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DEPARTMENT OF DEFENSE STANDARD PRACTICE

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR SURFACE SHIPS AND SUBMARINES (CABLES)

(PART 1 OF 7 PARTS)

AMSC N/A AREA SESS

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

3. In order to provide flexibility in the use and update of the installation methods, this standard is issued in eight parts; the base standard 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

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

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1. SCOPE

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

1.2 Applicability. The installation requirements and methods in this document are intended to be used by all installing activities. These methods establish standards for installations in all naval ships and are not identifiable to any specific ship class or type, except as noted. The methods in this document are for new construction as well as for conversions, alterations, and repairs.

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.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-15024	-	Plates, Tags, and Bands for Identification of Equipment, General Specification for
MIL-PRF-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-PRF-64266	-	Connectors, Fiber Optic, Circular and Rectangular, Plug and Receptacle Style, Multiple Removable Genderless Termini, Environment Resisting General Specification for
MIL-DTL-83522	-	Connectors, Fiber Optic, Single Ferrule, General Specification for
MIL-PRF-85045	-	Cables, Fiber Optic, General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-1678-1	-	Fiber Optic Cabling Systems Requirements and Measurements (Part 1: Design, Installation and Maintenance Requirements) (Part 1 of 6 Parts)
MIL-STD-2042	-	Fiber Optic Cable Topology Installation Standard Methods for Surface Ships and Submarines
MIL-STD-2042-2	-	Fiber Optic Cable Topology Installation, Standard Methods for Surface Ships and Submarines (Equipment) (Part 2 of 7 Parts)
MIL-STD-2042-3	-	Fiber Optic Cable Topology Installation, Standard Methods for Surface Ships and Submarines (Cable Penetrations) (Part 3 of 7 Parts)
MIL-STD-2042-4	-	Fiber Optic Cable Topology Installation, Standard Methods for Surface Ships and Submarines (Cableways) (Part 4 of 7 Parts)
MIL-STD-2042-5	-	Fiber Optic Cable Topology Installation, Standard Methods for Surface Ships and Submarines (Connectors and Interconnections) (Part 5 of 7 Parts)

MIL-STD-2042-6 - Fiber Optic Cable Topology Installation, Standard Methods for Surface Ships and Submarines (Tests) (Part 6 of 7 Parts)

(Copies of these documents are available online at http://quicksearch.dla.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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

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

(Copies of this document are available online at http://webstore.ansi.org.)

SAE INTERNATIONAL

SAE-AMS-QQ-A-250 - Aluminum and Aluminum Alloy Plate and Sheet; General Specification

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

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-440 - Fiber Optic Terminology

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

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

3. DEFINITIONS

3.1 General fiber optics terms. Definitions for general fiber optics terms used in this standard practice are in accordance with TIA-440.

3.2 Other fiber optics terms. Definitions for other terms as they are used in this standard practice are given in the general standard MIL-STD-2042.

3.3 Abbreviations and acronyms. The following abbreviations and acronyms are used in this standard:

a. BOF: Blown Optical Fiber
b. FOCP: Fiber Optic Cable Plant
c. FOCT: Fiber Optic Cable Topology
d. FOICB: Fiber Optic Interconnection Box
e. EPDM: Ethylene Propylene Diene Monomer
f. LED: Light Emitting Diode
g. OFCC: Optical Fiber Cable Component
h. OFCS: Optical Fiber Communication System
i. TRB: Tube Routing Box

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 in accordance with MIL-PRF-85045. Substitute cables shall not be used without authorized approval (see 4.3). Fibers shall be in accordance with MIL-PRF-49291, either Type SM (single-mode) or Type MM (multimode).

4.1.2 Spare optical fibers. Spare fibers shall be provided in both trunk cables and local cables that penetrate bulkheads or decks.

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 °C (-40 °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 1 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 1 year or longer may be installed if it passes the visual inspection in accordance with MIL-STD-2042-6, Method 6A1, and if the optical attenuation is less than the value specified in MIL-STD-2042-6, Method 6B1. A blown optical fiber (BOF) cable that has been in storage for 1 year or longer may be installed if it passes the visual inspection in accordance with MIL-STD-2042-6, Method 6A1, and if a ball bearing with a minimum outer diameter of 4.5 millimeters will pass through each BOF tube within the cable in accordance with MIL-STD-2042-6, Method 6H1. Cables shall be stored on reels with minimum diameters of 24 times the cable outside diameter, or coiled so that the bend diameter is 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. The minimum short-term bend diameter of conventional optical fiber cable is eight times the cable outside diameter. The minimum short-term bend diameter of BOF cable is 0.127 meter (5 inches) for single-tube BOF cable, 0.45 meter (17.7 inches) for seven-tube BOF cable, and 1 meter (39 inches) for nineteen-tube BOF cable. It is recommended that cables not be handled in ambient temperatures at or below 2 °C (36 °F) in accordance with MIL-STD-2042-4.

4.1.4 Cables entering interconnection boxes or other equipment. Cables shall enter interconnection boxes or other equipment in accordance with the methods in MIL-STD-2042-2.

4.1.5 Cable penetrations. The passing of cables through decks and bulkheads shall be in accordance with the methods in MIL-STD-2042-3. Trunk and local conventional cables that penetrate decks and bulkheads shall contain spare (unallocated) fibers.

4.1.6 Cable installation and protection. Cables shall be installed in the cableways and protected in accordance with MIL-STD-2042-4.

4.1.7 Cable connections. Cable connections to end user equipment shall be made with multiple-terminus heavy duty connectors in accordance with MIL-PRF-28876 or MIL-PRF-64266, single-terminus light duty connectors in accordance with MIL-DTL-83522, or Navy-approved commercial light duty connectors. Connectors shall be assembled in accordance with MIL-STD-2042-5. Light duty connectors used for equipment connections shall be housed within that equipment. Light duty connectors used for cable interconnections internal to the FOCP shall be housed within interconnection boxes in accordance with MIL-STD-2042-2.

4.1.7.1 Termination of fibers. The four categories of fibers are as follows:

a. Allocated and used.

b. Allocated and not used.

c. Unallocated.

d. Unused.

4.1.7.1.1 Allocated and used fibers. All allocated and used trunk and local cable fibers shall be terminated in accordance with the methods in MIL-STD-2042-2 or MIL-STD-2042-5.

4.1.7.1.2 Allocated and not used fibers. All allocated and not used fibers shall be terminated in accordance with the methods in MIL-STD-2042-2 or MIL-STD-2042-5.

4.1.7.1.3 Unallocated fibers. Spare (unallocated) fibers shall be terminated in accordance with the methods in MIL-STD-2042-2 or MIL-STD-2042-5. Growth fibers shall not be terminated unless the cable termination is a heavy duty, multi-terminus connector. All unallocated fibers terminating in a heavy duty, multi-terminus connector shall be terminated in accordance with the methods in MIL-STD-2042-5 until the connector is fully populated with termini. Unallocated fibers remaining after fully populating the connector shall be cut off. Stowage of unterminated fiber in the heavy duty connector backshell shall not be permitted.

4.1.7.1.4 Unused fibers. Unused fibers shall not be terminated and shall be stowed in accordance with the methods in MIL-STD-2042-2, unless the unused fiber is part of a cable terminating in a heavy duty, multi-terminus connector. All unused fibers terminating in a heavy duty, multi-terminus connector shall be terminated in accordance with the methods in MIL-STD-2042-5 until the connector is fully populated with termini. Unused fibers remaining after fully populating the connector shall be cut off. Stowage of unterminated fiber in the heavy duty connector backshell shall not be permitted.

4.1.7.2 Connection of BOF tubes. Growth and unused spare tubes (allocated or not allocated) shall remain disconnected inside of tube routing boxes (TRBs) and fiber optic interconnection boxes (FOICBs) until the tube is identified for fiber installation. Growth and unused spare tubes shall be end sealed in accordance with MIL-STD-2042-2, Method 2J1.

4.1.8 Cable testing. Cables shall undergo testing before, during, and after installation in accordance with MIL-STD-2042-6.

4.1.9 Cable and fiber marking. All cables shall be marked as specified herein. Cable identification tags external to the equipment shall be located in accordance with MIL-STD-2042-4. Cable tags shall be of a size suitable to accommodate the required marking but shall have a minimum width of 13 millimeters (½ inch). Tags and strips for marking cables shall be of soft aluminum tape having a natural finish in accordance with MIL-DTL-15024 and SAE-AMS-QQ-A-250. Capital letters shall be used on cable tags; the height of all letters shall be not less than 5 millimeters (3⁄16 inch), and letters and numbers shall be embossed to at least 0.4 millimeters (1⁄64 inches) above the surface.

4.1.9.1 Fiber identification markers. Permanent cable markers with the fiber identification shall be used to identify optical fiber cable components (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. Damage to the outermost jacket of conventional optical fiber cables and BOF cables shall be repaired according to procedures specified herein (see 5.2). Conventional optical fiber cables with damage extending beyond the cable outer jacket to the aramid yarn strength members or to the OFCC outer jacket shall be replaced. Single-tube BOF cables with damage extending beyond the cable outer jacket to the aramid yarn strength members or to the BOF tubes shall be replaced. Multiple-tube BOF cables with damage extending beyond the cable outer jacket to the aramid yarn strength members or to the BOF tubes shall be replaced or 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). The BOF cable furcation shall take place within a compartment or as approved by the Naval Surface Warfare Center, Dahlgren Division (see 6.4).

4.2 Safety precautions. The following safety precautions shall 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; however, 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 (LEDs) and laser diodes may not be visible, but may still be hazardous to the unprotected eye. Do not stare into the end of an optical fiber connected to a light emitting diode (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. 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. Do not 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.

4.3 Method improvement. Where the methods herein cannot be implemented, users shall submit proposed new methods or proposed modifications of existing methods, as specified (see 6.4).

4.4 Personnel qualifications. Fiber optic installers, supervisors, and Quality Assurance (QA) personnel shall meet Navy shipboard personnel proficiency requirements identified in MIL-STD-1678-1, Requirement 1306 for all fiber optic installations, modifications, and repairs.

4.5 Or equal. MIL-STD-2042 uses the term "or equal" to permit the use of parts, components, or tools that are equivalent and can perform the same function as the specified products. The use of the equivalent product is allowed as long as the same functional characteristics, performance, equipment safety, personnel safety, suitability for marine service, life cycle cost, maintenance cost, and supportability are attained, and agreement is obtained from NAVSEA (see 6.4). The request for agreement for the use of "equal" products shall include data that supports that functional and performance equivalence is retained.

