diameter applies to the completed installation.

3.22 Non-redundant channel (NRC). Any allocated and used active link that has no system required backup link.

3.23 Normal channel. An allocated and used active link between system equipment that has a designated active backup link.

3.24 Optical fiber cable. A cable that contains optical fibers.

3.24.1 BOF cable. A cable that contains one or more BOF tubes through which optical fibers or optical fiber bundles are blown.

3.24.2 Conventional optical fiber cable. An optical fiber cable in which the optical fiber is an integral part of the cable and is installed during the cable manufacturing process.

3.25 Optical fiber cable component (OFCC). A buffered fiber augmented with a concentric layer of strength members and an overall jacket.

3.26 Outlet box. A small termination box used to break out a local cable from an FOICB or TRB to one or more end user equipments within a compartment or area.

3.27 Spare fiber. A fiber reserved for use as a maintenance spare in the event of damage to an allocated fiber within the FOCT.

3.27.1 FOCP spare fiber. An unallocated spare fiber for use by any system using the FOCP.

3.27.2 System spare fiber. A spare fiber that is allocated and not used and that is reserved for use by a specific system.

3.28 System growth fiber. An allocated and not used fiber identified as a growth requirement for a specific system.

3.29 System redundant fiber. An allocated and not used fiber identified by the user system as a required alternately routed fiber.

3.30 System specific cable. An optical fiber cable that connects end user equipments and does not interface with a FOCP (see 3.16).

3.31 Trunk. A set of trunk cables that run along the same cableways between two FOCP boxes (TRBs, FOICBs).

3.32 Trunk cable. An optical fiber cable that runs between two FOICBs. Typically, trunk cables are run in the main cableways and have higher fiber counts per cable than local cables.

3.32.1 Conventional trunk cable. A conventional optical fiber cable that runs between two FOICBs.

3.32.2 BOF trunk cable. A single BOF cable connected between two FOCP TRBs or between a FOCP TRB and a FOCP FOICB. A BOF trunk cable contains multiple BOF trunk tubes.

3.33 Tube furcation unit. An assembly attached to the end of a BOF tube in a BOF cable used to separate the fibers and provide a cable structure to facilitate the termination of the optical fibers from that BOF tube.

3.34 Unallocated fiber. A fiber that is not designated for use for any system, but is required as part of the FOCT configuration. Unallocated fibers include FOCP spare fibers and FOCP growth fibers.

3.35 Unused fiber. A fiber that is not designated for use for any system and not required as part of the FOCT configuration. Unused fibers occur within the fiber optic cable topology when the required systems fibers are less than the number of fibers available within a standard cable size.

4. GENERAL REQUIREMENTS

4.1 Cables. Fiber optic cables for Naval shipboard application shall be in accordance with MIL-PRF-85045.

4.1.1 Cable selection. Cables selected shall be those referenced in ship specifications, ship installation drawings, contract drawings, or other approved drawings as specified in the contract or by the cognizant Government activity. Substitute cables shall not be used without authorized approval (see 3.6). In those instances where the installing activity (see 3.19) is responsible for determining the correct type and size cable for a specific application, the fiber optic cables shall be selected in accordance with MIL-PRF-85045. Fibers shall be in accordance with MIL-PRF-49291, either type SM (single mode) or type MM (multimode) as required by the system.

4.1.2 Spare optical fibers. The number of spare optical fibers shall be in accordance with the ship specification and system drawings. Spare fibers are provided in both trunk cables and local cables that penetrate bulkheads or decks (see 3.20 and 3.32).

4.1.3 Cable storage and handling.

4.1.3.1 Cable storage. Cables shall be stored in a dry place protected from the weather and limited to a temperature range of not less than -40 degrees Celsius (°C) [-40 degrees Fahrenheit (°F)] nor greater than +70°C (+158°F). It is recommended that cables be limited to a maximum temperature +30°C (+86°F). A cable that has been in storage for less than one year may be installed if a visual inspection of the cable shows no mechanical damage that would impair the watertight integrity of the cable's outer sheath or the integrity of the interior components. A conventional optical fiber cable that has been in storage for one year or longer may be installed if it passes the visual inspection (see Method 6A1 in Part 6 of this standard practice), and if the optical attenuation (see Method 6B1 in Part 6 of this standard practice) is less than the value specified. A BOF cable that has been in storage for one year or longer may be installed if it passes the visual inspection (see Method 6A1 in Part 6 of this standard practice), and if a ball bearing with a minimum outer diameter of 4.5 mm will pass through each BOF tube within the cable. Cables shall be stored on reels with minimum diameters of 24 times the cable outside diameter, or coiled so that the bend diameter shall be not less than 24 times the cable outside diameter. BOF cables shall not be stored where they may be exposed to direct sunlight, or on reels placed on their sides. Bare ends of stored cables shall be sealed against moisture using heat shrink end caps as specified herein (see 5.1). Terminated cables shall be sealed against moisture using connector dust covers (for multiple terminus connectors), plastic caps or heat shrink end caps as specified herein (see 5.1).

4.1.3.2 Cable handling. During handling, the conventional optical fiber cable and the BOF cable shall be protected from crushing, kinks, twists, and bends that violate the minimum short term bend diameter of the cable (see 3.21). The minimum short-term bend diameter of conventional optical fiber cable is eight times the cable outside diameter. The minimum short-term bend diameters of BOF cable are 0.13 m (5 in) for single tube BOF cable, 0.46 m (18 in) for seven-tube BOF cable and 1.0 m (39 in) for nineteen-tube BOF cable. It is recommended that cables not be handled in ambient temperatures at or below 36°F (2°C) (see Part 4 of this standard practice).

4.1.4 Cables entering interconnection boxes or other equipment. Cables shall enter interconnection boxes or other equipment in accordance with the methods in Part 2 of this standard practice.

4.1.5 Cable penetrations. The passing of cables through decks and bulkheads shall be in accordance with the methods in Part 3 of this standard practice.

4.1.6 Cable installation and protection. Cables shall be installed in the cableways and protected in accordance with Part 4 of this standard practice.

4.1.7 Cable connections. Cable connections to equipment external to the fiber optic cable topology, such as end user equipment (see 3.14), shall be made with multiple terminus heavy duty connectors in accordance with MIL-C-28876, single terminus light duty connectors in accordance with MIL-C-83522, or Navy approved commercial light duty connectors as specified in the system drawings. Connectors shall be assembled as specified in Part 5 of this standard practice. Light duty connectors used for external equipment connections shall be housed within that equipment. Light duty connectors used for cable interconnections internal to the fiber optic cable topology shall be housed within interconnection boxes, as specified in Part 2 of this standard practice.

4.1.7.1 Termination of fibers. There are four categories of fibers:

a. Allocated and used (see 3.4).

b. Allocated and not used (see 3.3).

c. Unallocated (see 3.34).

d. Unused (see 3.35).

The quantity of the first three categories shall be as specified in the ship specification and on the system drawings.

4.1.7.1.1 Allocated and used fibers. The allocated and used trunk and local cable fibers shall be terminated in accordance with the fiber optic cable plant and system drawings.

4.1.7.1.2 Allocated and not used fibers. The allocated and not used shall be terminated in accordance with the system or fiber optic cable plant drawings.

4.1.7.1.3 Unallocated fibers. Trunk and local cables that penetrate decks and bulkheads shall contain spare (unallocated) fibers. Spare fibers shall be terminated in accordance with the system or fiber optic cable plant drawings. Growth fibers shall not be terminated unless the cable termination is a heavy duty multi-terminus connector or the termination is specified in the fiber optic cable plant or system drawings.

4.1.7.1.4 Unused fibers. The unused fibers shall not be terminated unless otherwise specified in the fiber optic cable plant or system drawings.

4.1.8 Cable testing. Cables shall undergo testing before, during, and after installation in accordance with Part 6 of this standard practice.

4.1.9 Cable and fiber marking. All cables shall be marked in accordance with the ship specification and system drawings and as specified herein. Cable identification tags external to the equipment shall be located as specified in Part 4 of this standard practice. Cable tags shall be of a size suitable to accommodate the required marking but shall have a minimum width of 13 mm (1/2 in). Tags and strips for marking cables shall be of soft aluminum tape having a natural finish in accordance with MIL-A-2877. Capital letters shall be used on cable tags; height of all letters shall be not less than 5 mm (3/16 in), and letters and numbers shall be embossed to at least 0.4 mm (1/64 in) above the surface.

4.1.9.1 Fiber identification markers. Permanent cable markers marked with the fiber identification specified in the ship specification and system drawings shall be used to identify OFCCs or single fiber cables at their termination point within the interconnection box. The identification markers shall always be installed with the left hand marking group next to the termination point. The marker shall be positioned so that it can be easily read without disturbing other components within the equipment. The marker base color shall be white.

4.1.9.2 Heavy-duty connector designation tag. Cables that terminate in a heavy-duty connector shall have a tag placed on the cable next to the connector designating the jack to which the connector is to be attached.

4.1.10 Cable repair (see 3.12). Damage to the outermost jacket of conventional optical fiber cable and BOF cable shall be repaired according to procedures specified herein (see 5.2). Conventional optical fiber cable with damage extending beyond the cable outer jacket to the Kevlar strength members or to the OFCC outer jacket shall be replaced. BOF cables with damage extending beyond the cable outer jacket to the Kevlar strength members or to the BOF tubes may be cut to remove the damaged section and spliced according to the procedures specified herein (see 5.3).

4.1.11 BOF cable splicing. BOF cables may be installed into the ship in a modular fashion and joined to form single continuous cables. BOF cables to be joined to form a single continuous cable shall be spliced according to the procedures specified herein (see 5.3).

4.1.12 BOF cable furcation. Multiple-tube BOF cables may be furcated into multiple BOF single tube cables. If a multiple-tube BOF cable is identified for furcation to several BOF single tube cables, the use of a tube routing box instead of a BOF cable furcation should be considered. Multiple-tube BOF cables shall be furcated according to the procedures specified herein (see 5.4).

4.2 Safety precautions. The following safety precautions apply:

a. Observe all written safety precautions given in the methods of this standard practice.

b. Observe all warning signs on equipment and materials.

c. The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an optical fiber communication system (OFCS) is inherently an eye safe system; but, when an optical fiber connection is broken and optical viewing instruments are used, it is possible that hazardous energy can enter the eye. For this reason four service group hazard classes have been devised to indicate the degree of hazard and required hazard control measures. Refer to ANSI Z136.2 for a full technical definition. The following laser safety precautions shall apply:

   (1) Ensure personnel are familiar with the laser degree of hazard and the required control measures.

   (2) Light generated by light emitting diodes (LED's) and laser diodes may not be visible but may still be hazardous to the unprotected eye. Never stare into the end of an optical fiber connected to an LED or laser diode and do not stare into broken, severed or disconnected optical cables.

   (3) Do not view the primary beam or a specular reflection from an OFCS with an optical microscope, eye loupe or other viewing instrument. The instrument may create a hazard due to its light gathering capability.

d. Safety glasses shall be worn when handling bare fibers. Always handle cable carefully to avoid personal injury. The ends of optical fibers may be extremely sharp and can lacerate or penetrate the skin or cause permanent eye damage if touched to the eye. If the fiber penetrates the skin, it most likely will break off, in which case the extraction of the fiber should be performed by trained medical personnel to prevent further complications.

e. Wash your hands after handling bare fibers.

f. Never look into the end of a BOF tube. Always wear approved safety glasses when handling BOF tubes that may be connected to a pressure source.

g. Do not eat or drink in the vicinity of bare optical fibers. Ingested optical fibers may cause serious internal damage.

