DEPARTMENT OF THE NAVY
NAVAL SURFACE WARFARE CENTER
CARDEROCK DIVISION

NAVAL SHIP SYSTEMS
ENGINEERING STATION
5001 S. BROAD STREET
PHILADELPHIA, PA 19112-1403

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Commander, Carderock Division, Naval Surface Warfare Center,
Naval Ship Systems Engineering Station, Philadelphia, PA

To: Commander, Naval Sea Systems Command Headquarters (Code 05Z5)
Commander, Naval Air Systems Command Headquarters Patuxent River (Code 4.5)
Commander, Space and Naval Warfare Systems Command Headquarters San Diego (Code PMW-165)

GUIDANCE DOCUMENT: APPROACHES TO FIBER OPTIC CABLE & HARNESS REPLACEMENT/REPAIR

(1) Approaches to Fiber Optic Cable/Harness Replacement/Repair, Revision B of 19 Feb 2003

1. Purpose
This letter addresses guidelines to be used for the determining the applicable approach to fiber optic cable and harness replacement or repair. It is recognized that no one approach is appropriate for each Platform (such as ship, aircraft or ground-based) or the specific variants of each Platform. The intent of this letter is to specify policy where existing or to otherwise define the approaches to consider along with guidance for the selection. Enclosure (1) provides further guidance for selection. Future documentation will identify specific fiber optic components and equipment to be used for cable/harness repair. This identification will be done to keep training and support efforts to a manageable level.

2. Approaches to cable/harness replacement
Cable/harness replacement should be considered over repair whenever the Platform or application can accommodate this type of approach. Two approaches to cable/harness replacement to be employed are:

a. Redundancy. Fiber optic cable/harness design is to include provisions for redundancy when the application permits. These provisions include cable spares (or jacketed fiber) and patch panels. Damaged cables/harnesses are replaced by substituting to one of the cables (or jacketed fiber) identified as a spare by moving connectors at the patch panels. The redundant cable, when not a part of a cable harness, should be separated from the normal cable to maximize survivability.

b. Threading. Replacement cable is to be located adjacent to existing cable/harness when the application permits and redundancy cannot be accommodated.

3. Approaches to cable/harness repair
Cable/harness repair should be considered only when the Platform or application cannot accommodate a replacement approach. Three approaches to cable/harness repair are to be employed and the most suitable one selected for the Platform/application. These approaches are:

a. Fusion splice.

b. Snap lock splice.

c. Mechanical splice.

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4. NAVAIR aircraft policy
   a. Cable replacement/repair approach is Platform specific.

   b. Repair kit requirements, if any, are to be defined by each Platform.

   c. Commonality Fiber Optic Working Group will standardize:
      (1) Type of single terminus connectors and other items required for patching.
      (2) Procedure to "thread" new cabling along side of an existing cable harness.
      (3) Type of fusion splicer.
      (4) Specific types of mechanical splices.

5. Navy shipboard policy
   a. Replacement approach is to be used in which patching is done with designated cable (or jacketed fiber) spares.

   b. Fusion splices are not approved for general shipboard use in new construction or repair.

   c. Fusion splices may be used within OEM equipment, but are not repairable/replaceable by Navy or shipyard personnel.

6. Points of contact
Please direct questions or comments to the Naval Surface Warfare Center Carderock Division, Ship Systems Engineering Station (NSWCCD-SSES) point of contact for fiber optic component testing and principle contact for NAVAIR/SPAWAR applications on this subject is E. Bluebond. He can be contacted by FAX: (215) 897-8509 or E-mail: bluebondej@nswccd.navy.mil. The Naval Surface Warfare Center, Dahlgren Division (NSWC DD) point of contact for specification requirements and principle contact for NAVSEA applications on this subject is G. Brown. He can be contacted by FAX: (540) 653-8673 or E-mail: browngd@nswc.navy.mil.

M. STUSNICK
By direction

Copy to:
NAVSEA 05Z5 (M. McLean)
NAVSEA 05Z5 (H. Lewis)
NAVSEA 05J2 (J. Moschopoulos)
NSWC DD B35 (G. Brown)
NAVAIR 1.0 (G. Celala)
NAVAIR 3.1 (P. Arnason)
NAVAIR 3.2 (M. Breckon)
NAVAIR 4.4.4.3 (W. Boblitt)
NAVAIR 4.4.4.3 (M. Peppas)
NAVAIR 4.5.1.1 (G. Walles)
NAVAIR 4.5.7 (D. Glista)
NAVAIR 4.5 7 (M. Beranek)
NAVAIR 4.5.7 (A. Burroughs)

NAVAIR 4.8.1.3 (A. Michon)
SPAWAR PMW-165 (N.Freije)
SPAWAR. PMW-165 (R. Orchard)
SPAWAR PMW-165 (D. Kinsey)
SPAWAR 04N-43A (D. Zsutty)
SPAWAR 051 (C. Suggs)
DSCC-VQP (R. Marbais)
DSCC-VAT (D. Leight)

Guidance Document
Approaches to Fiber Optic Cable/Harness Replacement/Repair

Replacement approaches.

a. Redundancy.
  (1) Applications. When the application permits, provisions for redundancy should be included. Included in a redundant configuration are cable spares (or jacketed fiber) and patch panels. Damaged cables are replaced by substituting to one of the cables identified as a spare by moving connectors at the patch panels.
  (2) Advantages.
    (a) Cable rerouting can take place with a minimum of downtime.
    (b) Requires minimum level of skill to perform substituting operation.
  (3) Disadvantages.
    (a) Initial cost is greater to install cables that may not be used.
    (b) Redundant cables add weight that some Platforms may not be able to tolerate.

b. Threading.
  (1) Applications. When the application permits and redundancy cannot be accommodated, threading of replacement cabling may be done along with existing cable harness.
  (2) Advantages.
    (a) Threading approach does not require that cabling within an existing cable harness be disturbed.
  (3) Disadvantages.
    (a) Replacement cable may need to be threaded through areas with no or limited access.
    (b) Damaged cable remains in cable harness resulting in additional weight once the new cable is installed.
    (c) Requires level of skill to thread cable and replace termini of the damaged cable in the connector with that of the threaded cable.