5. DETAILED REQUIREMENTS

5.1 Cable end sealing. Unterminated cables that are not to be terminated within 14 days shall have their ends sealed against moisture in accordance with Method 1A1. 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 in accordance with Method 1A1. Alternatively, OFCCs shall be end-sealed individually in accordance with Method 1E1. Loose tube furcation cables (from a BOF furcation unit) that are not to be terminated shall be end-sealed in accordance with Method 1E1.

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

5.3 BOF cable splicing. BOF cables to be spliced shall be spliced in accordance with Method 1C1.

5.4 BOF cable furcation. Multiple-tube BOF cables to be furcated shall be furcated in accordance with Method 1D1.

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, loose tube cable furcation, and BOF cable furcation depicted in this standard practice have been developed, tested, and approved so that the shipboard fiber optic installations described can withstand the environmental and operational conditions aboard U.S. Navy vessels. They are intended primarily for new construction; however, they are applicable for conversion, alteration, or repair of existing ships.

6.2 Acquisition requirements. Acquisition documents should specify the following:

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

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: Multiple tube BOF to single-tube BOF furcation

Group E: OFCC and loose tube furcation end sealing

The designation system was completed as follows:

1	B	1	-	II
MIL-STD-2042 part number	Functional group	Method number within group	-	Alternate procedure within method

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 Proposed new methods or method modifications. As specified (see 4.3), proposed new methods or proposed modifications of existing methods should be submitted to DLGR_NSWC_FO_ENG@navy.mil or Department of the Navy, Naval Surface Warfare Center, Dahlgren Division, ATTN: Fiber Optic Engineering Manager, 17214 Avenue B, Suite 126, Dahlgren, VA 22448-5147.

6.5 Dahlgren shipboard fiber optics website. The NSWC Dahlgren fiber optic website houses additional shipboard fiber optic information and policy letters that may be applicable to the requirements in this standard. Due to the dynamic nature of web addresses, the current website URL can be obtained by e-mailing DLGR_NSWC_FOWEB@navy mil with the subject line “WEBSITE URL REQUEST”. An automated reply will contain the current web address.

6.6 Subject term (key word) listing.

Component

Connections

Handling

Marking

Penetrations

Repair

Selection

Storage

Testing

6.7 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.

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 OFCC and loose tube furcation cable end sealing, refer to Method 1E1.

2. DOCUMENTS APPLICABLE TO METHOD 1A1

2.1 General. The documents listed in this section are specified in Method 1A1. 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 Method 1A1, whether or not they are listed.

2.2 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-AS81765 - Insulating Components, Molded, Electrical, Heat-Shrinkable, General Specification for

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

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

3. REQUIRED EQUIPMENT AND MATERIALS

3.1 Equipment and materials. The equipment and materials in table 1A1-I shall be used to perform this procedure. More detail on approved sources for items with reference numbers can be found on the Dahlgren shipboard fiber optics website (see 6.5). The list on which items appear is indicated by the two-letter prefix as follows:

a. TL = Recommended Tool List

b. TS = Recommended Test Equipment List

TABLE 1A1-I. Equipment and materials.

Reference #	Description	Quantity
TL-0071	Safety glasses	1
	Emery cloth (or fine file)	As required
TL-0069	Scale, 15.24 cm (6 inches)	1
TL-0101	Heat gun	1
TL-0044 or TL-0002	Isopropyl alcohol, 99% pure anhydrous or alcohol pad, sealed	1
	End cap (Raychem SSC series, or equal [see 4.5])	1
TL-0016	Cloth, cleaning, white	As required
TL-0013	Canned air	As required

4. PROCEDURE

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

a. Wear safety glasses 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, do not stare into the end of a fiber connected to a laser source or LED.

e. Do not 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.

4.2 Procedure. The following steps shall be performed:

NOTE: End caps shall be in accordance with SAE-AS81765. 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.

NOTE: If end-sealing a bundled group of OFCCs inside of equipment (e.g., an FOICB), the diameter of the OFCC bundle shall be measured and an end cap with an expanded inner diameter slightly larger than the measure diameter shall be selected.

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

Cable type	Cable OD nominal, mm (inch)	End cap		
		Length (min)	Expanded inside diameter (I.D.) (min)	Recovered I.D. (max)
4-fiber	8.1 (0.32)	30.5 (1.20)	10.2 (0.40)	4.6 (0.18)
8-fiber	11.1 (0.44)	40.6 (1.60)	15.2 (0.60)	6.4 (0.25)
8-fiber (outboard)	14.4 (0.57)	61.0 (2.40)	20.6 (0.81)	9.4 (0.37)
18-fiber	14.3 (0.56)	61.0 (2.40)	20.6 (0.81)	9.4 (0.37)
18-fiber (outboard)	17.4 (0.69)	61.0 (2.40)	20.6 (0.81)	9.4 (0.37)
36-fiber	20.8 (0.82)	68.6 (2.70)	25.4 (1.00)	11.4 (0.45)
90-fiber	38.5 (1.52)	101.6 (4.00)	50.8 (2.00)	22.9 (0.90)
Single-tube	11.1 (0.44)	40.6 (1.60)	15.2 (0.60)	6.4 (0.25)
7-tube	30.25 (1.19)	91.4 (3.60)	39.4 (1.55)	18.0 (0.71)
19-tube	50.8 (2.00)	114.3 (4.50)	83.8 (3.30)	38.1 (1.50)

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

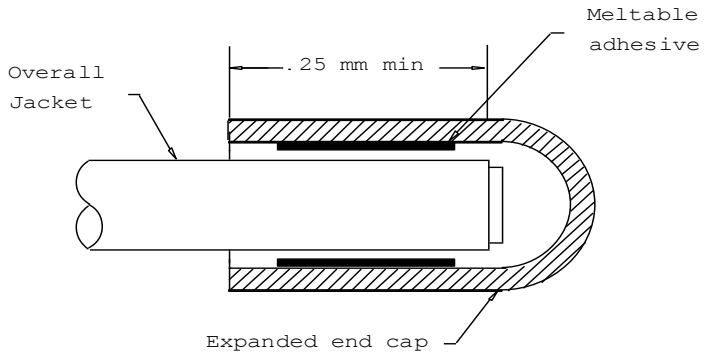

FIGURE 1A1-1. Installing expanded end cap on cable.

Step 5. Hold the heat gun approximately 100 millimeters (4 inches) from the end cap and move the heat gun back and forth over the end cap as heat is applied. Shrink the end cap from closed end to open end to avoid trapping air. (NOTE: Minimum recovery temperature is 121 °C [250 °F]).

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

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.

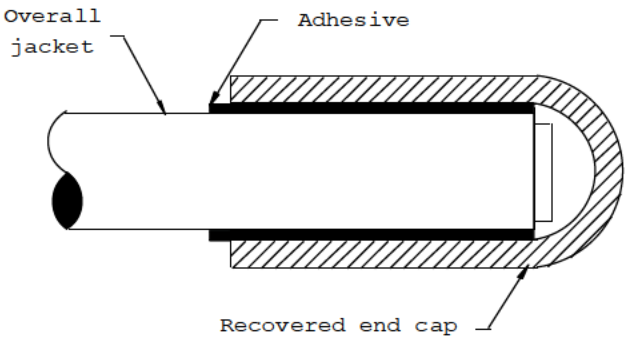

FIGURE 1A1-2. Completed end seal.

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 aramid yarn strength members intact. There are three procedures contained in this method that provide different options for cable jacket repair. Procedure I utilizes a wraparound sleeve with rail closure for repair. This is the recommended and preferred method. Procedure II utilizes a tube sleeve for cable jacket repair. Procedure III utilizes a rubber tape solution for cable jacket repair.

2. DOCUMENTS APPLICABLE TO METHOD 1B1

2.1 General. The documents listed in this section are specified in Method 1B1. 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 Method 1B1, 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.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-I-19166 - Insulation Tape, Electrical, High-Temperature, Glass Fiber, Pressure-Sensitive

(Copies of this document are available online at http://quicksearch.dla.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.

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 online at www.sae.org.)

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

3. REQUIRED EQUIPMENT AND MATERIALS

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

4. PROCEDURES

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

a. Wear safety glasses 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 equipment and materials.

d. When visually inspecting an optical fiber, do not stare into the end of a fiber connected to a laser source or LED.

e. Do not 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.

4.2 Procedure I: Wraparound sleeve with rail closure.

4.2.1 Equipment and materials. The equipment and materials in table 1B1-I shall be used to perform this procedure. More detail on approved sources for items with reference numbers can be found on the Dahlgren shipboard fiber optics website (see 6.5). The list on which items appear is indicated by the two-letter prefix as follows:

a. TL = Recommended Tool List

b. TS = Recommended Test Equipment List

TABLE 1B1-I. Equipment and materials.

Reference #	Description	Quantity
TL-0071	Safety glasses	1
TL-0069	Scale, 15.24 cm (6 inches)	1
	Electrician's knife	1
	Emery cloth (or fine file)	As required
	Adhesive and sealant tape (Raychem Thermofit S1030, or equal [see 4.5])	As required
	Repair sleeve (Raychem CRSM-x-1200, or equal [see 4.5])	1
TL-0101	Heat gun	1
TL-0044 or TL-0002	Isopropyl alcohol, 99% pure anhydrous or alcohol pad, sealed	1
TL-0016	Cloth, cleaning, white	As required
TL-0013	Canned air	As required
NOTE: The cable jacket repair sleeve material shall be in accordance with SAE-AMS-DTL-23053/15. 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.		

4.2.2 Wraparound sleeve with rail closure. The following steps shall be performed:

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

TABLE 1B1-II. Repair sleeve dimensions (wrap-around).

Cable type	Cable OD nominal, mm (inch)	B dimension, mm (inch)	Repair sleeve dimensions mm (inch)			
			Length (min)	Rail to rail		Wall thickness after shrinking (±10%)
				Expanded (min)	Recovered (max)	
4-fiber	8.1 (0.32)	76.0 (3.0)	A + 2B	45.7 (1.8)	23.9 (0.94)	2.0 (0.08)
8-fiber	11.1 (0.44)	76.0 (3.0)	A + 2B	45.7 (1.8)	23.9 (0.94)	2.0 (0.08)
18-fiber	17.4 (0.69)	76.0 (3.0)	A + 2B	79.8 (3.14)	48.5 (1.91)	2.0 (0.08)
36-fiber	20.8 (0.82)	76.0 (3.0)	A + 2B	79.8 (3.14)	48.5 (1.91)	2.0 (0.08)
90-fiber	38.5 (1.52)	76.0 (3.0)	A + 2B	215.5 (8.48)	75.8 (2.98)	2.0 (0.08)
Single-tube	11.1 (0.44)	76.0 (3.0)	A + 2B	45.7 (1.80)	23.9 (0.94)	2.0 (0.08)
7-tube	29.0 (1.14)	76.0 (3.0)	A + 2B	215.5 (8.48)	75.8 (2.98)	2.0 (0.08)
7-tube	31.5 (1.24)	76.0 (3.0)	A + 2B	215.5 (8.48)	75.8 (2.98)	2.0 (0.08)
19-tube	50.8 (2.00)	76.0 (3.0)	A + 2B	215.5 (8.48)	75.8 (2.98)	2.0 (0.08)
NOTE: Refer to figure 1B1-2 for a definition of A and B dimensions.						