5. DETAILED REQUIREMENTS

5.1 Cable end sealing. Unterminated cables that are not to be terminated within 14 days (unless otherwise specified by the contract or supervisor of shipbuilding) shall have their ends sealed against moisture in accordance with Method 1A1 of this standard practice. OFCCs broken out within equipment (such as in an interconnection box) that are not to be terminated shall be grouped into bundles, and the bundle ends sealed using Method 1A1 of this standard practice as a guide. Loose tube furcation cables (from a BOF furcation unit) that are not to be terminated shall be end sealed in accordance with Method 1E1 of this standard practice. BOF tubes that are not to be populated with BOF fiber or bundles shall be end sealed in accordance with Method 2J1 of this standard practice.

5.2 Cable repair. Damage to outer jackets of conventional optical fiber cable and BOF cable (see 4.1.10) shall be repaired using cable jacket repair sleeves or tape, in accordance with Method 1B1 of this standard practice.

5.3 BOF cable splicing. BOF cables shall be spliced using Method 1C1 of this standard practice.

5.4 BOF cable furcation. Multiple-tube BOF cables shall be furcated using Method 1D1 of this standard practice.

6. NOTES

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

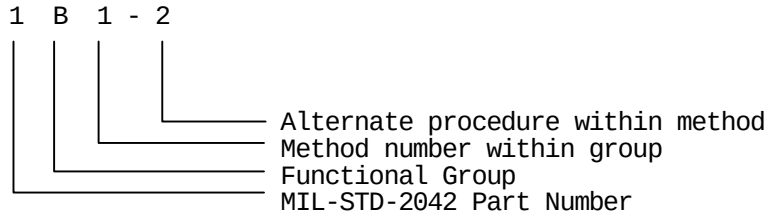
6.1 Intended use. The methods for cable end-sealing, cable repair, BOF cable splicing, and BOF cable furcation depicted in this standard practice are intended primarily for new construction; however, they are applicable for conversion or alteration of existing ships.

6.2 Issue of DODISS. When this standard practice is used in acquisition, the applicable issue of DODISS must be cited in the solicitation (see 2.2.1 and 2.3).

6.3 Standard method designation. To simplify the usage of this standard practice, an alphanumeric designation system was developed to identify and locate a given method. The methods were grouped together by function as follows:

Group A: Cable end sealing
Group B: Cable jacket repair
Group C: BOF cable splicing
Group D: BOF cable furcation
Group E: OFCC end sealing

Then the designation system was completed as follows:



Thus, method 1B1-2 identifies the second alternate procedure within method 1 of group B in Part 1 (MIL-STD-2042-1) of MIL-STD-2042.

6.4 Subject term (key word) listing.

Component
Connections
Marking
Penetrations
Repair
Selection
Storage and handling
Testing

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.

Preparing activity:
NAVY – SH

(Project SESS-0005)

METHOD 1A1

CABLE END SEALING

1. SCOPE.

1.1 Scope. This method describes a procedure for conventional fiber optic cable and BOF cable end sealing during temporary and long-term storage to prevent water or other liquids from entering into the cable or damaging the fibers. For installed loose tube furcation cable end sealing refer to Method 1E1.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 1A1-I shall be used to perform this procedure.

TABLE 1A1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Emery cloth (or fine file)	As required
Ruler	1
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
End cap (Raychem SSC series or equal)	1
Wipes	As required
Canned air	As required

3. PROCEDURE.

3.1 Safety Summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers.

b. Do not touch the ends of the fiber as they may be razor sharp. Wash your hands after handling bare fiber.

c. Observe warnings and cautions on the equipment and materials.

d. When visually inspecting an optical fiber, never stare into the end of a fiber connected to a laser source or LED.

e. Never look into the end of a BOF tube. Always wear approved safety glasses when handling BOF tubes that may be connected to a pressure source.

3.2 Procedure.

NOTE: End caps shall meet the requirements of MIL-I-81765/1 and table 1A1-II. The cap interior shall be coated with a heat-activated adhesive.

Step 1 - Abrade the conventional or BOF cable jacket circumferentially over the length that will be in contact with the end cap using emery cloth or a fine file.

Step 2 - Clean the abraded area of the conventional cable or BOF cable with a wipe dampened with alcohol and blow dry as necessary.

Step 3 - Select an end cap in accordance with table 1A1-II.

TABLE 1A1-II. End cap data and sizes for fiber optic cable.

Cable type	Cable OD mm (in) nominal	End cap dimensions mm (in)		
		Length (min)	Expanded I.D.(min)	Recovered I.D.(max)
4-Fiber	8.1 (0.32)	30.2 (1.19)	10.0 (0.39)	4.0 (0.16)
8-Fiber	11.1 (0.44)	49.8 (1.96)	20.0 (0.79)	7.5 (0.30)
8-Fiber (outboard)	14.4 (0.57)	49.8 (1.96)	20.0 (0.79)	7.5 (0.30)
18-Fiber	14.3 (0.56)	49.8 (1.96)	20.0 (0.79)	7.5 (0.30)
18-Fiber (outboard)	17.4 (0.69)	49.8 (1.96)	20.0 (0.79)	7.5 (0.30)
36-Fiber	20.8 (0.82)	80.9 (3.19)	35.0 (1.38)	15.0 (0.59)
90-Fiber	38.5 (1.52)	128.9 (5.08)	55.0 (2.17)	25.0 (0.98)
Single-Tube	11.1 (0.44)	49.8 (1.96)	20.0 (0.79)	7.5 (0.30)
7-Tube	29.0 (1.14) or 31.5 (1.24)	80.9 (3.19)	35.0 (1.38)	15.0 (0.59)
19-Tube	50.8 (2.00)	128.9 (5.08)	55.0 (2.17)	25.0 (0.98)

Step 4 - Slide the end cap over the end of the conventional cable or BOF cable to be sealed. Position the end cap to ensure a 25 mm (1 in) minimum overlap (see figure 1A1-1).

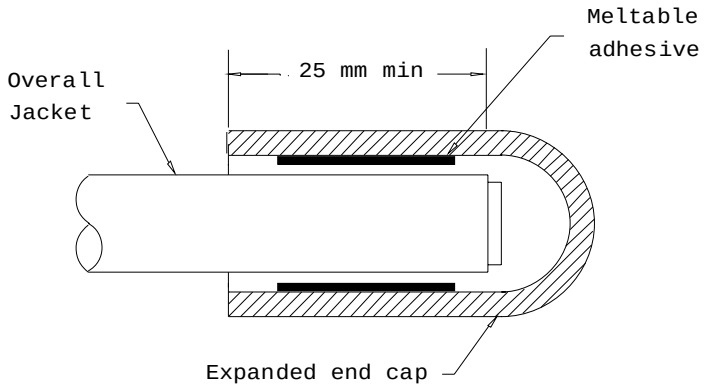


FIGURE 1A1-1. Installing expanded end cap on cable.

Step 5 - CAUTION: Do not overheat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the sleeve and allow the cable jacket to cool before reheating, if the cable jacket shows any signs of bubbling.

Hold the heat gun approximately 100 mm (4 in) from the end cap and as heat is applied, move the heat gun back and forth over the end cap. Shrink the end cap from closed end to open end to avoid trapping air. (NOTE: Minimum recovery temperature is 121°C (250°F).

Step 6 - When the end cap has recovered enough to assume the configuration of the cable and excess adhesive appears at the end of the cap, discontinue heating (see figure 1A1-2). (NOTE: Additional heat will not make end cap shrink more tightly.)

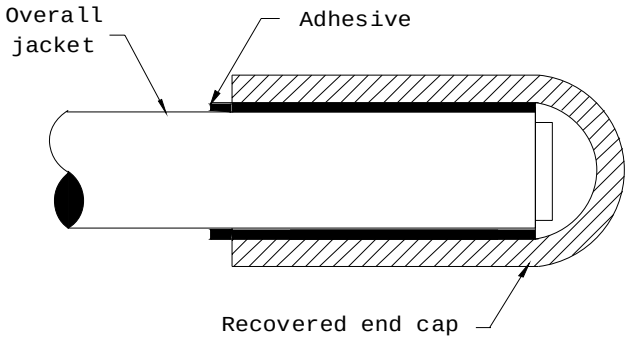


FIGURE 1A1-2. Completed end seal.

METHOD 1B1

CABLE JACKET REPAIR

1. SCOPE.

1.1 Scope. This method describes procedures for repairing the damaged outer jacket of an inboard conventional cable or a BOF cable, with Kevlar strength members intact.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the ends of the fiber as they may be razor sharp. Wash your hands after handling bare fiber.

c. Observe warnings and cautions on equipment and materials.

d. When visually inspecting an optical fiber, never stare into the end of a fiber connected to a laser source or LED.

e. Never look into the end of a BOF tube. Always wear approved safety glasses when handling BOF tubes that may be connected to a pressure source.

3.2 Procedure I. Method 1B1-1. Wraparound sleeve with rail closure.

3.2.1 The equipment and materials in table 1B1-I shall be used to perform this procedure.

TABLE 1B1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Electricians knife	1
Emery cloth (or fine file)	As required
Adhesive and sealant tape (Raychem Thermofit S1030 or equal)	As required
Repair sleeve (Raychem CRSM-x-1200 or equal)	1

TABLE 1B1-I. Equipment and materials - continued.

Description	Quantity
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

NOTE: The cable jacket repair sleeve material shall meet the requirements of SAE AMS-DTL-23053/15 and table 1B1-II. The material shall be coated with a heat-activated adhesive and fabricated into a wrap around sleeve with a rail closure system as shown on the figures below.

Step 1 - Select a repair sleeve in accordance with table 1B1-II.

TABLE 1B1-II. Repair sleeve dimensions (wraparound).

Cable type	Cable OD nominal mm (in)	B dimension mm (in)	Repair sleeve dimensions mm (in)			
			Length (minimum)	Rail to rail		Wall thickness after shrinking (+/- 10%)
				Expanded (minimum)	Recovered (maximum)	
4-fiber	8.1 (.32)	76 (3.0)	A + 2B	45.7 (1.8)	23.9 (.94)	2.0 (0.08)
8-fiber	11.1 (.44)	76 (3.0)	A + 2B	45.7 (1.8)	23.9 (.94)	2.0 (0.08)
18-fiber	17.4 (0.69)	76 (3.0)	A + 2B	79.8 (3.14)	48.5 (1.91)	2.0 (0.08)
36-fiber	20.8 (.82)	76 (3.0)	A + 2B	79.8 (3.14)	48.5 (1.91)	2.0 (0.08)
90-fiber	38.5 (1.52)	76 (3.0)	A + 2B	215.5 (8.48)	75.8 (2.98)	2.0 (0.08)
Single-tube	11.1 (.44)	76 (3.0)	A + 2B	45.7 (1.8)	23.9 (.94)	2.0 (0.08)
7-tube	29.0 (1.14) or 31.5 (1.24)	76 (3.0)	A + 2B	215.5 (8.48)	75.8 (2.98)	2.0 (0.08)
19-tube	50.8 (2.00)	76 (3.0)	A + 2B	215.5 (8.48)	75.8 (2.98)	2.0 (0.08)

Step 2 - Trim off the frayed, burned, or protruding jacket material with a knife using care not to damage the Kevlar, OFCC jacket, or BOF tubes (see figure 1B1-1). Square up the jacketing where required.

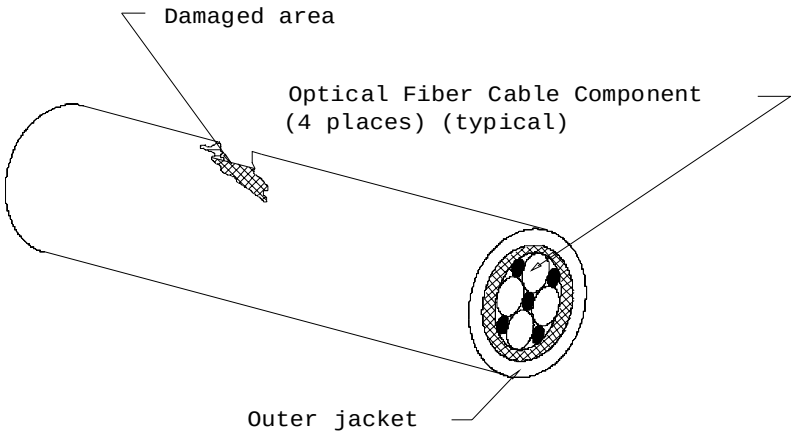


FIGURE 1B1-1. Damaged cable.