2. Repair approaches.

Fusion splice.
  (1) Applications. Joining of two cables during initial installation or two broken cables for cable repair. This approach is usually done where there is a splice enclosure with splice trays to house the splices. There must be sufficient length of cable allotted in the cable harness for strip back of cable jacket and the splicing operation. Also, the optical cable to be spliced and the fusion splicer must be compatible and there must be sufficient room near the cable ends for the fusion splicer to be used.
  (2) Advantages.
    (a) Obtain a fused joint that is stronger than the surrounding fiber.
    (b) Low loss value at the joint. Fused joints may be of an average, lower loss value than for a mechanical connection (either splice or connector).
      1 Single mode loss of 0.05 to 0.2 dB for fusion splice versus 0.2 to 0.5 dB for a mechanical connection.
      2 Multimode loss of 0.01 to 0.2 dB for fusion splice versus 0.1 to 0.2 dB for a mechanical splice or 0.2 to 0.5 dB for a mechanical connection.

Enclosure (1)

(c) Low optical return loss value at the fused joint.

(3) Disadvantages.

(a) User skill level.

1 Must perform on continual basis to become/remain proficient.

2 Must use skill in setup, selection of correct profile parameters, etc.

(b) Automation.

1 Does not eliminate skill requirement for strip and cleave operations.

2 Increases access requirement.

(c) Environmental factors

1 Cleanliness and accessibility are a necessity.

2 Optical loss can vary with environmental change if splice is not fused properly. The splice may deceivingly appear to be adequate when visually inspected.

3 Splice performance may be unstable if splice protectors are not used correctly.

(d) Quality assurance.

1 Difficult to assess splice quality in the field. Visual inspection is not adequate.

(e) Process.

1 Fiber recoating required for high reliability.

(f) Added optical loss.

1 Spliced cable contains an additional interface that results in additional optical loss and an interface that may degrade over time.

(g) Electrical power.

1 Electric power required for fusing the fibers.

2 Electric arc constitutes an explosion hazard.

(h) Cost.

1 Higher initial equipment cost for fusion splicer.

2 Requires investment and maintenance of a good quality cleaver.

(i) Parameter settings.

1 Different parameter settings need to be established for each fiber configuration.

2 Parameter settings must be adjusted to compensate for factors such as electrode wear.

b. Snap lock splice.

(1) Applications. Joining of two cables during initial installation or two broken cables for cable repair. This approach is usually done when a more substantial connection interface is required. There must be sufficient room near the damaged cable end for the stripping and polishing operations to be performed. The splice consists of two MIL-T-29504 Termini and a snap lock housing.

(2) Advantages.

(a) Requires no additional training beyond training for MIL-T-29504 termini used with the compatible multiple termini connectors (such as MIL-PRF-28876 or MIL-DTL-38999) and no deviation of current termination procedures.

(b) Requires no additional maintenance of personnel proficiency beyond the applications noted above.

(c) Requires no additional materials (including tools) and consumable items to support terminations beyond the applications noted above.

(d) Potential for multiple sources of supply for principal splice components.Disadvantages.

(a) Requires use of epoxy. Reliability equates to difference between operating temperature and glass transition temperature.

1 As temperature increases, useful life decreases.

2 As temperature increases, fiber creep and pullback increases.
3 Limited shelf life.

(b) Requires sufficient space and cable length to place a terminus on one end of the cable.
(c) Requires level of skill to terminate one terminus on the cable end (including strip and cleave operations) and to replace terminus of the damaged cable in the connector with that of the replacement terminus.
(d) Spliced cable contains an additional interface that results in additional optical loss and an interface that may degrade over time.
(e) Electrical power required for curing operation.
(f) Optical loss and return loss

c. Mechanical splice.

(1) Applications. Joining of two cables during initial installation or two broken cables for cable repair. This approach is usually done where there is a splice enclosure with splice trays to house the splices. There must be sufficient length of cable allotted in the cable harness for strip back of cable jacket. Also, there must be sufficient room near the cable ends for operations to adequately secure the cable splice.
(2) Advantages.
(a) Requires less skill to accomplish repairs.Can be performed with no need for electric power for some splice designs (using hand tools only).Disadvantages.
(a) Requires investment and maintenance of a good quality cleaver.
(b) Splice construction/materials limits scope of applications more than other types of cable repair approaches.
(c) Spliced cable contains an additional interface that results in additional optical loss and an interface that may degrade over time.
(d) User skill required for strip and cleave operations.
(e) Splice performance may be unstable if splice protectors are not used correctly.
(f) Difficult to assess splice quality in the field.

NAVAIR fiber optic cable/harness replacement/repair approach.

a. Cable repair/replacement approach is Platform specific.
b. Repair kit requirements, if any, are to be defined by each Platform.
c. Commonality will identify the following items.
(1) Standardize on type of fusion splicer.
(2) Standardize on a few specific mechanical splices.
(3) Standardize on procedure to “thread” new cabling along side of an existing cable harness.
(4) Standardize on single terminus connectors and other items required for patching.

4. Navy Shipboard fiber optic cable replacement/repair approach.

a. Patching done with designated spare cables.
b. Fusion splices are not approved for general shipboard use in new construction or repair.
c. Fusion splices may be used within OEM equipment, but are not repairable/replaceable by Navy or shipyard personnel.

DOC: CblRepairGuide.doc