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

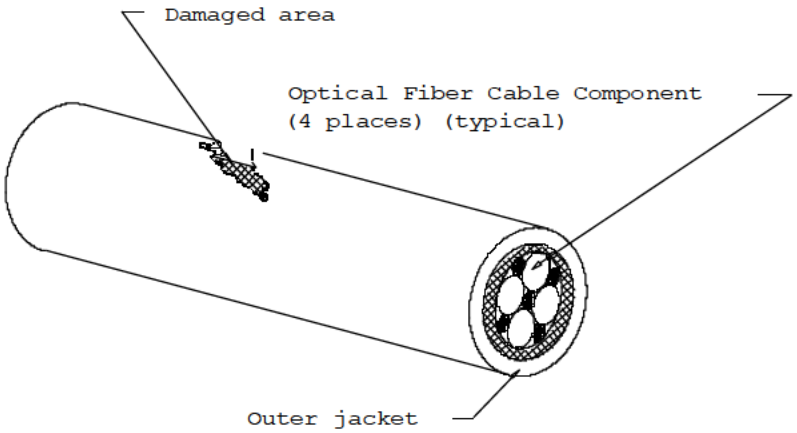

FIGURE 1B1-1. Damaged cable.

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

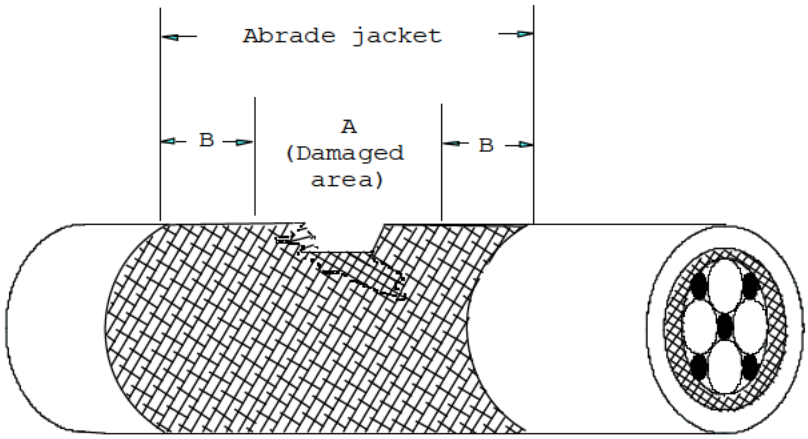

FIGURE 1B1-2. Cable preparation.

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 millimeters (4 inches) away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-3).

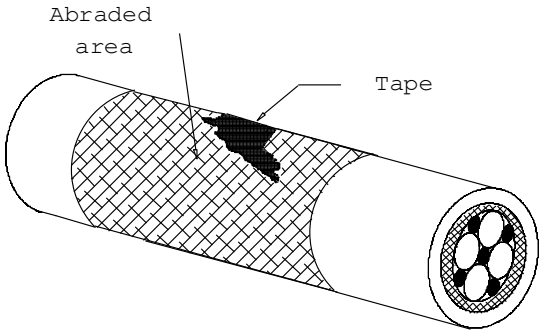

FIGURE 1B1-3. Tape contoured to cable.

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

Step 7. Hold the heat gun approximately 100 millimeters (4 inches) away from the cable and apply heat to all parts of the cable jacket to which the repair sleeve is to be applied.

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.

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

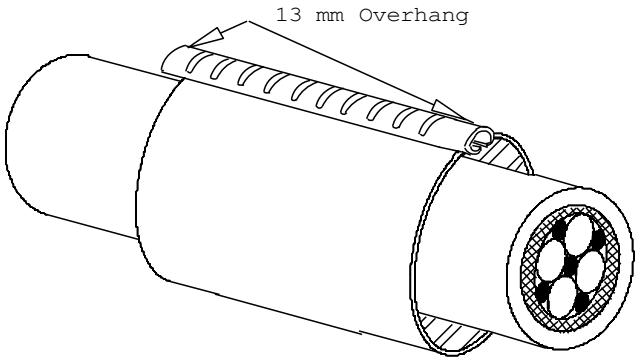

FIGURE 1B1-4. Installing sleeve.

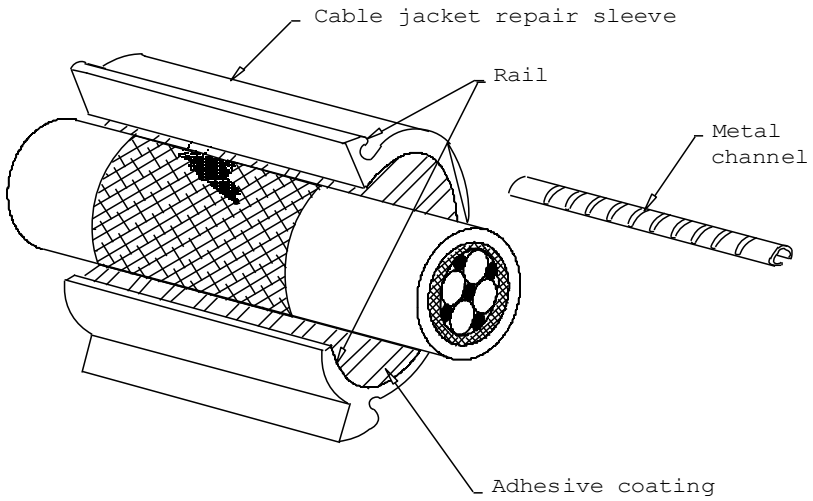

FIGURE 1B1-5. Assembled sleeve.

Step 9. Center the sleeve over the damaged area and, holding the heat gun approximately 100 millimeters (4 inches) 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.

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.

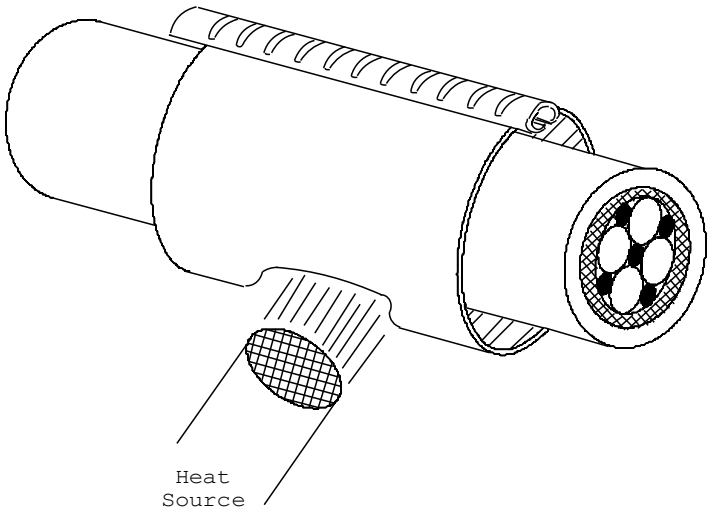

FIGURE 1B1-6. Shrinking sleeve.

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).

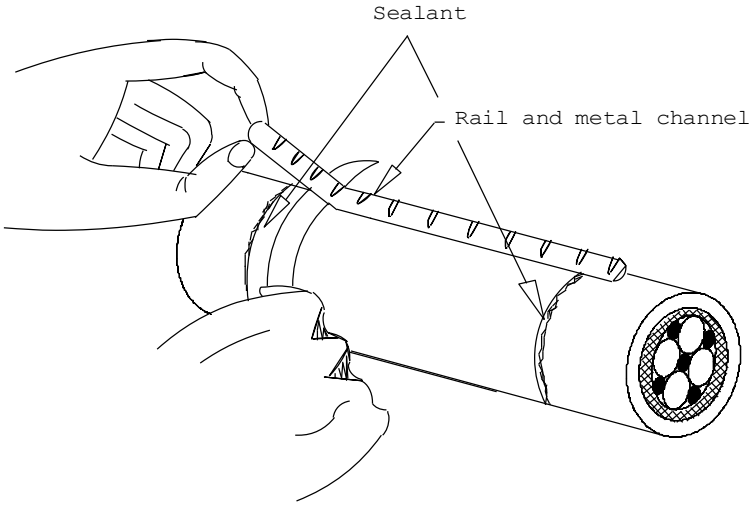

FIGURE 1B1-7. Trimming rails and metal channel.

4.3 Procedure II: Tube sleeve.

4.3.1 Equipment and materials. The equipment and materials in table 1B1-III shall be used to perform this procedure. More detail on approved sources for items with reference numbers can be found on the Dahlgren shipboard fiber optics website (see 6.5). The list on which items appear is indicated by the two-letter prefix as follows:

a. TL = Recommended Tool List

b. TS = Recommended Test Equipment List

TABLE 1B1-III. Equipment and materials.

Reference #	Description	Quantity
TL-0071	Safety glasses	1
TL-0069	Scale, 15.24 cm (6 inches)	1
	Electrician's knife	1
	Emery cloth (or fine file)	As required
	Repair sleeve (Raychem SST-FR series, or equal [see 4.5])	1
	Adhesive and sealant tape (Raychem Thermofit S1030, or equal [see 4.5])	As required
TL-0101	Heat gun	1
TL-0044 or TL-002	Isopropyl alcohol, 99% pure anhydrous or alcohol pad, sealed	1
TL-0016	Cloth, cleaning, white	As required
TL-0013	Canned air (or compressed air)	As required
NOTE: The cable repair sleeve material shall be in accordance with 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.		

4.3.2 Tube sleeve. The following steps shall be performed:

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 aramid yarn, OFCC jacket, or BOF tubes (see figure 1B1-8). Square up the jacketing where required.