NOTE: Refer to figure 1B1-2 for a definition of A and B dimensions.

Step 3 - Abrade the jacket circumferentially to the dimension shown using emery cloth or a fine file (see table 1B1-II and figure 1B1-2).

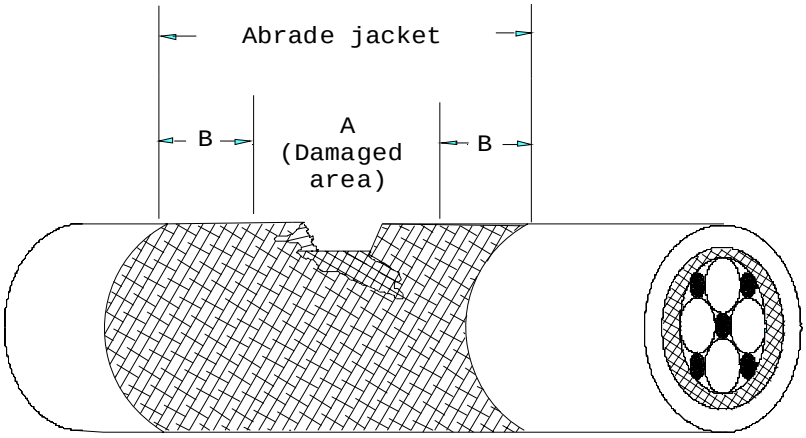


FIGURE 1B1-2. Cable preparation.

Step 4 - Clean the abraded area with a wipe dampened with alcohol, and blow dry with air.

Step 5 - Fill any large depressions or voids with tape, as required, to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of the adhesive tape and heat them slightly with the heat gun to soften them. Roll the tape with your fingers and press it into the damaged area. Repeat the process until the damaged area is filled, then, holding the heat gun approximately 100 mm (4 in) away, apply just enough heat to the tape to form and contour the tape to the cable (see figure 1B1-3).

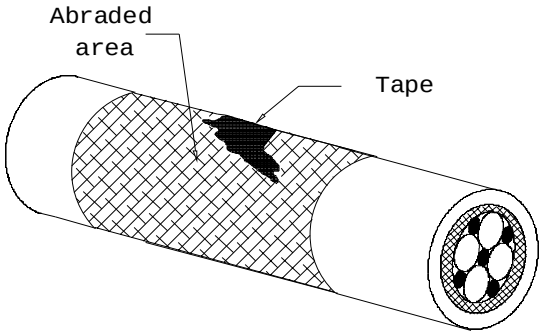


FIGURE 1B1-3. Tape contoured to cable.

Step 6 - Cut the cable jacket repair sleeve to the proper length (see table 1B1-II).

Step 7 - CAUTION: Do not overheat the cable. The jacket should be just warm to the touch. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket.

Hold the heat gun approximately 100 mm (4 in) away from the cable and apply heat to all parts of the cable jacket to which the repair sleeve is to be applied.

Step 8 - Assemble the repair sleeve as shown (see figure 1B1-4). Leave approximately 13 mm (0.5 in) overhang of channel on both sides of sleeve (see figure 1B1-5).

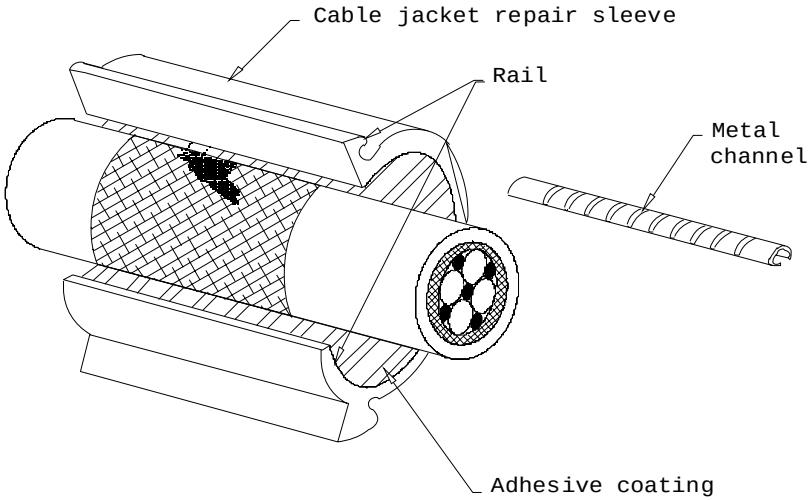


FIGURE 1B1-4. Installing sleeve.

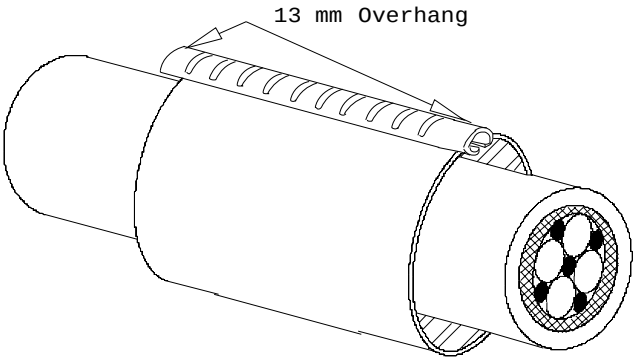


FIGURE 1B1-5. Assembled sleeve.

Step 9 - CAUTION: Do not overheat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the sleeve and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

Center the sleeve over the damaged area and, holding the heat gun approximately 100 mm (4 in) away, heat evenly from the center to the ends around the entire sleeve until the sleeve changes color indicating a full recovery (see figure 1B1-6). Melted sealant should be visible at the end of sleeve.

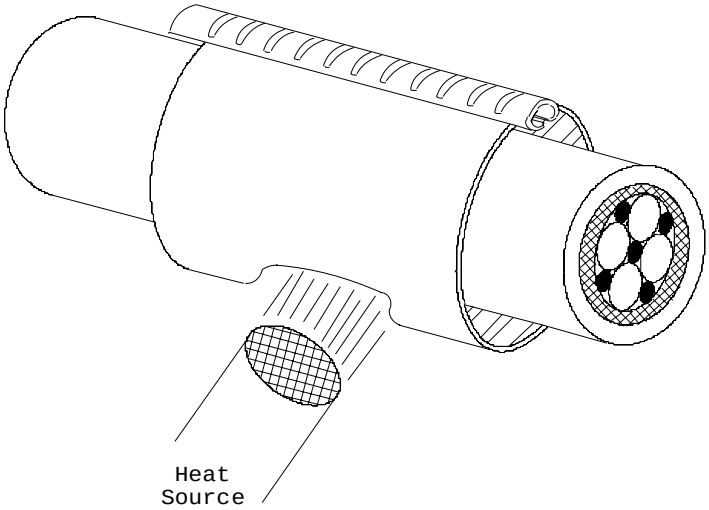


FIGURE 1B1-6. Shrinking sleeve.

Step 10 - When the sleeve has cooled, the rail and metal channel may be trimmed from the sleeve to provide greater flexibility to the cable (see figure 1B1-7).

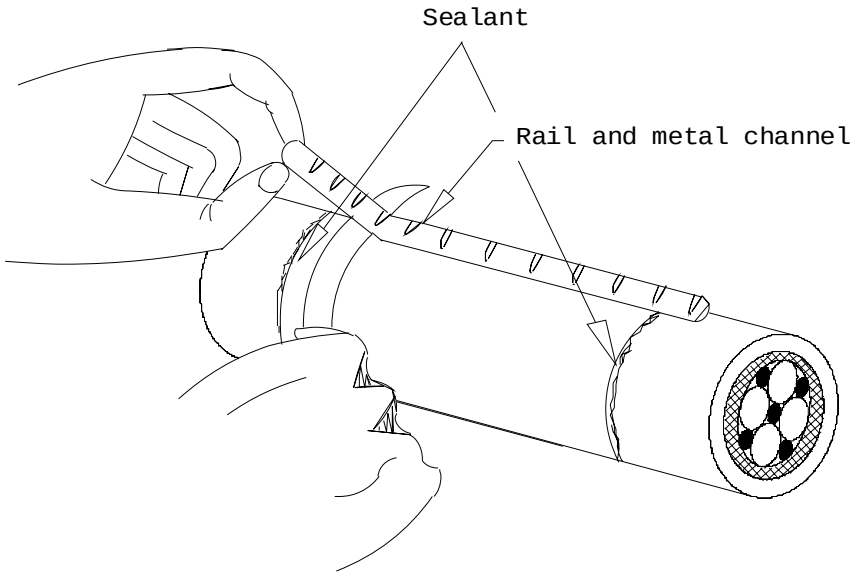


FIGURE 1B1-7. Trimming rails and metal channel.

3.3 Procedure II. Method 1B1-2 tube sleeve.

3.3.1 The equipment and materials in table 1B1-III shall be used to perform this procedure.

TABLE 1B1-III. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Electricians knife	1
Emery cloth (or fine file)	As required
Repair sleeve (Raychem SST-FR series or equal)	1
Adhesive and sealant tape (Raychem Thermofit S1030 or equal)	As required
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

NOTE: The cable repair sleeve material shall meet the requirements of SAE AMS-DTL-23053/15 and table 1B1-IV. The material shall be coated with a heat-activated adhesive and fabricated into a tube shape as shown on the figures below.

Step 1 - Select a repair sleeve in accordance with table 1B1-IV.

Step 2 - Trim off the frayed, burned, or protruding jacket material with a knife using care not to damage the Kevlar, OFCC jacket, or BOF tube (see figure 1B1-8). Square up the jacketing where required.

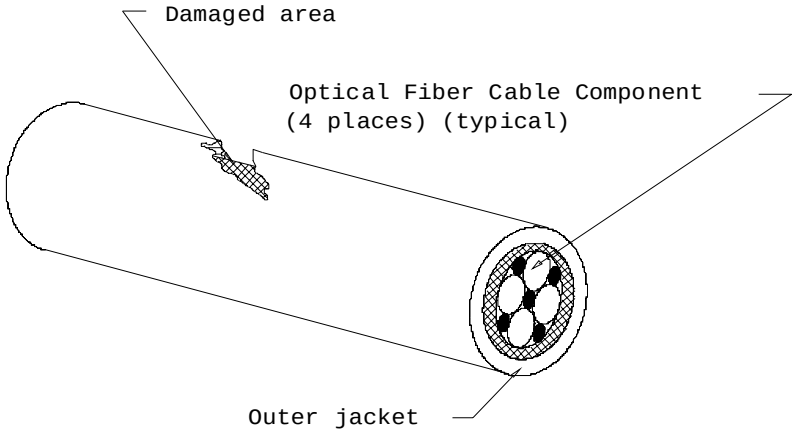


FIGURE 1B1-8. Damaged cable.

TABLE 1B1-IV. Repair sleeve dimensions (tube).