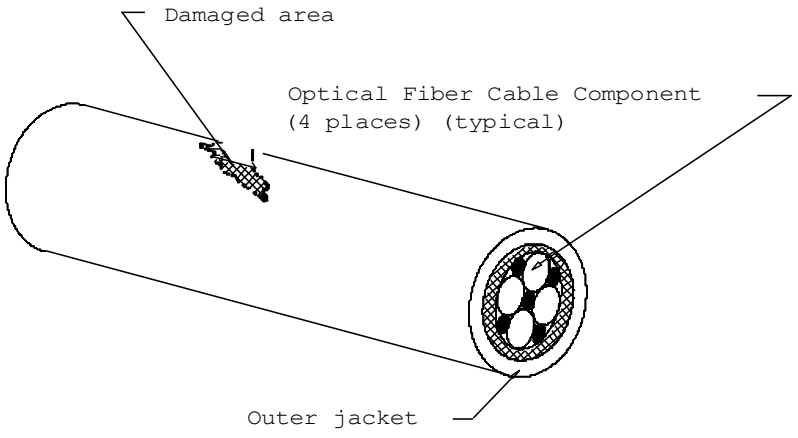

FIGURE 1B1-8. Damaged cable.

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

Cable type	Cable OD nominal, mm (inch)	B dimension, mm (inch)	Repair sleeve dimensions, mm (inch)			
			Length (minimum)	Rail to rail		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)	3.0 (0.12)
8-fiber	11.1 (0.44)	101 (4.0)	A + 2B	19.1 (0.75)	5.6 (0.22)	3.0 (0.12)
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 (0.16)
Single-tube	11.1 (0.44)	101 (4.0)	A + 2B	19.1 (0.75)	5.6 (0.22)	3.0 (0.12)
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 (0 90)	3.9 (0.16)
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 an emery cloth or a fine file (see table 1B1-IV and figure 1B1-9).

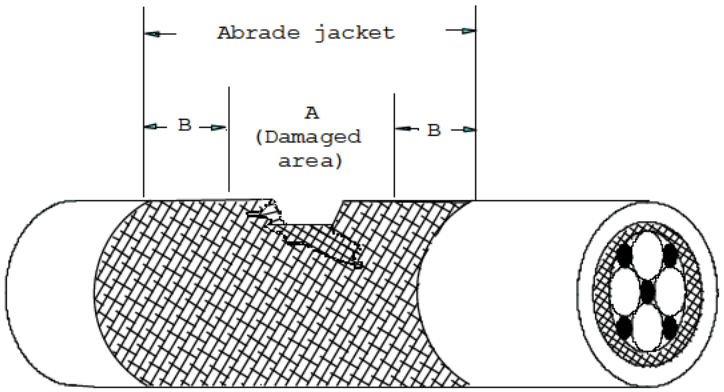

FIGURE 1B1-9. Cable preparation.

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 millimeters (4 inches) away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-10).

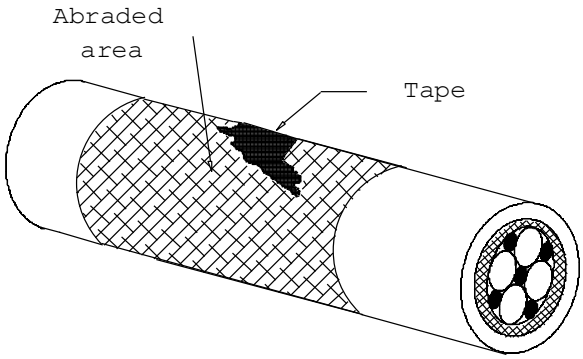

FIGURE 1B1-10. Tape contoured to cable.

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

Step 7. Center the repair sleeve over the damaged area. Hold the heat gun approximately 100 millimeters (4 inches) away and heat the center by applying heat evenly around the sleeve until it shrinks over cable (see figure 1B1-11). Working toward one end, shrink the sleeve to the cable until sealant is flowing at one end of the sleeve. Repeat the procedure on the other half of the sleeve (see figure 1B1-12).

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.

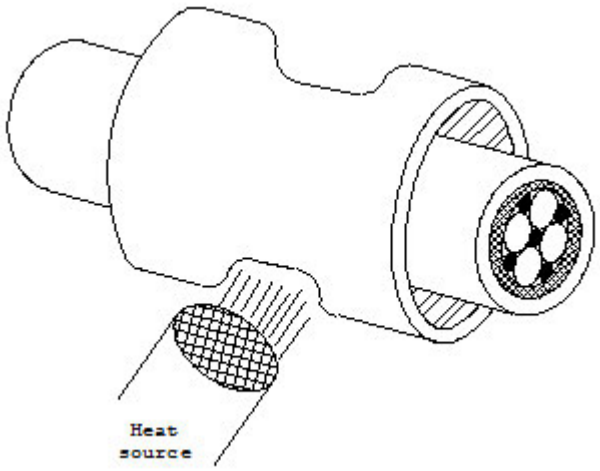

FIGURE 1B1-11. Shrinking the sleeve.

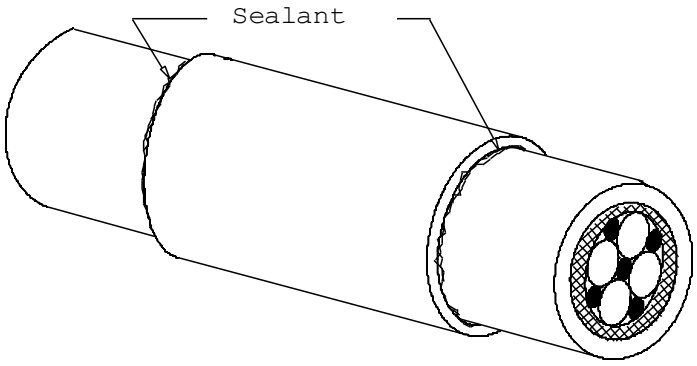

FIGURE 1B1-12. Completed repair.

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

4.4 Procedure III: Rubber tape.

4.4.1 Equipment and materials. The equipment and materials in table 1B1-V shall be used to perform this procedure. More detail on approved sources for items with reference numbers can be found on the Dahlgren shipboard fiber optics website (see 6.5). The list on which items appear is indicated by the two-letter prefix as follows:

a. TL = Recommended Tool List

b. TS = Recommended Test Equipment List

TABLE 1B1-V. Equipment and materials.

Reference #	Description	Quantity
TL-0071	Safety glasses	1
TL-0069	Scale, 15.24 cm (6 inches)	1
	Electrician's knife	1
	Emery cloth (or fine file)	As required
	Adhesive and sealant tape (Raychem Thermofit S1030, or equal [see 4.5])	As required
TL-0101	Heat gun	1
	Fiberglass tape 25.4 mm (1 inch) (MIL-I-19166)	As required
	Electrical coating (3M Scotch Kote, or equal [see 4.5])	As required
TL-0044 or TL-0002	Isopropyl alcohol, 99% pure anhydrous or alcohol pad, sealed	1
TL-0016	Cloth, cleaning, white	As required
TL-0013	Canned air	As required

4.4.2 Rubber tape. The following steps shall be performed:

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

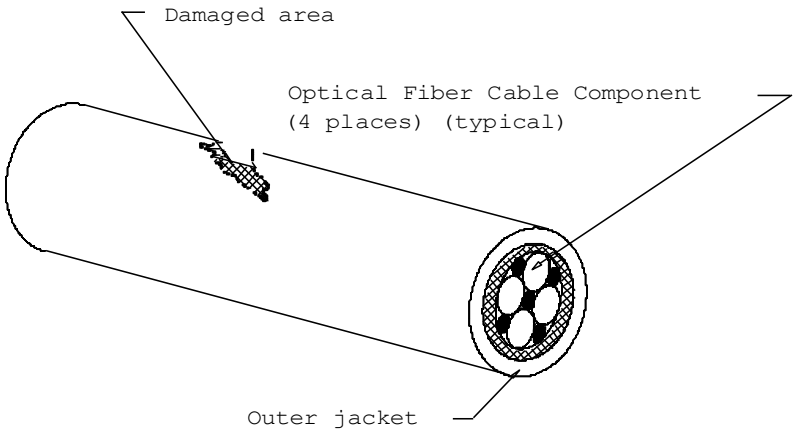

FIGURE 1B1-13. Damaged cable.

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

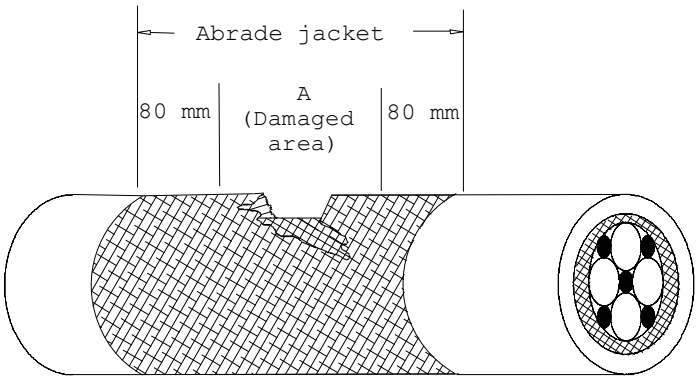

FIGURE 1B1-14. Cable preparation.

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 the process until the damaged area is filled; then, holding the heat gun approximately 100 millimeters (4 inches) away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-15).

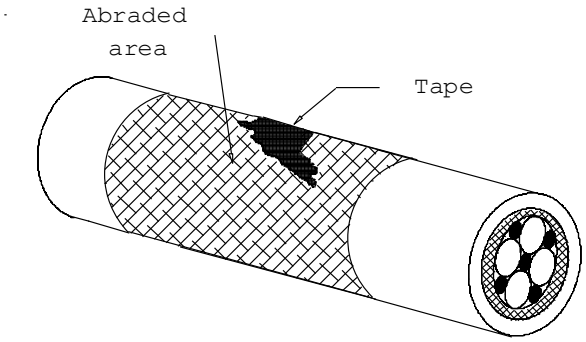

FIGURE 1B1-15. Tape contoured to the cable.

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. Holding the heat gun approximately 100 millimeters (4 inches) 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.

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 tape and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

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

METHOD 1C1
BOF CABLE SPLICING

1. SCOPE

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

2. DOCUMENTS APPLICABLE TO METHOD 1C1

2.1 General. The documents listed in this section are specified in Method 1C1. 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 Method 1C1, 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.

COMERCIAL ITEM DESCRIPTIONS

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

(Copies of this document are available online at http://quicksearch.dla.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.

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 online at www.sae.org.)

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

3. REQUIRED EQUIPMENT AND MATERIALS.

3.1 Equipment and materials. The equipment and materials in table 1C1-I shall be used to perform this procedure. More detail on approved sources for items with reference numbers can be found on the Dahlgren shipboard fiber optics website (see 6.5). The list on which items appear is indicated by the two-letter prefix as follows:

a. TL = Recommended Tool List

b. TS = Recommended Test Equipment List

TABLE 1C1-I. Equipment and materials.

Reference #	Description	Quantity
TL-0071	Safety glasses	1
TL-0012	Cable jacket-stripping tool	1
	BOF cable cutter	1
	Tube cutter	1
TL-0045	Aramid yarn cutting shears	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
TL-0101	Heat gun	1
	Heat shrink sleeve (SAE-AMS-DTL-23053/15)	As required
	Cold shrink sleeve (3M CST-S series, or equal [see 4.5]) (optional alternative to heat shrink)	As required
	Tape	As required
	Tube coupler (A-A-59731-U-8)	As required
TL-0016	Cloth, cleaning, white	As required
TL-0044 or TL-0002	Isopropyl alcohol, 99% pure anhydrous or alcohol pad, sealed	1
	6.35-mm (0.25-inch) cotton swab	As required
TL-0046	Marking pen, permanent	1
TL-0013	Canned air	As required
TL-0069	Scale, 15.24 cm (6 inches)	1

4. PROCEDURE

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

a. Observe warnings and cautions on equipment and materials.

b. Do not 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.

4.2 Procedure.

NOTE: The heat shrink sleeve material shall be in accordance with 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.

4.2.1 Coupling the BOF cable tubes. The following steps shall be performed:

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

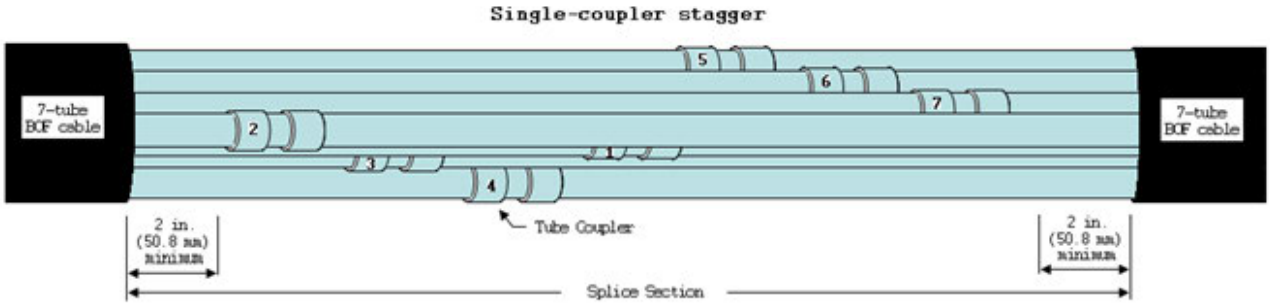

FIGURE 1C1-1. Example tube coupler stagger scheme.

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. The collocating of couplers within the pipe is permitted as needed.

NOTE: Tubes shall not have tube couplers installed closer than 50 millimeters (2 inches) 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 pipe 150 millimeters (6 inches) in length.

NOTE: The inner diameter of the pipe shall be no greater than 8 millimeters (0.3 inch) larger than the outer diameter of the BOF cable.

Step 4. Assemble a female threaded pipe adapter to each 150-millimeter (6-inch) 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 shall be compatible with the female threaded pipe adapters assembled to the splice end pipes.

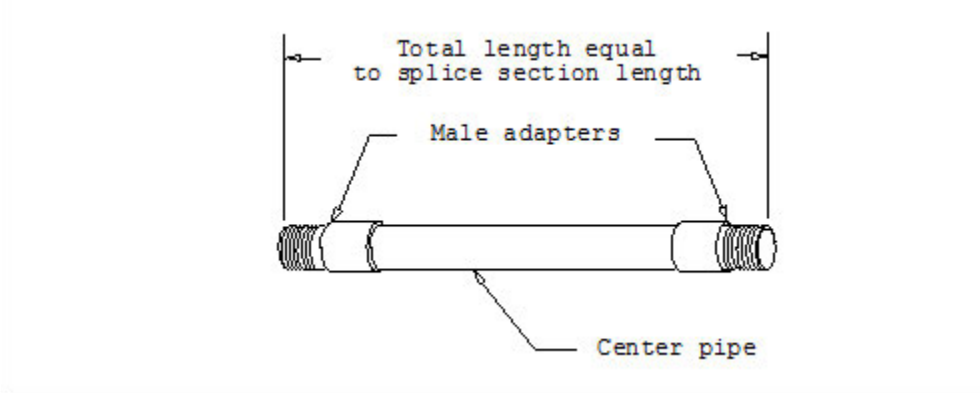

FIGURE 1C1-2. Splice center section length.

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 millimeters (1.2 inch).

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 millimeters (8 inches) 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 (see figure 1C1-3).

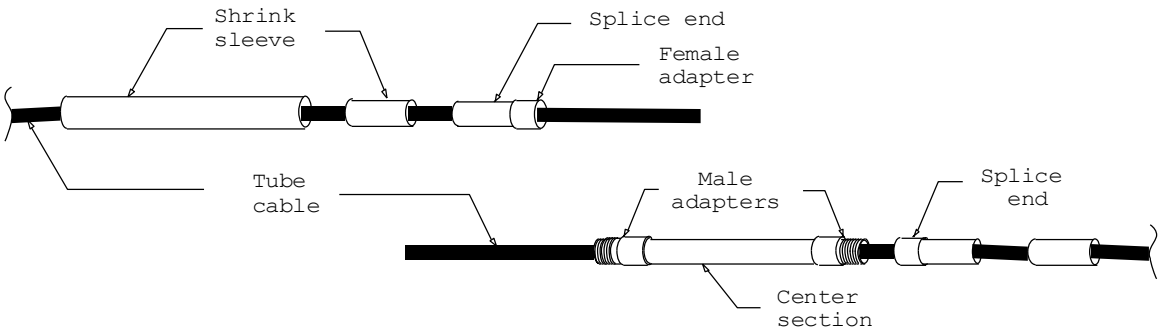

FIGURE 1C1-3. Splice parts on the BOF cables.

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 each BOF cable end.

NOTE: Individual BOF tubes shall not be 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: Individual BOF tubes shall not be punctured, crushed, or kinked while trimming back the cable elements.

Step 15. 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.

Step 16. 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: Wipe BOF tube with alcohol before inserting coupler.

NOTE: If the tube coupler is not a new tube coupler, it is recommended to swab the inside of the coupler with a cotton swab to remove previous tube coating debris before installing the coupler onto a tube.

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

Step 17. Apply an axial load of approximately 22 newtons (5 pounds) between the two tubes to verify that both BOF tubes are properly engaged into the tube coupler.

Step 18. 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.

Step 19. Repeat steps 16 and 17 for tube number two of each of the BOF cables.

Step 20. 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.

4.2.2 Assembling the splice body. The following steps shall be performed:

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).

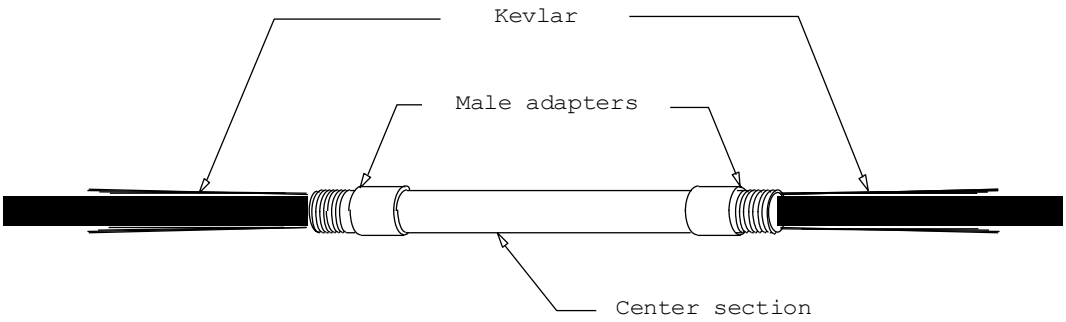

FIGURE 1C1-4. Positioning the splice center section.

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

Step 3. Holding the aramid yarn taught 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 three complete revolutions.

NOTE: The BOF cable shall not rotate as the splice end is tightened onto the splice center section.

NOTE: When metal pipe is used, uncoupling and recoupling of the pipe sections shall be minimized as this may damage the aramid yarn.

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

Step 4. Repeat step 3 for the second splice end.

Step 5. Form the aramid yarn up over the center section and tape the aramid yarn 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 an 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 millimeters (3 inches).

Step 8. For heat shrink sleeves only: Holding the heat gun approximately 100 millimeters (4 inches) 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.

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 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 an 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. Place the sleeve so that it is approximately centered over the splice.

Step 12. For heat shrink sleeves only: Holding the heat gun approximately 100 millimeters (4 inches) 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.

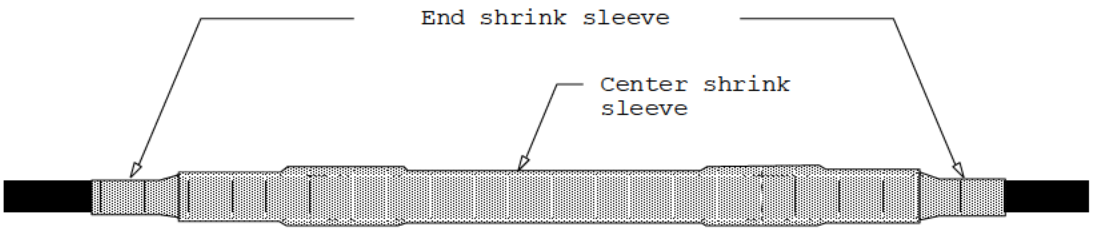

FIGURE 1C1-5. Completed splice.

Step 13. Verify the continuity of each spliced tube with a ball bearing using MIL-STD-2042-6, Method 6H1.

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

METHOD 1C2
7-TUBE BOF CABLE SPLICING (NON-WATERTIGHT)

1. SCOPE

1.1 Scope. This method describes procedures for splicing together two 7-tube BOF cable ends. This method is only applicable for the splicing of 7-tube BOF cables and is only applicable for non-watertight applications. This procedure should not be used to splice a damaged 7-tube BOF cable if any of the tubes contain operational fibers.

2. DOCUMENTS APPLICABLE TO METHOD 1C2

2.1 General. The documents listed in this section are specified in Method 1C2 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 Method 1C2 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.

COMERCIAL ITEM DESCRIPTIONS

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

(Copies of this document are available online at http://quicksearch.dla.mil/).

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

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

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

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

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

3. REQUIRED EQUIPMENT AND MATERIALS.

3.1 Equipment and materials. The equipment and materials in the table 1C2-I shall be used to perform these procedures. More detail on approved sources for items with reference numbers can be found on the Dahlgren shipboard fiber optics website (see 6.5). The list on which items appear is indicated by the two-letter prefix as follows:

a. TL = Recommended Tool List
b. TS = Recommended Test Equipment List

TABLE 1C2-I. Equipment and materials.