Cable type	Cable OD mm (in) nominal	B Dimension mm (in)	Repair sleeve dimensions mm (in)			
			Length (minimum)	Inside diameter		Wall thickness after shrinking (+/- 10%)
				Expanded (minimum)	Recovered (maximum)	
4-Fiber	8.1 (0.32)	101 (4.0)	A + 2B	19.1 (0.75)	5.6 (0.22)	2.4 (0.10)
8-Fiber	11.1 (0.44)	101 (4.0)	A + 2B	19.1 (0.75)	5.6 (0.22)	2.4 (0.10)
18-Fiber	17.4 (0.69	101 (4.0)	A + 2B	27.9 (1.10)	9.5 (0.38)	3.0 (0.12)
36-Fiber	20.8 (0.82)	101 (4.0)	A + 2B	27.9 (1.10)	9.5 (0.38)	3.0 (0.12)
90-Fiber	38.5 (1.52)	101 (4.0)	A + 2B	50.7 (2.00)	19.1 (0.75)	3.9 (.16)

TABLE 1B1-IV. Repair sleeve dimensions (tube) continued.

Cable type	Cable OD mm (in) nominal	B Dimension mm (in)	Repair sleeve dimensions mm (in)			
			Length (minimum)	Inside diameter		Wall thickness after shrinking (+/- 10%)
				Expanded (minimum)	Recovered (maximum)	
Single-Tube	11.1 (0.44)	101 (4.0)	A + 2B	19.1 (0.75)	5.6 (0.22)	2.4 (0.10)
7-Tube	29.0 (1.14)	101 (4.0)	A + 2B	38.1 (1.50)	12.7 (0.50)	3.6 (0.14)
7-Tube	31.5 (1.24)	101 (4.0)	A + 2B	38.1 (1.50)	12.7 (0.50)	3.6 (0.14)
19-Tube	50.8 (2.00)	101 (4.0)	A + 2B	68.6 (2.70)	22.9 (.90)	3.9 (.16)

NOTE: Refer to figure 1B1-9 for a definition of A and B dimensions.

Step 3 - Abrade the jacket circumferentially to the dimension shown using emery cloth or a fine file (see table 1B1-IV and figure 1B1-9).

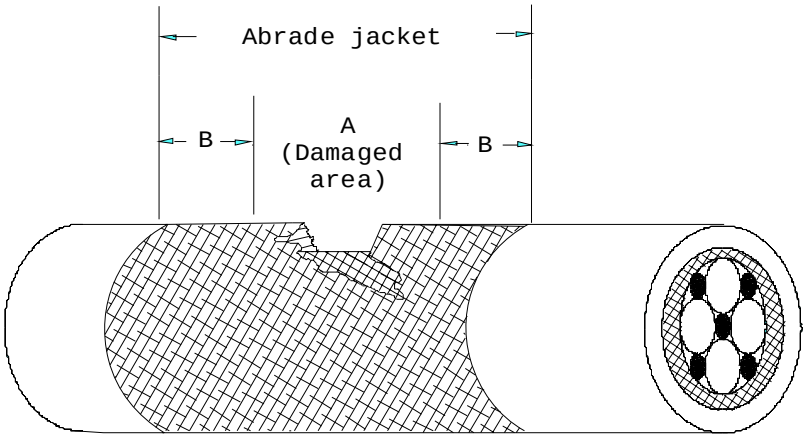


FIGURE 1B1-9. Cable preparation.

Step 4 - Clean the abraded area with alcohol and blow dry with air.

Step 5 - Fill any large depressions or voids with tape, as required, to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of the adhesive tape and heat them slightly with the heat gun to soften them. Roll the tape with your fingers and press it into the damaged area. Repeat the process until the damaged area is filled, then, holding the heat gun approximately 100 mm (4 in)

away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-10).

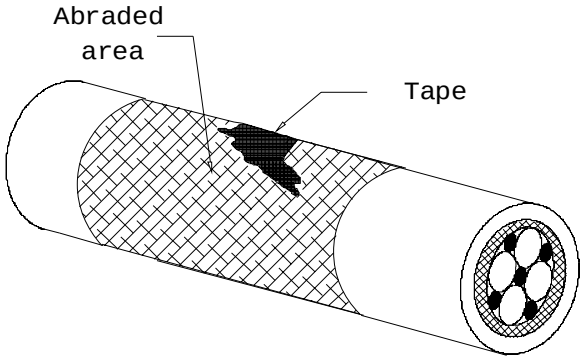


FIGURE 1B1-10. Tape contoured to cable.

Step 6 - Cut the cable jacket repair sleeve to the proper length (see table 1B1-IV.)

Step 7 - CAUTION: Do not overheat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the sleeve and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

Center the repair sleeve over the damaged area. Hold the heat gun approximately 100 mm (4 in) away and heat the center by applying heat evenly around the sleeve until it shrinks over cable (see figure 1B1-11). Working towards one end, shrink the sleeve to the cable until sealant is flowing at end of the sleeve. Repeat the procedure on the other half of the sleeve (see figure 1B1-12).

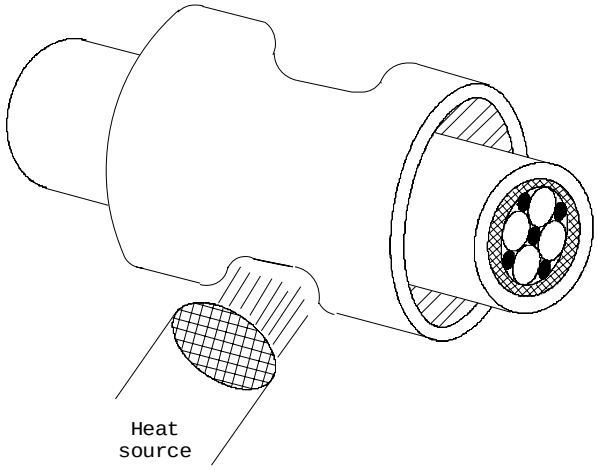


FIGURE 1B1-11. Shrinking the sleeve.

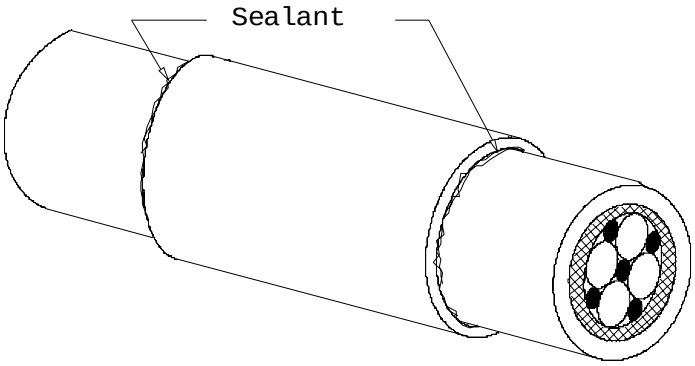


FIGURE 1B1-12. Completed repair.

Step 8 - Remove heat and allow the sleeve to cool.

3.4 Procedure III. Method 1B1-3 rubber tape.

3.4.1 The equipment and materials in table 1B1-V shall be used to perform this procedure.

TABLE 1B1-V. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Electricians knife	1
Emery cloth (or fine file)	As required
Adhesive and sealant tape (Raychem Thermofit S1030 or equal)	As required
Heat gun (Raychem 500B or equal)	1
Fiberglass tape (1 in.)	As required
Electrical coating (3M Scotch Kote or equal)	As required
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

Step 1 - Trim off any frayed, burned, or protruding jacket material with a knife using care not to damage the Kevlar, OFCC jacket, or BOF tubes (see figure 1B1-13). Square up the jacketing where required.

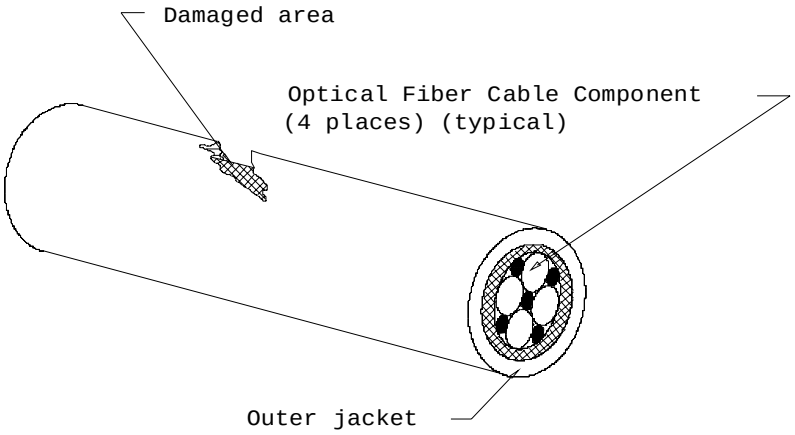


FIGURE 1B1-13. Damaged cable.

Step 2 - Abrade the jacket circumferentially approximately 80 mm (3 in) on either side of the damaged area using emery cloth or a fine file (see figure 1B1-14).

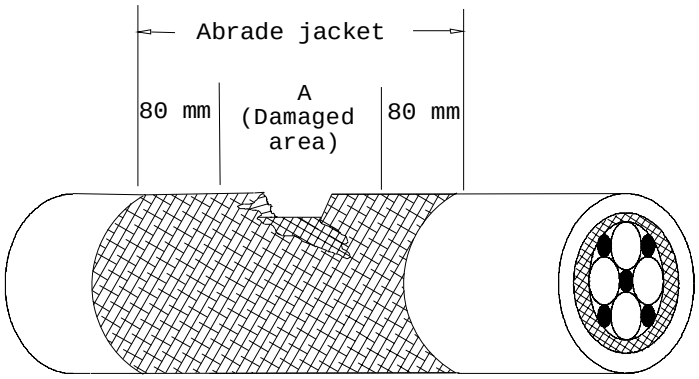


FIGURE 1B1-14. Cable preparation.

Step 3 - Clean the abraded area with alcohol and blow dry with air.

Step 4 - Fill any large depressions or voids with adhesive tape as required to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of adhesive tape and heat them slightly with the heat gun to soften them. Roll the tape with your fingers and press them into the damaged area. Repeat process until the damaged area is filled, then, holding the heat gun approximately 100 mm (4 in) away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-15).

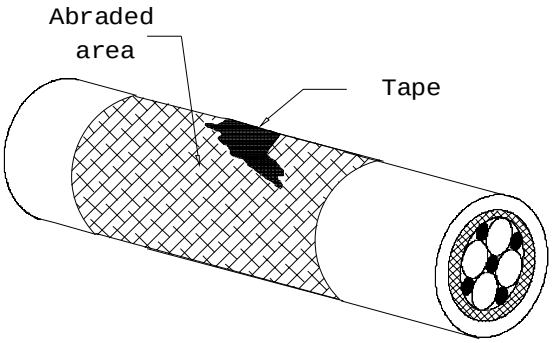


FIGURE 1B1-15. Tape contoured to the cable.

Step 5 - Cover the entire abraded area with one layer of half lapped adhesive and sealant tape, pulling the tape to approximately one-half its original thickness.

Step 6 - Cover the adhesive and sealant tape with one layer of half lapped fiberglass tape.

Step 7 - CAUTION: Do not over heat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the tape and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

Holding the heat gun approximately 100 mm (4 in) away from the cable, heat the entire area covered by the tape for approximately 3.5 minutes with the heat gun to blend the adhesive and sealant into the fiberglass tape.

Step 8 - Apply a coat of electrical coating to the entire area and let it set a minimum of 10 minutes.

3.5 Procedure IV. Method 1B1-4. Wraparound sleeve with adhesive closure.

3.5.1 The equipment and materials in table 1B1-VI shall be used to perform this procedure.

TABLE 1B1-VI. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Electricians knife	1
Emery cloth (or fine file)	As required
Adhesive and sealant tape (Raychem Thermofit S1030 or equal)	As required
Repair sleeve (Raychem SFR series or equal)	1

TABLE 1B1-VI. Equipment and materials - continued.

Description	Quantity
Repair sleeve (Raychem SFR series or equal)	1
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

NOTE: The cable repair sleeve material shall meet the requirements of SAE AMS-DTL-23053/15 and table 1B1-VII. The material shall be coated with a heat-activated adhesive and fabricated into a wrap with a self adhesive closure system as described below.