Reference #	Description	Quantity
TL-0071	Safety glasses	1
TL-0069	Scale, 15.24 cm (6 inches)	1
TL-0012	Cable jacket-stripping tool	1
	BOF cable cutter	1
	Tube cutter	1
TL-0045	Aramid yarn cutting shears	1
	Flexible steel conduit, size code 12 (Glenair P/N EM12, or equal [see 4.5])	1
	EPDM cold shrink environmental seal (3M CTS 090-220-1200, or equal [see 4.5])	2
	8mm tube locking clip (John Guest P/N PM1808R, or equal [see 4.5])	As required
	Tube coupler (A-A-59731-U-8)	As required
	Emery cloth (or fine file)	As required
TL-0016	Cloth, cleaning, white	As required
TL-0046	Marking pen, permanent	1
	6.35 mm (0.25 inch) cotton swab	As required
TL-0044 or TL-0002	Isopropyl alcohol, 99% pure anhydrous or alcohol pad, sealed	As required
TL-0013	Canned air	As required

4. PROCEDURES.

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

a. Observe warnings and cautions on equipment and materials.

b. Do not 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.

4.2 7-tube BOF cable splicing procedure.

4.2.1 7-tube BOF cable and tube preparation. The following steps shall be performed:

Step 1. Determine the desired length of the splice section and the tube coupler stagger scheme (see figure 1C2-1).

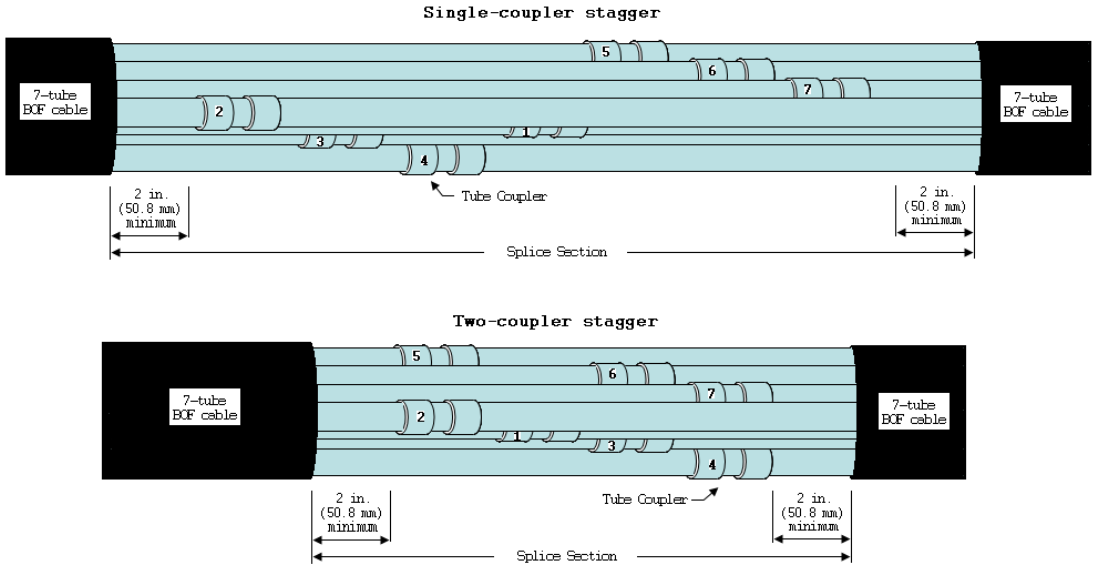

FIGURE 1C2-1. Example tube coupler stagger schemes.

NOTE: The length of the splice section depends on the tube coupler stagger scheme. The 1.5-inch inner diameter flexible steel conduit, size code 12, only supports two tube coupler stagger schemes (see table 1C2-II).

TABLE 1C2-II. Tube coupler stagger schemes.

Tube coupler stagger scheme	Description	Length of splice section inch (mm)	Minimum length for flexible steel conduit inch (mm)
Single-coupler stagger	One straight tube coupler is attached every 2 inches along the length of the splice section	18 (457)	22 (558)
Two-coupler stagger	Two straight tube couplers attached every 2 inches along the length of the splice section	12 (305)	16 (406)

NOTE: Tubes shall not have tube couplers installed closer than 2 inches (50.8 millimeters) from 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. Measure each BOF cable, from the cable end, a distance equal to the splice section length and mark the cable outer jacket.

Step 4. With the cable jacket-stripping tool, ring cut each BOF cable jacket at the mark and strip the jacket from each BOF cable end.

NOTE: The individual BOF tubes shall not be punctured, crushed, or kinked while removing the BOF cable jacket.

Step 5. Trim back the cable fillers, strength members, and waterblocking tape around the BOF tubes to the BOF cable jacket edge.

NOTE: The individual BOF tubes shall not be punctured, crushed, or kinked while removing the BOF cable jacket.

Step 6. Slide Ethylene Propylene Diene Monomer (EPDM) cold shrink environmental seals onto each of the two 7-tube BOF cables with the loose pull tab on the cold shrink on the side away from the end of the cable (see figure 1C2-2).

Step 7. Slide the flexible steel conduit onto the end of one of the two BOF cables (see figure 1C2-2.)

NOTE: The length of the flexible steel conduit shall be not less than the minimum length specified in table 1C2-II for the particular tube stagger scheme selected.

NOTE: The flexible steel conduit shall be cut and terminated in accordance with procedures described in S9407-AB-HBK-010, to maintain conduit integrity and to prevent damage to the 7-tube BOF cable.

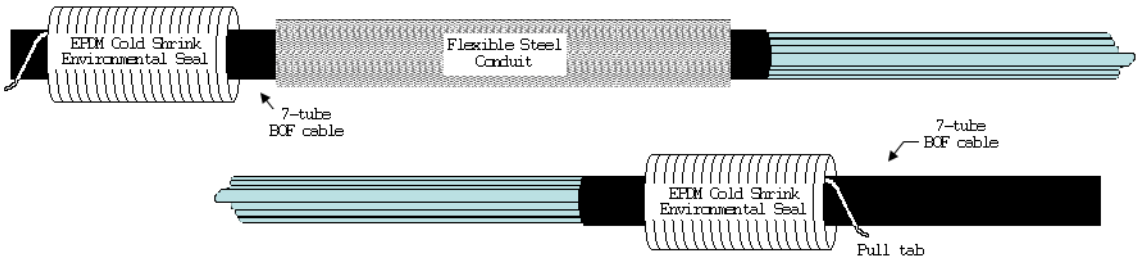

FIGURE 1C2-2. 7-tube BOF cables with cold shrink and conduit.

4.2.2 Cutting and forming the BOF cable tube stagger. The following steps shall be performed:

NOTE: The method for cutting the individual BOF tubes on the first 7-tube BOF cable depends on the tube couple stagger scheme selected. The cut locations are measured from the cable jacket, out.

NOTE: The individual BOF tubes are numbered “1” through “7”. The center tube is tube number “1”.

NOTE: If the “single-coupler stagger” scheme was selected, step 1a shall be performed. If the “two-coupler stagger” scheme was selected, step 1b shall be performed.

Step 1a. For the “single-coupler stagger” scheme, perform the following:

a. Use the tube cutter to cut tube number “7” approximately 2.75 inches from the end of the cable jacket. Visually verify that the end of the tube has been cut perpendicular to the tube length.

b. Use the tube cutter to cut tube number “6” approximately 2 inches from the end of tube number “7”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

c. Use the tube cutter to cut tube number “5” approximately 2 inches from the end of tube number “6”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

d. Use the tube cutter to cut tube number “1”, the center tube, approximately 2 inches from the end of tube number “5”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

e. Use the tube cutter to cut tube number “4” approximately 2 inches from the end of tube number “1”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

f. Use the tube cutter to cut tube number “3” approximately 2 inches from the end of tube number “4”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

g. Use the tube cutter to cut tube number “2” approximately 2 inches from the end of tube number “3”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

h. Clean the end of each BOF tube with a wipe dampened with alcohol and blow dry, as necessary.

Step 1b. For the "two-coupler stagger" scheme, perform the following:

a. Use the tube cutter to cut tube number "7" approximately 2.75 inches from the end of the cable jacket. Visually verify that the end of the tube has been cut perpendicular to the tube length.

b. Use the tube cutter to cut tube number "4" approximately 2.75 inches from the end of the cable jacket. Visually verify that the end of the tube has been cut perpendicular to the tube length.

c. Use the tube cutter to cut tube number "6" approximately 2 inches) from the end of tube number "7". Visually verify that the end of the tube has been cut perpendicular to the tube length.

d. Use the tube cutter to cut tube number "3" approximately 2 inches from the end of tube number "4". Visually verify that the end of the tube has been cut perpendicular to the tube length.

e. Use the tube cutter to cut tube number "1", the center tube, approximately 2 inches from the end of tube number "6". Visually verify that the end of the tube has been cut perpendicular to the tube length.

f. Use the tube cutter to cut tube number "5" approximately 2 inches from the end of tube number "1". Visually verify that the end of the tube has been cut perpendicular to the tube length.

g. Use the tube cutter to cut tube number "2" approximately 2 inches from the end of tube number "1". Visually verify that the end of the tube has been cut perpendicular to the tube length.

h. Clean the end of each BOF tube with a wipe dampened with alcohol and blow dry, as necessary.

NOTE: The method for cutting the individual BOF tubes on the second 7-tube BOF cable also depends on the tube couple stagger scheme selected. The difference is that the BOF tubes are cut in reverse order, with the cut locations measured from the cable jacket, out. If the "single-coupler stagger" scheme was selected, Step 2.a shall be performed. If the "two-coupler stagger" scheme was selected, Step 2.b shall be performed.

Step 2a. For the "single-coupler stagger" scheme, perform the following:

a. Use the tube cutter to cut tube number "2" approximately 2.75 inches from the end of the cable jacket. Visually verify that the end of the tube has been cut perpendicular to the tube length.

b. Use the tube cutter to cut tube number "3" approximately 2 inches from the end of tube number "2". Visually verify that the end of the tube has been cut perpendicular to the tube length.

c. Use the tube cutter to cut tube number "4" approximately 2 inches from the end of tube number "3". Visually verify that the end of the tube has been cut perpendicular to the tube length.

d. Use the tube cutter to cut tube number "1", the center tube, approximately 2 inches from the end of tube number "4". Visually verify that the end of the tube has been cut perpendicular to the tube length.

e. Use the tube cutter to cut tube number "5" approximately 2 inches from the end of tube number "1". Visually verify that the end of the tube has been cut perpendicular to the tube length.

f. Use the tube cutter to cut tube number "6" approximately 2 inches from the end of tube number "5". Visually verify that the end of the tube has been cut perpendicular to the tube length.

g. Use the tube cutter to cut tube number "7" approximately 2 inches from the end of tube number "6". Visually verify that the end of the tube has been cut perpendicular to the tube length.

h. Clean the end of each BOF tube with a wipe dampened with alcohol and blow dry, as necessary.

Step 2b. For the "two-coupler stagger" scheme, perform the following:

a. Use the tube cutter to cut tube number "2" approximately 2.75 inches from the end of the cable jacket. Visually verify that the end of the tube has been cut perpendicular to the tube length.

b. Use the tube cutter to cut tube number "5" approximately 2.75 inches from the end of the cable jacket. Visually verify that the end of the tube has been cut perpendicular to the tube length.

c. Use the tube cutter to cut tube number "1", the center tube, approximately 2 inches from the end of tube number "2". Visually verify that the end of the tube has been cut perpendicular to the tube length.

d. Use the tube cutter to cut tube number "3" approximately 2 inches from the end of tube number "1". Visually verify that the end of the tube has been cut perpendicular to the tube length.

e. Use the tube cutter to cut tube number “6” approximately 2 inches from the end of tube number “1”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

f. Use the tube cutter to cut tube number “4” approximately 2 inches from the end of tube number “3”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

g. Use the tube cutter to cut tube number “7” approximately 2 inches from the end of tube number “6”. Visually verify that the end of the tube has been cut perpendicular to the tube length.

h. Clean the end of each BOF tube with a wipe dampened with alcohol and blow dry, as necessary.

4.2.3 Coupling the BOF cable tubes. The following steps shall be performed:

NOTE: Regardless of the tube couple stagger scheme selected, BOF cables shall always be spliced with matching tube numbers coupled together.

NOTE: If a tube coupler is not a new tube coupler, it shall be swabbed with a cotton swab to remove previous tube coating debris before installing the coupler onto a tube.

Step 1. Ensure that the EPDM cold shrink environmental seals have been placed onto each of the two 7-tube BOF cables and that the flexible steel conduit has been placed onto one of the two 7-tube BOF cables (see figure 1C2-2).

Step 2. Slide a tube coupler onto tube number “1” on one of the two 7-tube BOF cables and firmly seat the tube within the tube coupler. Slide tube number “1” from the other 7-tube BOF cable into the other end of the tube coupler and firmly seat the tube within the tube coupler.

Step 3. Apply an axial load of approximately 22 newtons (5 pounds) between the two tubes to verify that both BOF tubes are properly engaged into the tube coupler.

Step 4. Insert 8-millimeter tube locking clips onto both ends of the tube coupler (see figure 1C2-3).

NOTE: It may be necessary to insert more than one e-clip onto each end of the tube coupler to ensure that the compression fitting cannot be “engaged”.

Step 5. Repeat Steps 2 through 4 for tube number “2”.

Step 6. Repeat Steps 2 through 4 for tube number “3”.

Step 7. Repeat Steps 2 through 4 for tube number “4”.

Step 8. Repeat Steps 2 through 4 for tube number “5”.

Step 9. Repeat Steps 2 through 4 for tube number “6”.

Step 10. Repeat Steps 2 through 4 for tube number “7”.

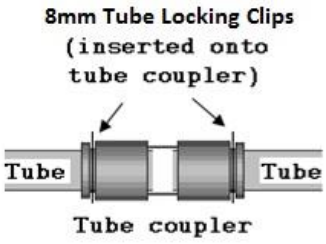

FIGURE 1C2-3. 8-mm tube locking clip installation.

4.2.4 Assembling the splice body. The following steps shall be performed:

Step 1. Slide the flexible steel conduit over the splice region such that the spice region is centered inside the conduit. Mark the end locations of the conduit on the 7-tube BOF cable jackets.

Step 2. Abrade each 7-tube BOF cable jacket circumferentially over the length that will be in contact with the EPDM cold shrink environmental seals using emery cloth. This is approximately 5 inches (127 millimeters) from the mark on the cable jacket, away from the splice region. Clean the abraded jacket of each 7-tube BOF cable with a wipe dampened with alcohol and blow dry, as necessary.

Step 3. Re-align the flexible steel conduit over the splice region. Slide one of the EPDM cold shrink environmental seals over the end of the conduit so that the cold shrink overlaps onto conduit approximately 6 inches (152.4 millimeters).

Step 4. Grasping the end of the cold shrink and the conduit with one hand, begin removing the center support on the cold shrink seal by pulling the “loose pull tab” while unwinding it (in a counter-clockwise direction) with the other hand. As the cold shrink constricts onto and approaches the end of the conduit, re-align the opposite end of the conduit with the mark on the cable jacket. Re-grasp the open end of the flexible steel conduit and the 7-tube BOF cable and finish removing the center support of the cold shrink seal by pulling out the remainder of the “loose pull tab” (see figure 1C2-4).

FIGURE 1C2-4. Half-finished splice.

Step 5. Slide the second EPDM cold shrink environmental seal over the opposite end of the flexible steel conduit so that the cold shrink overlaps onto conduit approximately 6 inches (152.4 millimeters).

Step 6. Grasping the end of the cold shrink and the conduit with one hand, begin removing the center support on the second cold shrink seal by pulling the “loose pull tab” while unwinding it (in a counter-clockwise direction) with the other hand. As the cold shrink constricts onto and approaches the end of the conduit, grasp the opposite end of the conduit, over the cold shrink, where the conduit and cable jacket meet and finish removing the center support of the cold shrink seal by pulling out the remainder of the “loose pull tab” (see figure 1C2-5).

FIGURE 1C2-5. Finished splice.

Step 7. Verify the continuity of each spliced tube with a ball bearing, as per Method 6H1.

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

METHOD 1D1
MULTIPLE-TUBE TO SINGLE-TUBE 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. This method is not intended to accommodate future use of non-furcated and unused BOF tubes. These tubes will be permanently end sealed and rendered unusable by this method. If unused BOF tubes in the cable to be furcated are planned as growth for modernization in the future, then use of a tube routing box for tube interconnections per MIL-STD-2042-2 should be considered instead of this furcation method.

2. DOCUMENTS APPLICABLE TO METHOD 1D1

2.1 General. The documents listed in this section are specified in Method 1D1 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 Method 1D1 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.

COMERCIAL ITEM DESCRIPTIONS

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

DEPARTMENT OF DEFENSE SPECIFICATIONS

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

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-2042-2 - Fiber Optic Cable Topology Installation, Standard Methods for Surface Ships and Submarines (Equipment) (Part 2 of 7 Parts)

(Copies of these documents are available online at http://quicksearch.dla.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.

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 online at www.sae.org.)

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

3. REQUIRED EQUIPMENT AND MATERIALS.

3.1 Equipment and materials. The equipment and materials in table 1D1-I shall be used to perform this procedure. More detail on approved sources for items with reference numbers can be found on the Dahlgren shipboard fiber optics website (see 6.5). The list on which items appear is indicated by the two-letter prefix as follows:

a. TL = Recommended Tool List

b. TS = Recommended Test Equipment List

TABLE 1D1-I. Equipment and materials.

Reference #	Description	Quantity
TL-0071	Safety glasses	1
TL-0012	Cable jacket-stripping tool	1
	BOF cable cutter	1
	Tube cutter	1
TL-0045	Aramid yarn cutting shears	1
TL-0101	Heat gun	1
	Adhesive/sealant tape (Raychem Thermofit S1030, or equal [see 4.5])	As required
	Heat shrink sleeves (Raychem SST-FR series, or equal [see 4.5])	As required
	Cold shrink sleeves (3M CST-S series, or equal [see 4.5]). (Optional alternative to heat shrink)	As required
	Tube coupler (A-A-59731-U-8)	As required
TL-0016	Cloth, cleaning, white	As required
TL-0044 or TL-0002	Isopropyl alcohol, 99% pure anhydrous or alcohol pad, sealed	1
TL-0013	Canned air	As required
	6.35 mm (0.25 inch) cotton swab	As required
	Tape	As required
TL-0069	Scale, 15.24 cm (6 inches)	1
TL-0046	Marking pen	1

4. PROCEDURES

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

a. Observe warnings and cautions on equipment and materials.

b. Do not 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.

4.2 Procedure. The following steps shall be performed:

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 (inch)
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 strips of approximately equal width around the cable circumference.

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

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: The individual BOF tubes shall not be 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: The individual BOF tubes shall not be punctured, crushed, or kinked while trimming back the cable elements.

Step 6. For each BOF tube, use the tube cutter to trim approximately 76 millimeters (3.0 inches) off the end of the tube. Visually verify that the end of each tube is cut perpendicular to the tube length.

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 centimeters (20 inches) from the end of the cable.

NOTE: The heat shrink sleeve material shall be in accordance with SAE-AMS-DTL-23053/15.

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 mm (inch)
	I.D. (min) mm (inch)	I.D. (max) mm (inch)	Wall thickness mm (inch)	
7-tube	68.6 (2.7)	22.9 (0.90)	3.9(0.16)	279 (12)
19-tube	114.3 (4.5)	44.5 (1.75)	4.3 (0.17)	305 (13)

Step 8. For each BOF tube that will not be connected to a single-tube BOF cable, end-seal the BOF tube in accordance with MIL-STD-2042-2, Method 2J1, Step 3.a.

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 centimeters (1.5 inches) 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: The individual tube shall not be 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.

NOTE: The individual BOF tubes shall not be punctured, crushed, or kinked while trimming back the cable elements.

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

Step 12. 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-millimeter (5-inch) 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 be in accordance with SAE-AMS-DTL-23053/15.

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) mm (inch)	**I.D. (max) mm (inch)**	**I.D. (min) mm (inch)**
27.9 (1.1)	9.5 (0.375)	27.9 (1.1)

Step 14. Slide a tube coupler onto the BOF tube and firmly seat the tube within the tube coupler.

NOTE: If a tube coupler is not a new tube coupler, the inside of the coupler should be swabbed with a cotton swab to remove previous tube coating debris before installing the coupler onto a tube.

NOTE: There shall be a 2- to 3-millimeter (0.1-inch) gap between the tube coupler and the single-tube BOF cable jacket. If no gap exists, remove the tube from the tube coupler, strip off 2 to 3 millimeters (0.1 inch) of the single-tube BOF cable jacket, and reinstall the tube within the tube coupler.

Step 15. Apply an axial load of approximately 22 newtons (5 pounds) 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. For heat shrink sleeves only: Holding the heat gun approximately 100 millimeters (4 inches) 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).