Step 1 - Select a repair sleeve in accordance with table 1B1-VII.

TABLE 1B1-VII. Repair sleeve dimensions (wraparound).

Cable type	Cable OD mm (in) nominal	B Dimension mm (in)	Repair sleeve dimensions mm (in)			
			Length (minimum)	Inside diameter		Wall thickness after shrinking (+/- 10%)
				Expanded (minimum)	Recovered (maximum)	
36-Fiber	20.8 (.82)	76 (3.0)	A + 2B	31.8 (1.25)	12.7 (.50)	2.0 (0.08)
90-Fiber	38.5 (1.52)	76 (3.0)	A + 2B	52.1 (2.05)	20.8 (82)	2.0 (0.08)
7-tube	29.0 (1.14)	76 (3.0)	A + 2B	31.8 (1.25)	12.7 (.50)	2.0 (0.08)
7-tube	31.5 (1.24)	76 (3.0)	A + 2B	43.2 (1.70)	17.3 (.68)	2.0 (0.08)
19-tube	50.8 (2.00)	76 (3.0)	A + 2B	116.84 (4.60)	46.7 (1.84)	2.0 (0.08)

NOTE: Refer to figure 1B1-17 for a definition of A and B dimensions.

NOTE: Repair sleeves are not currently available for the conventional 4-fiber, 8-fiber cable, 18 fiber, and single-tube BOF cable sizes.

Step 2 - Trim off any frayed, burned, or protruding jacket material with a knife using care not to damage the Kevlar, OFCC jacket, or BOF tubes (see figure 1B1-16). Square up the jacketing where required.

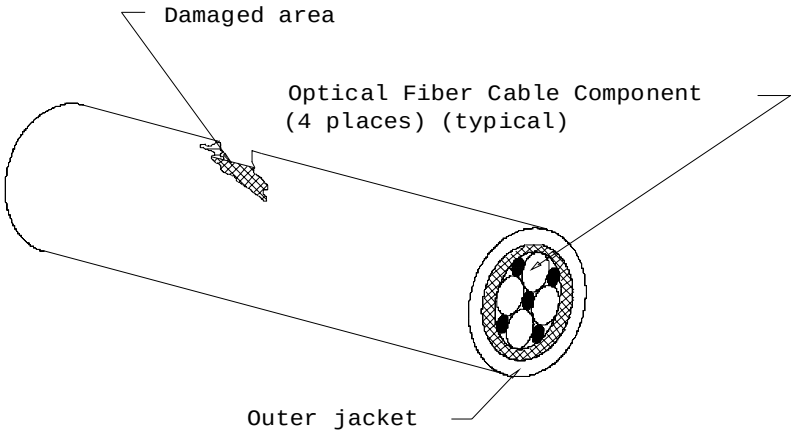


FIGURE 1B1-16. Damaged cable.

Step 3 - Abrade the jacket circumferentially to the dimension shown using emery cloth or a fine file (see figure 1B1-17).

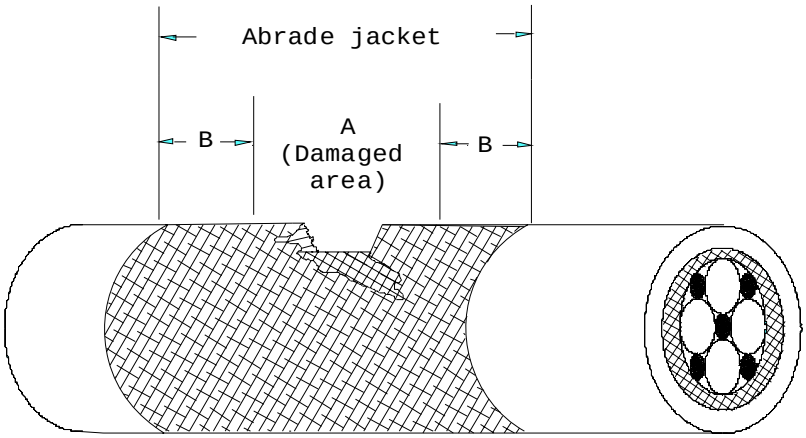


FIGURE 1B1-17. Cable preparation.

Step 4 - Clean the abraded area with alcohol and blow dry with air.

Step 5 - Fill any large depressions or voids with adhesive tape as required to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of adhesive tape and heat them slightly with the heat gun to soften them. Roll the tape with your fingers and press them into the damaged area. Repeat process until the damaged area is filled, then, holding the heat gun approximately 100 mm (4 in) away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-18).

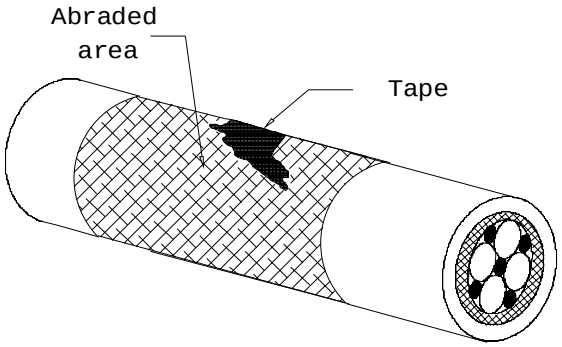


FIGURE 1B1-18. Tape contoured to cable.

Step 6 - Cut the cable jacket repair sleeve to the proper length (see table 1B1-VII.)

Step 7 - CAUTION: Do not overheat the cable. The jacket should be just warm to the touch. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket.

Hold the heat gun approximately 100 mm (4 in) away from the cable and apply heat to all parts of the cable jacket to which the repair sleeve is to be applied.

Step 8 - Remove the protective release tape from both flaps of the sleeve to expose the surfaces of the contact adhesive.

Step 9 - Place the sleeve around the cable so that the sealant side of the sleeve is next to the cable, align the sleeve side edges, and press the contact surfaces together along the full length of the sleeve (see figure 1B1-19).

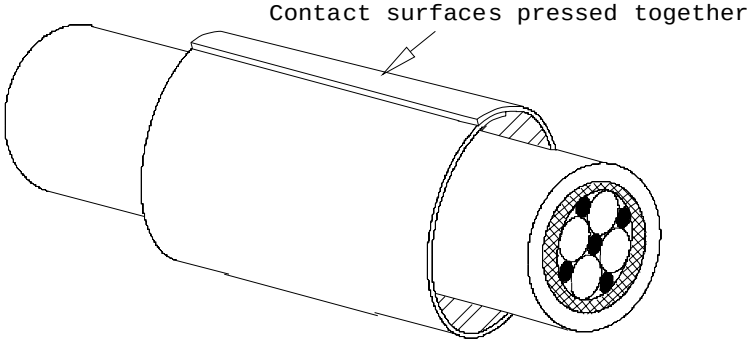


FIGURE 1B1-19. Assembled sleeve.

Step 10 - CAUTION: Do not over heat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the tape and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

Center the repair sleeve over the damaged area. Hold the heat gun approximately 100 mm (4 in) away and heat the center by applying heat evenly around the sleeve until it shrinks over cable (see figure 1B1-20). Working towards one end, shrink the sleeve to the cable until

sealant is flowing at end of the sleeve. Repeat the procedure on the other half of the sleeve (see figure 1B1-21).

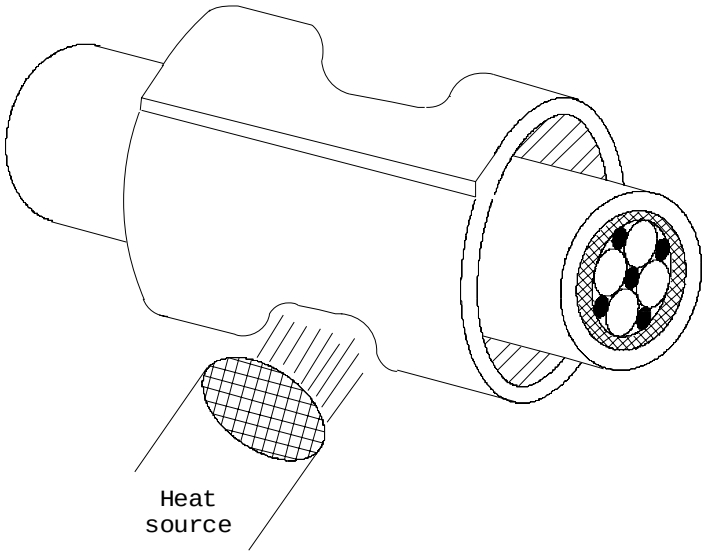


FIGURE 1B1-20. Shrinking the sleeve.

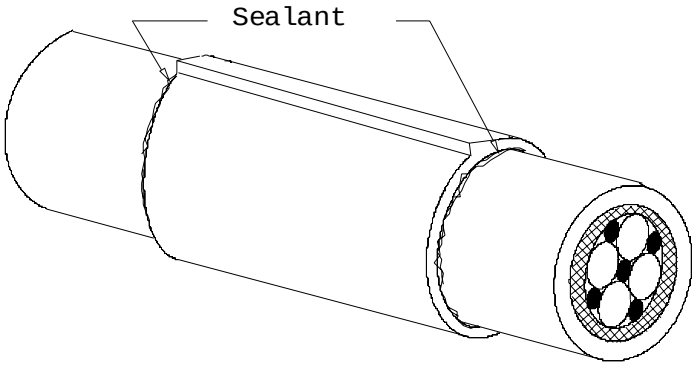


FIGURE 1B1-21. Completed repair.

Step 11 -Remove heat and allow the sleeve to cool.

METHOD 1C1

BOF CABLE SPLICING

1. SCOPE

1.1 Scope. This method describes procedures for splicing together two multi-tube BOF cable ends. This method is only applicable for the splicing of multi-tube BOF cables. This procedure should not be used to splice a damaged multi-tube cable if any of the tubes contain operational fibers.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURE

3.1 Safety summary. The following safety procedures shall be observed:

a. Observe warnings and cautions on equipment and materials.

b. Never look into the end of a BOF tube. Always wear approved safety glasses when handling BOF tubes that may be connected to a pressure source.

3.2 Procedure.

3.2.1 The equipment and materials in table 1C1-I shall be used to perform this procedure.

TABLE 1C1-I. Equipment and materials.

Description	Quantity
Cable jacket stripping tool (NAVSEA DWG 6872811-08 or equal)	1
BOF cable cutter	1
Tube cutter	1
Kevlar shears (NAVSEA DWG 6872811-16 or equal)	1
Pipe (metal or polymer, approved for shipboard use)	As required
Male threaded pipe adapter (compatible with pipe)	2
Female threaded pipe adapter (compatible with pipe)	2
Pipe cutter	1
Heat gun (Raychem 5008 or equal)	1
Heat shrink sleeving (Raychem SST-FR series or equal)	As required
Cold shrink sleeving (3M CST-S series or equal)	As required
Tape	As required
Tube coupler (A-A-59731 or equal)	As required
Wipes	As required
Alcohol bottle with alcohol/2-propanol	1

TABLE 1C1-I. Equipment and materials -continued.

Description	Quantity
Canned air	As required
Ruler	1
Emery cloth	As required

NOTE: The heat shrink sleeve material shall meet the requirements of SAE AMS-DTL-23053/15. The material shall be coated with a heat-activated adhesive and fabricated into a tube shape as shown on the figures below.

3.2.2 Coupling the BOF cable tubes.

Step 1 - Determine the desired length of the splice section and the tube coupler stagger scheme (see figure 1C1-1).