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

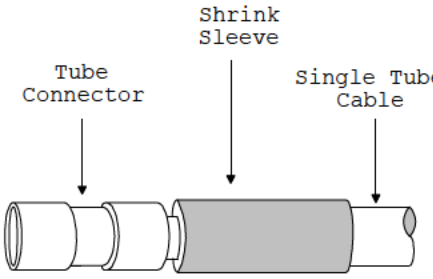

FIGURE 1D1-1. Installed single-tube BOF cable sleeve.

Step 17. 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 newtons (5 pounds) 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 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 and heat them slightly with the heat gun to soften them. 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).

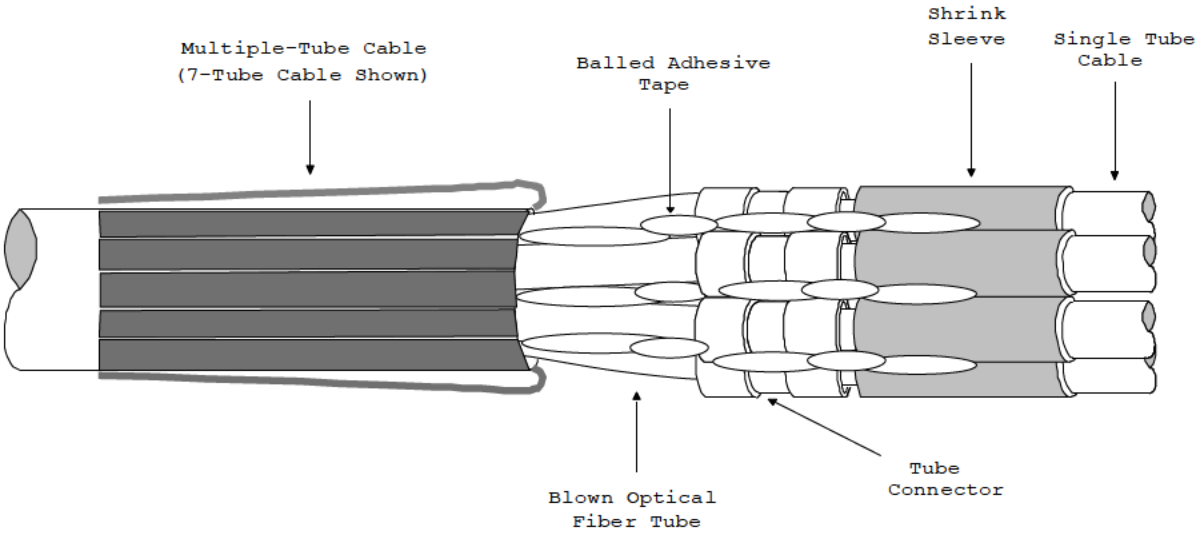

FIGURE 1D1-2. Tape contoured to the cable.

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 tape around the entire area, starting at the multiple-tube cable jacket and ending approximately 25 millimeters (1 inch) from the end of the single-tube cable shrink sleeves (see figure 1D1-3).

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

Step 22. Holding the heat gun approximately 100 millimeters (4 inches) away, apply just enough heat to the tape to form and contour the tape to the tubes.

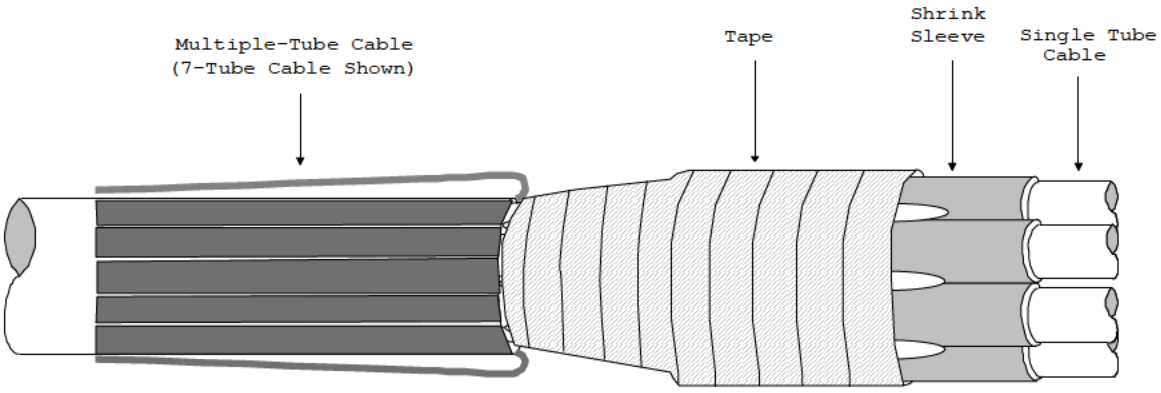

FIGURE 1D1-3. Completely taped cable end.

Step 23. Untape the cable jacket strips from the multiple-tube BOF cable and 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 to encase the BOF tubes and tube couplers. Press the cable jacket strips into the underlying tape.

Step 25. 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 millimeters (3 inches) and covers the taped section of the single-tube cables. Holding the heat gun approximately 100 millimeters (4 inches) 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).

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

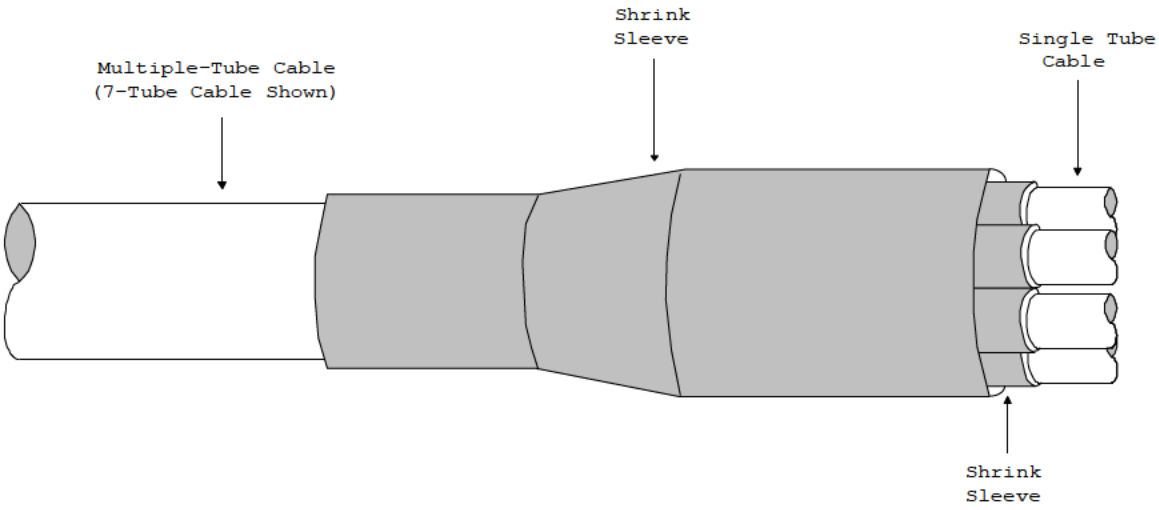

FIGURE 1D1-4. Completed furcation.

Step 26. Verify the continuity of each connected tube with a ball bearing using MIL-STD-2042-6, Method 6H1.

METHOD 1E1
OFCC AND LOOSE TUBE FURCATION CABLE END SEALING

1. SCOPE

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

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 Equipment and materials. The equipment and materials in table 1E1-I shall be used to perform this procedure. More detail on approved sources for items with reference numbers can be found on the Dahlgren shipboard fiber optics website (see 6.5). The list on which items appear is indicated by the two-letter prefix as follows:

a. TL = Recommended Tool List

b. TS = Recommended Test Equipment List

TABLE 1E1-I. Equipment and materials.

Reference #	Description	Quantity
TL-0071	Safety glasses	1
	Emery cloth	As required
TL-0101	Heat gun	1
TL-0044 or TL-0002	Isopropyl alcohol, 99% pure anhydrous or alcohol pad, sealed	1
	End cap (Raychem 101A011-3/86, or equal [see 4.5])	1
	Two-part epoxy (Devcon P/N 14250, or equal [see 4.5])	As required
TL-0016	Cloth, cleaning, white	As required
TL-0013	Canned air	As required

3. PROCEDURE.

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

a. Wear safety glasses 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, do not 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 loose tube furcation cable or OFCC 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 loose tube furcation cable or OFCC 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 loose tube furcation cable or OFCC to be sealed.

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

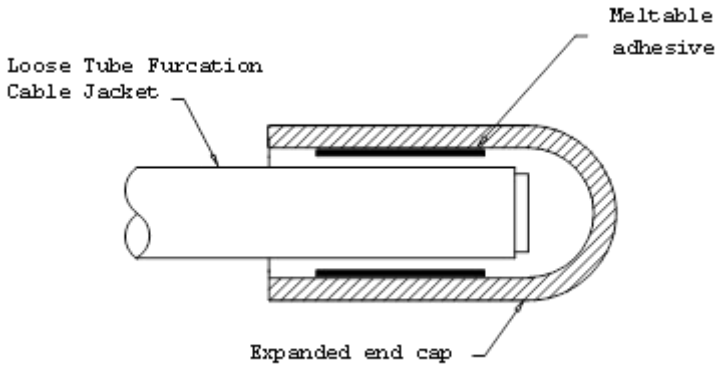

FIGURE 1E1-1. Installing expanded end cap on cable.

Step 4. Hold the heat gun approximately 100 millimeters (4 inches) 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.

CAUTION: Do not overheat the loose tube 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.

NOTE: Minimum recovery temperature shall be 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.

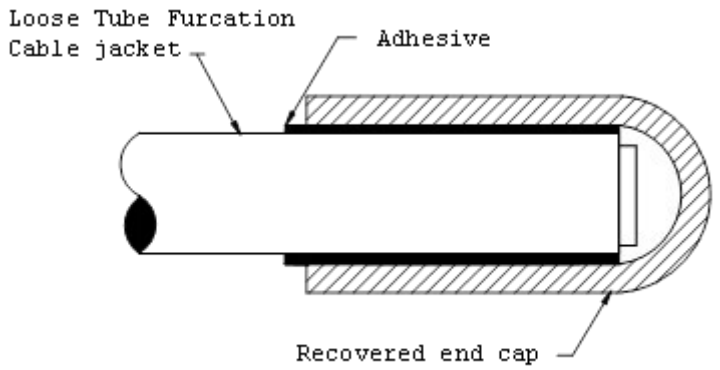

FIGURE 1E1-2. Completed end seal.

Preparing activity:
Navy – SH
(Project SESS-2014-005)

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