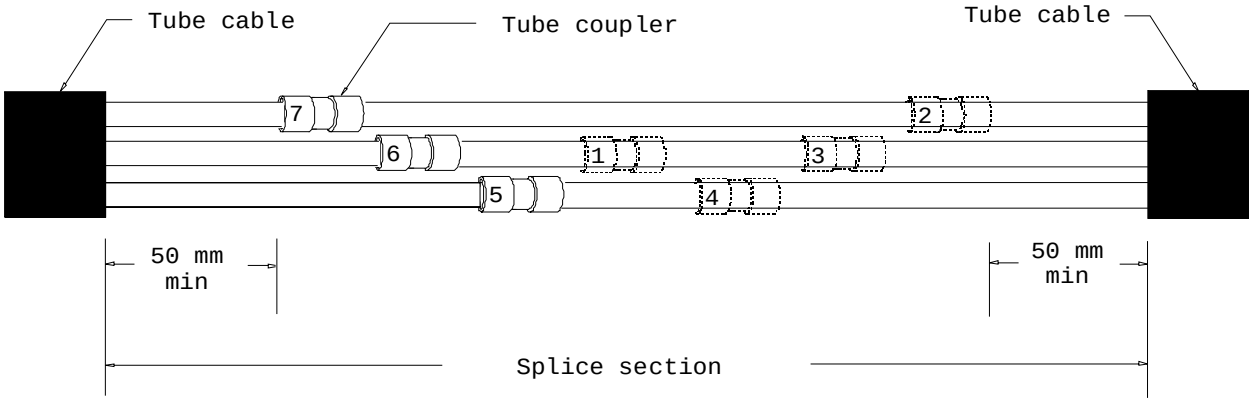


FIGURE 1C1-1. Example tube coupler stagger scheme.

NOTE: The length of the splice section depends on the diameter of pipe used for the splice center section and the number of tubes in the BOF cable. Center section pipes with inner diameters slightly larger than the BOF cable outer diameter will require long splice section lengths to allow for tube coupler staggering within the splice. Larger center section pipe diameters allow for shorter tube coupler stagger distances and a shorter overall splice section length.

NOTE: Tubes shall not have tube couplers installed closer than 50 mm (2 in) to the ends of the splice section.

Step 2 - Place the two BOF cables approximately in their final installed configuration. With the BOF cable cutter, trim the two BOF cables to the desired length.

NOTE: The two BOF cables should be cut so that they have an overlap equal to the splice section length.

Step 3 - Select pipe for the splice ends with an inner diameter slightly larger than the BOF cable outer diameter. With the pipe cutter, cut two lengths of the pipe 150 mm (6 in) in length.

NOTE: The inner diameter of the pipe should be no greater than 8 mm (0.3 in) larger than the outer diameter of the BOF cable.

Step 4 - Assemble a female threaded pipe adapter to each 150 mm (6 in) section of pipe using approved procedures.

Step 5 - Select pipe for the splice center section. With the pipe cutter, cut the pipe to length (see figure 1C1-2).

NOTE: The splice center section pipe diameter may be larger than the splice end pipe diameter, but the male threaded pipe adapters used on the center section pipe must be compatible with the female threaded pipe adapters assembled to the splice end pipes.

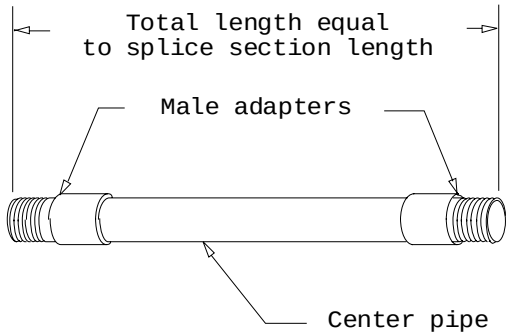


FIGURE 1C1-2. Splice center section length.

Step 6 - Assemble the male threaded pipe adapters to each end of the center section pipe using approved procedures.

NOTE: The total length of the assembled male threaded adapters and center section pipe shall be equal to the splice section length.

Step 7 - Determine the total splice length. The total splice length can be obtained by mating the two splice ends to the splice center section and measuring the length of the assembly.

Step 8 - Cut a length of heat shrink sleeve (with an inner diameter greater than the outer diameter of the splice center section and splice ends) equal to the total splice length minus 30 mm (1 in).

NOTE: A cold shrink sleeve may be used in lieu of a heat shrink sleeve.

Step 9 - Cut two lengths of heat shrink sleeve (with an inner diameter greater than the outer diameter of pipe on the splice end) approximately 200 mm (8 in) in length.

NOTE: A cold shrink sleeve may be used in lieu of a heat shrink sleeve.

Step 10 - Slide the shrink sleeves, the splice ends, and the splice center section onto the two BOF cables as shown in figure 1C1-3.

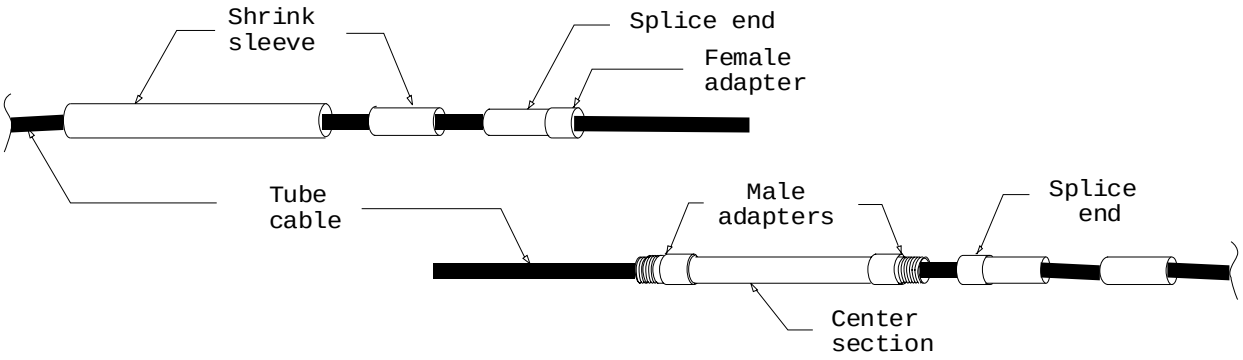


FIGURE 1C1-3. Splice parts on the BOF cables.

Step 11 -Measure each BOF cable from the cable end a distance equal to the splice section length, and mark the cable outer jacket.

Step 12 -With the cable jacket-stripping tool, ring cut each BOF cable jacket at the mark and strip the jacket from the each BOF cable end.

NOTE: Make sure that the individual BOF tubes are not punctured, crushed, or kinked while removing the BOF cable jacket.

Step 13 -Trim the strength members so that they extend one half of the splice section length from the BOF cable outer jacket. Fold them back along the BOF cable outer jacket and tape them to the jacket (the tape will be removed later).

Step 14 -Trim back the cable fillers and waterblocking tape around the BOF tubes to the BOF cable jacket edge.

NOTE: Make sure that the individual BOF tubes are not punctured, crushed, or kinked while trimming back the cable elements.

Step 15 -Position the two cable ends so that the BOF tube ends from one cable align with the other cable’s outer jacket end.

Step 16 -Use the tube cutter to cut tube number one of both BOF cables at approximately the center of the splice section. Visually verify that the ends of both tubes are cut perpendicular to the tube length. Clean the end of each BOF tube with a wipe dampened with alcohol and blow dry as necessary.

Step 17 -Slide a tube coupler onto one of the BOF tubes and firmly seat the tube within the tube coupler. Slide the second BOF tube into the other end of the tube coupler and firmly seat the tube within the tube coupler.

NOTE: The distance between the two BOF cable jackets should now be equal to the splice section length.

Step 18 -Apply an axial load of approximately 22 N (5 lbs) between the two tubes to verify that both BOF tubes are properly engaged into the tube coupler.

Step 19 -Referring to the stagger scheme determined in Step 1, use the tube cutter to cut tube two of each of the two BOF cables to the appropriate length. Visually verify that the end of each tube is cut perpendicular to the tube length. Clean the end of each BOF tube with a wipe dampened with alcohol and blow dry as necessary.

Step 20 - Repeat steps 16 and 17 for tube number two of each of the BOF cables.

Step 21 - Repeat steps 18 and 19 for each of the other tubes in the BOF cables.

NOTE: BOF cables shall always be spliced with matching tube numbers coupled together.

3.2.3 Assembling the splice body.

Step 1 - Slide the splice center section over the tubes so that the ends of the male pipe adapters are lined up with the ends of the BOF cable jackets (see figure 1C1-4).

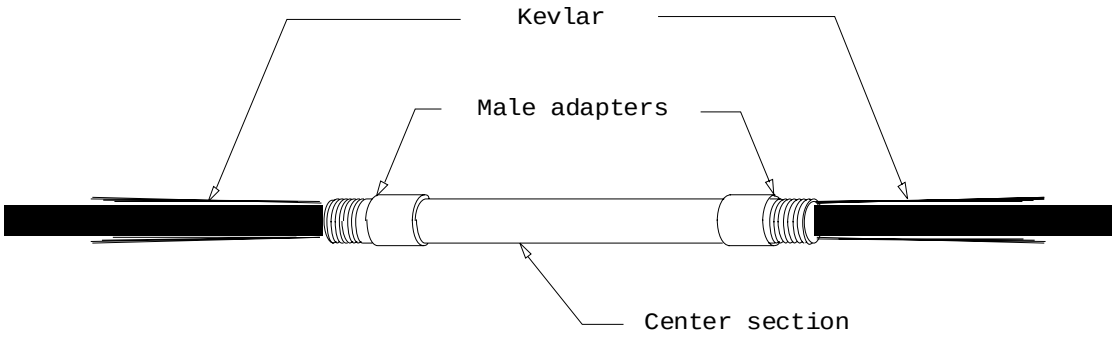


FIGURE 1C1-4. Positioning the splice center section.

Step 2 - Remove the tape from the Kevlar and fold the Kevlar over the splice center section. Ensure that the Kevlar is uniformly distributed around the center section.

Step 3 - Holding the Kevlar taut and the center section against the end of the BOF cable jacket, slide the first splice end up to the splice center section and engage the adapter threads for a minimum of 3 complete revolutions.

NOTE: Make sure that the BOF cable does not rotate as the splice end is tightened onto the splice center section.

NOTE: When metal pipe is used, minimize uncoupling and recoupling the pipe sections as this may damage the Kevlar.

NOTE: Once the splice end is engaged, movement of the BOF cable into or out of the splice should not occur.

Step 4 - Repeat step 4 for the second splice end.

Step 5 - Form the Kevlar from both ends up over the center section and tape the Kevlar ends to the splice near the center of the splice.

Step 6 - Abrade each BOF cable jacket circumferentially over the length that will be in contact with the short shrink sleeve using emery cloth. Clean the end of each of the BOF cable jackets with a wipe dampened with alcohol and blow dry as necessary.

Step 7 - Slide the short shrink sleeve up over one end of the splice. The sleeve should be placed so that it covers the pipe on the splice end and extends beyond the splice end a minimum of 80 mm (3 in).

Step 8 - CAUTION: Do not overheat the BOF cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the BOF cable jacket. Discontinue heating of the sleeve and allow the BOF cable jacket to cool before reheating if the BOF cable jacket shows any signs of bubbling.

For heat shrink sleeves only: Holding the heat gun approximately 100 mm (4 in) away from the heat shrink sleeve, shrink the sleeve from the middle to both ends around the entire sleeve. Heat until the sleeve has shrunk to a snug fit around the splice end pipe and the BOF cable, and the sealant is flowing at the ends.

For cold shrink sleeves only: Remove the sleeve center support and allow the sleeve to shrink into place.

Step 9 - Repeat steps 7 and 8 for the other end of the splice.

Step 10 - Abrade each short shrink sleeve circumferentially over the length that will be in contact with the long shrink sleeve using emery cloth. Clean the end of each of the short shrink sleeves with a wipe dampened with alcohol and blow dry as necessary.

Step 11 - Slide the long shrink sleeve up the BOF cable. The sleeve should be placed so that it is approximately centered over the splice.

Step 12 - For heat shrink sleeves only: Holding the heat gun approximately 100 mm (4 in) away from the heat shrink sleeve, shrink the sleeve from the middle to both ends around the entire sleeve. Heat until the sleeve has shrunk to a snug fit around the BOF cable splice, and the sealant is flowing at the ends (see figure 1C1-5).

For cold shrink sleeves only: Remove the sleeve center support and allow the sleeve to shrink into place.

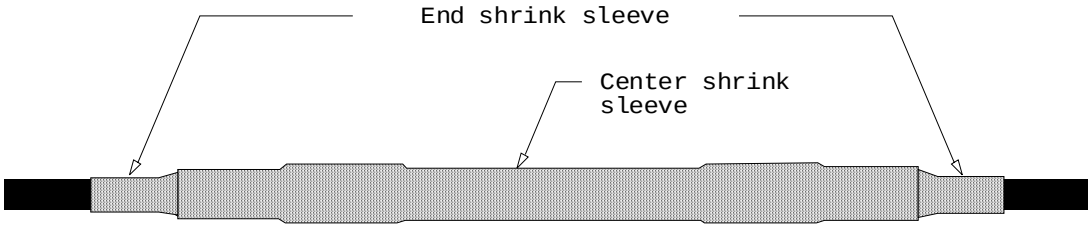


FIGURE 1C1-5. Completed splice.

Step 13 - Verify the continuity of each spliced tube with a ball bearing using method 6H1 of this standard.

NOTE: Alternatively, the continuity of each spliced tube may be verified prior to assembling the splice body.

METHOD 1D1

BOF CABLE FURCATION

1. SCOPE

1.1 Scope. This method describes a procedure for furcating a multiple-tube BOF cable into an aggregate of single-tube BOF cables for distribution within the ship. This method is applicable to both seven-tube and nineteen-tube BOF cables.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURES

3.1 Safety summary. The following safety procedures shall be observed:

a. Observe warnings and cautions on equipment and materials.

b. Never look into the end of a BOF tube. Always wear approved safety glasses when handling BOF tubes that may be connected to a pressure source.

3.2 Procedure.

3.2.1 The equipment and materials in table 1D1-I shall be used to perform this procedure.

TABLE 1D1-I. Equipment and materials.

Description	Quantity
Cable jacket stripping tool (NAVSEA DWG 6872811-08 or equal)	1
BOF cable cutter	1
Tube cutter	1
Kevlar shears (NAVSEA DWG 6872811-16 or equal)	1
Heat gun (Raychem 5008 or equal)	1
Tape sealant (Raychem SFTS-1 or equal)	As required
Heat shrink sleeves (Raychem SST-FR series or equal)	As required
Cold shrink sleeves (3M CST-S series or equal)	As required
Tube coupler (A-A-59731 or equal)	As required
Wipes	As required
Alcohol bottle with alcohol/2-propanol	1
Canned air	As required
Tape	As required
Emery cloth	As required

TABLE 1D1-I. Equipment and materials - continued.

Description	Quantity
Ruler	1
Marking pen	1

Step 1 - With the BOF cable cutter, trim the multiple-tube BOF cable to the desired length within the space.

Step 2 - From the cable end, measure the length shown in table 1D1-II and mark the cable outer jacket.

TABLE 1D1-II. Cable jacket cut length.

BOF cable type	Jacket cut length mm (in)
7-tube	127 (6.0)
19-tube	152 (7.0)

Step 3 - With the cable jacket-stripping tool, cut the cable jacket along the cable length from the mark to the cable end. Rotate the cable slightly and cut the cable jacket again in the same manner. Repeat until the cable jacket has been cut into approximately equal width strips around the cable circumference.

NOTE: The width of the cable jacket strips should be 12 mm to 18 mm (0.5 in to 0.75 in).

Step 4 - Separate the cable jacket strips from one another, fold them back along the cable length, and temporarily tape them to the cable.

NOTE: Make sure that the individual BOF tubes are not cut, punctured, crushed, or kinked while cutting and peeling back the BOF cable jacket.

Step 5 - Trim back the strength members, cable fillers and waterblocking tape around the BOF tubes approximately to the mark on the cable jacket.

NOTE: Make sure that the individual BOF tubes are not punctured, crushed, or kinked while trimming back the cable elements.

Step 6 - For each BOF tube, use the tube cutter to trim approximately 76 mm (3.0 in) off the end of the tube. Visually verify that the end of each tube is cut perpendicular to the tube length. Clean the end of each BOF tube with a wipe dampened with alcohol and blow dry as necessary.

Step 7 - Cut a length of heat shrink sleeve as shown in Table 1D1-III. Slide the heat shrink sleeve over the end of the multiple-tube BOF cable so that it is approximately 50 cm (2 ft) from the end of the cable.

NOTE: The heat shrink sleeve material shall meet the requirements of SAE AMS-DTL-23053/15 and table 1D1-III.

NOTE: A cold shrink sleeve may be used in lieu of a heat shrink sleeve.

TABLE 1D1-III. Heat shrink sleeve dimensions.

BOF Cable	Expanded	Fully Recovered		Length
	I.D. (min)	I.D. (max)	Wall Thickness	
7-tube	68.6 mm (2.7 in.)	22.9 mm (0.90 in.)	3.9 mm (0.16 in.)	279 mm (12 in.)
19-tube	114.3 mm (4.5 in.)	44.5 mm (1.75 in.)	4.3 mm (0.17 in.)	305 mm (13 in.)

Step 8 - For each BOF tube that will not be connected to a single tube BOF cable, end seal the BOF tube using a BOF tube coupler and a BOF tube fitting plug in accordance with Method 2J1 of this standard.

Step 9 - Access the single tube BOF cables that are to be connected to the multiple-tube BOF cable within the compartment. Select one cable and measure approximately 3.8 cm (1.5 in) from the end of the single tube BOF cable and mark the outer jacket. With the cable jacket-stripping tool, ring cut and remove the single tube BOF cable outer jacket up to the mark.

NOTE: Make sure that the individual tube is not cut, punctured, crushed, or kinked while removing the single tube BOF cable jacket.

Step 10 - Trim back any strength members or waterblocking tape around the BOF tube flush to the BOF cable jacket edge.

Step 11 - Use the tube cutter to trim approximately 16 mm (0.6 in) off the end of the BOF tube. Visually verify that the end of the tube is cut perpendicular to the tube length.

Step 12 - Abrade the end of each single tube cable jacket circumferentially over the length that will be in contact with the shrink tube using emery cloth. Clean the end of the single tube BOF cable jacket with a wipe dampened with alcohol and blow dry as necessary.

Step 13 - Cut a 127 mm (5.0 in) length of heat shrink sleeve (in accordance with the diameter in table 1D1-IV). Slide the heat shrink sleeve over the single tube BOF cable.

NOTE: The heat shrink sleeve material shall meet the requirements SAE AMS-DTL-23053/15 and table 1D1-IV.

NOTE: A cold shrink sleeve may be used in lieu of a heat shrink sleeve.

TABLE 1D1-IV. Heat shrink sleeve dimensions (single tube BOF cable).

Expanded	Fully Recovered	
I.D. (min)	I.D. (max)	Wall Thickness
27.9 mm (1.1 in.)	9.5 mm (0.375 in.)	3.1 mm (0.120 in.)

Step 14 - Clean the end of the BOF tube with a wipe dampened with alcohol and blow dry as necessary. Slide a tube coupler onto the BOF tube and firmly seat the tube within the tube coupler.

NOTE: There should be a gap (2 to 3 mm (0.1 in)) between the tube coupler and the single tube BOF cable jacket. If there is not a gap, remove the tube from the tube coupler, strip off 2 to 3 mm (0.1 in) of the single tube BOF cable jacket, and reinstall the tube within the tube coupler.

Step 15 - Apply an axial load of approximately 22 N (5 lbs) between the single tube BOF cable and the tube coupler to verify that the BOF tube is properly engaged into the tube coupler. Move the shrink sleeve up the single tube BOF cable so that it is even with the end of the single tube cable jacket.

Step 16 - CAUTION: Do not overheat the BOF cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the BOF tube and the BOF cable jacket. Discontinue heating of the sleeve and allow the BOF tube or BOF cable jacket to cool before reheating if either shows any signs of bubbling.

For heat shrink sleeves only: Holding the heat gun approximately 100 mm (4 in) away, heat evenly from the center to the ends around the entire sleeve. Heat until the sleeve has shrunk to a snug fit around the single tube cable and the sealant is flowing at the ends (see figure 1D1-1).

For cold shrink sleeves only: Remove the sleeve center support and allow the sleeve to shrink into place.

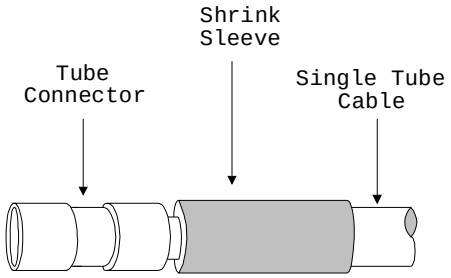


FIGURE 1D1-1. Installed single tube BOF cable sleeve.

Step 17 - Clean the end of the BOF tube of the multiple-tube BOF cable with a wipe dampened with alcohol and blow dry as necessary. Slide the tube coupler of the single tube BOF cable onto the BOF tube of the multiple-tube BOF cable and firmly seat the tube within the tube coupler.

Step 18 - Apply an axial load of approximately 22 N (5 lbs) between the single tube BOF cable and the multiple-tube BOF cable to verify that the BOF tubes are properly engaged into the tube coupler.

Step 19 - Repeat steps 9 through 18 for each single tube BOF cable to be connected.

Step 20 - Fill in any depressions or voids within the exposed BOF cable end with the sealant tape, to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of the adhesive tape. Roll the tape with your fingers and press it into the cable voids. Repeat the process until all of the BOF cable voids are filled (see figure 1D1-2).

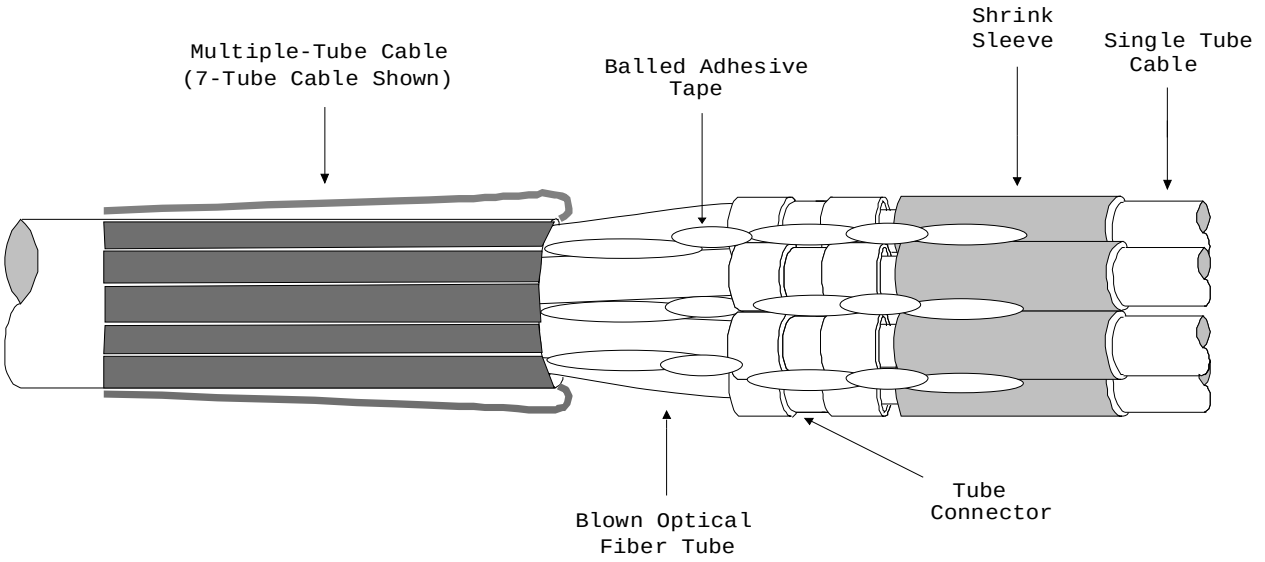


FIGURE 1D1-2. Tape contoured to the cable.

NOTE: Alternatively, MIL-I-3064 type HF plastic sealer may be used to fill/build up around the BOF tubes.

Step 21 - Apply one wrap of the sealant tape around the entire area, starting at the multiple-tube cable jacket and ending approximately 25 mm (1 in) from the end of the single tube cable shrink sleeves (See figure 1D1-3).

Step 22 - WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Holding the heat gun approximately 100 mm (4 in) away, apply just enough heat to the tape to form and contour the tape to the tubes.

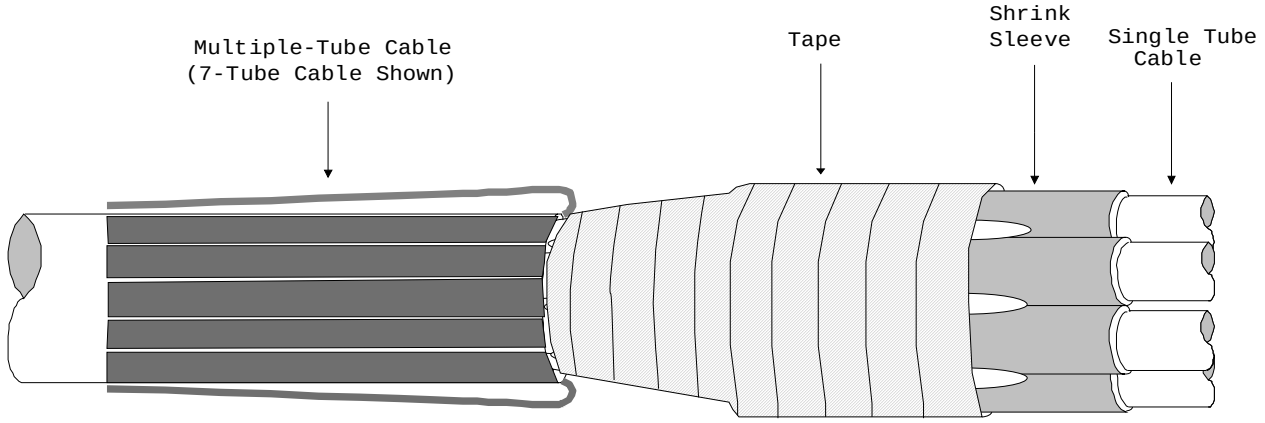


FIGURE 1D1-3. Completely taped cable end.

Step 23 - Untape the cable jacket strips from the multiple-tube BOF cable and abrade the cable jacket and the jacket strips circumferentially over the length that will be in contact with the shrink tube using emery cloth. Clean the multiple-tube BOF cable jacket and the jacket strips with a wipe dampened with alcohol and blow dry as necessary.

Step 24 - Fold the cable jacket strips over the taped area so as to encage the BOF tubes and tube couplers. Press the cable jacket strips into the underlying tape.

Step 25 - CAUTION: Do not overheat the BOF cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the BOF cable jacket. Discontinue heating of the sleeve and allow the BOF cable jacket to cool before reheating if the BOF cable jacket shows any signs of bubbling.

For heat shrink sleeves only: Slide the heat shrink sleeve up the multiple-tube BOF cable and position over the jacket strips so that the sleeve overlaps the uncut multiple tube cable jacket approximately 76 mm (3.0 in) and covers the taped section of the single tube cables. Holding the heat gun approximately 100 mm (4 in) away, heat evenly from the center to the ends around the entire sleeve. Heat until the sleeve has shrunk to a snug fit around the complete assembly and melted sealant is visible at the ends of the sleeve (see figure 1D1-4).

For cold shrink sleeves only: Position the sleeve as described above, remove the sleeve center support and allow the sleeve to shrink into place .

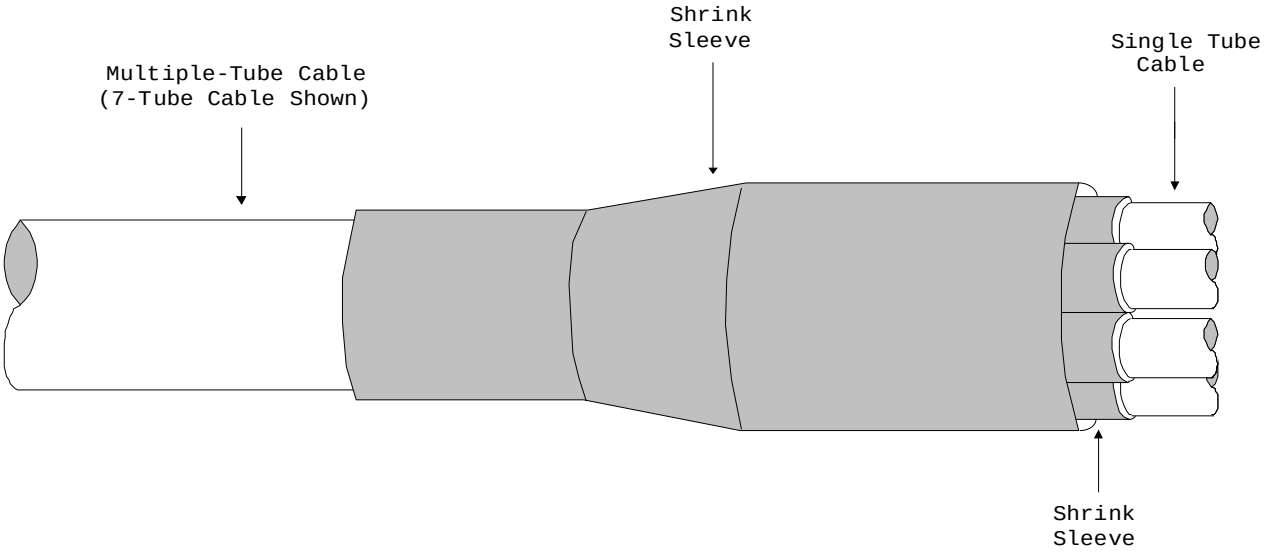


FIGURE 1D1-4. Completed furcation.

Step 26 - Verify the continuity of each connected tube with a ball bearing using method 6H1 of this standard.

METHOD 1E1

OFCC END SEALING

1. SCOPE.

1.1 Scope. This method describes a procedure for end sealing unterminated loose tube furcation cables (from BOF furcation units).

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 1E1-I shall be used to perform this procedure.

TABLE 1E1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Emery cloth	As required
Ruler	1
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
End cap (Raychem 101A011-3/86 or equal)	1
Two-part epoxy (Devcon P/N 14250 or equal)	As required
Wipes	As required
Canned air	As required

3. PROCEDURE.

3.1 Safety Summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers.

b. Do not touch the ends of the fiber as they may be razor sharp. Wash your hands after handling bare fiber.

c. Observe warnings and cautions on the equipment and materials.

d. Avoid skin contact with adhesives.

e. When visually inspecting an optical fiber, never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure.

NOTE: End caps shall be coated with a heat-activated adhesive.

Step 1 - Abrade the furcation cable jacket circumferentially over the length that will be in contact with the end cap using emery cloth.

Step 2 - Clean the abraded area of the furcation cable with a wipe dampened with alcohol and blow dry as necessary.

Step 3 – Thoroughly mix the two parts of the epoxy together and apply a small bead of the epoxy to the end face of the furcation cable to be sealed. (NOTE: The epoxy bead is applied to assure full sealing at the furcation cable end.)

Step 4 - Slide the end cap over the end of the furcation cable to be sealed. Position the end cap to ensure that the furcation cable is fully inserted into the end cap (see figure 1E1-1).

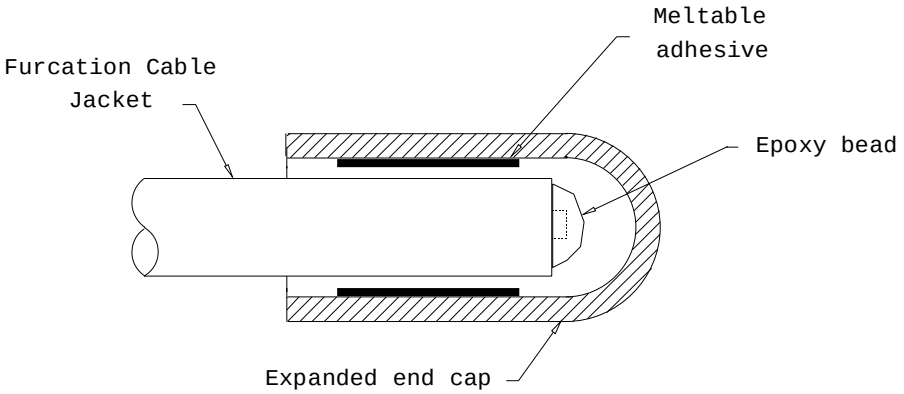


FIGURE 1E1-1. Installing expanded end cap on cable.

Step 4 - CAUTION: Do not overheat the furcation cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the sleeve and allow the cable jacket to cool before reheating, if the cable jacket shows any signs of bubbling.

Hold the heat gun approximately 100 mm (4 in) from the end cap and as heat is applied, move the heat gun back and forth over the end cap. Shrink the end cap from closed end to open end to avoid trapping air. (NOTE: Minimum recovery temperature is 121°C (250°F).

Step 5 - When the end cap has recovered enough to assume the configuration of the cable and excess adhesive appears at the end of the cap, discontinue heating (see figure 1E1-2). (NOTE: Additional heat will not make end cap shrink more tightly.)

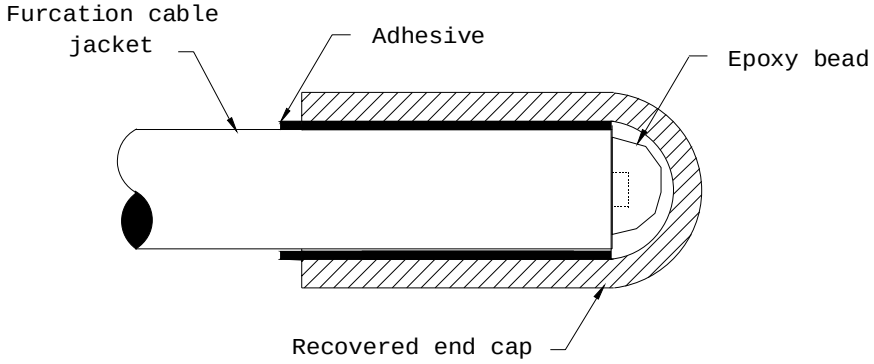


FIGURE 1E1-2. Completed end seal.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7.

3. The preparing activity must provide a reply within 30 days from receipt of the form.

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I RECOMMEND A CHANGE:	**1. DOCUMENT NUMBER** MIL-STD-2042-1	**2. DOCUMENT DATE (YYMMDD)**

3. DOCUMENT TITLE
FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS (CABLES)

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME Ruth Butler	b. TELEPHONE (Include Area Code) (1) Commercial (202) 781-3726 (2) AUTOVON 326-3726
c. ADDRESS (Include Zip Code) Commander, Naval Sea Systems Command ATTN: SEA 05Q 1333 Isaac Hull Avenue Southeast, Stop 5160 Washington Navy Yard, DC 20376-5160	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533 Fort Belvoir, Virginia 22060-6221 Telephone (703) 767-6888 DSN 427-6888