NAVAL SHIP SYSTEMS
ENGINEERING STATION
PHILADELPHIA, PA 19112-5083

DEPARTMENT OF THE NAVY
NAVAL SURFACE WARFARE CENTER
CARDEROCK DIVISION

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From: Commander, Carderock Division, Naval Surface Warfare Center, Philadelphia Station, Philadelphia, PA 19112-5083
To: Commander, Naval Sea Systems Command (SEA 03J2)

Subj: SHIPBOARD APPLICATIONS PROPER MEASUREMENT LOSS TEST PERFORMANCE

Ref: (a) Military Standard MIL-STD-2042A (SH) Fiber Optic Cable Topology Installation Standard Methods for Naval Ships of 11 Sep 1996

Encl: (1) Analysis Of Measurement Loss Test For A Fiber Optic Cable Assembly Perform To MIL-STD-2042 Method 6C1 Versus Using An Alternate Method dated 21 May 1997

1. Purpose. This letter addresses the necessity and requirement to perform an optical measurement loss test on a fiber optic cable assembly in accordance with reference (a). Improper measurement loss techniques are being used by some installation personnel. Recent problems with unacceptable measurement losses obtained were a result of measurement loss procedure used and not component flaw or installer fabrication technique. Use of proper measurement loss procedure will ensure accurate and repeatable data are obtained.

2. Background. Field measurements for fiber optic cable assembly loss being performed on an ongoing basis were analyzed. This analysis showed highly variable data and little, if any, correlation. These field measurements were being performed using different industry procedures and technical society standards. The Naval Surface Warfare Center, Dahlgren Division (NSWC DD) was tasked to investigate the problem and determine the corrective action required. NSWC DD identified problem areas with the measurement loss methods being used. These problem areas included the realization that most methods were- not measuring the cable assembly loss. The need to perform the measurements with low optical loss reference jumpers, measurement quality jumpers is the term used in MIL-STD-2042, was identified and determined to be a key issue. A proper and standardized method was developed, verified and incorporated into MIL-STD--2042.

3. Usage requirement. Naval Sea Systems Command (NAVSEA) requires implementation of this measurement loss method by incorporating the method as a standard practice in MIL-STD-2042. Several activities responsible for engineering oversight of fiber optic cable plant installation stated that they would switch to the standard practice once the need to do so was understood. Enclosure (1) was written in response to this request. Use of MIL-STD-2042 standard practice, including the use of measurement quality jumpers, for loss measurement is mandated, not requested. NSWC DD and the Naval Surface Warfare Center, Carderock Division, Ship Systems Engineering Station (NSWCCD-SSES) can assist in understanding and training to use the standard practice for the loss measurement.

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4. NSWC DD point of contact for fiber optic cable plant `development and test is G. Brown. He can be contacted at (540) 653-1579, FAX (540) 653-8673. NSWCCD-SSES point of contact and NAVSEA technical agent for fiber optic component QPL is E. Bluebond. He can be contacted at (215) 897-8510, Fax (215) 897-8509.

J.P. COPPOLA
By direction

Copy to:
NAVSEA O3~J21 (H. Lewis)
NAVSEA 01121 (K. Long)
NAVSEA 03J21 (C. Courchaine)
NSWC DD B35 (G. Brown)
DSCC-VQP (A. Eschmeyer)
DSCC-VQP (R. Wallace)
NSWCCD-SSES 954,9542 (2)

21 May 1997

Analysis of Measurement Loss Test
For A Fiber Optic Cable Assembly
Perform To MIL-STD-2042 Method 6C1
Versus Using an Alternate Method

1. Measurement Loss Test Method.
   a. MIL-STD-2042:
      (1) Obtain reference power measurement (see Figure 1).
         (a) Attach one reference jumper (Ref 1) between the source (light source) and detector (power meter or test set).
         (b) Record the output power measurement (P_1) in dBm.
      (2) Obtain cable assembly power measurement (see Figure 2).
         (a) Disconnect the reference jumper from the detector.
         (b) Attach this end of the reference jumper (Ref 1) to one end of the cable assembly.
         (c) Attach a second reference jumper (Ref 2) to the other end of the cable assembly.
         (d) Attach the free end of the reference jumper (Ref 2) to the detector.
         (e) Record the output power measurement (P_2) in dBm.
      (3) Calculate the measurement loss.
         (a) Subtract the output power measurements P_2-P_1 to obtain the measurement loss ($L_{ca} = P_2 - P_1$).
         (b) Record the cable assembly loss (L_{ca}).
         Note: This method determines the loss for two connectors at both ends of the cable assembly.

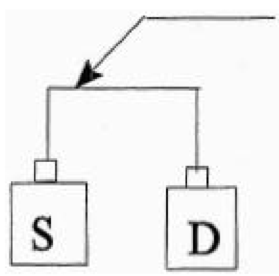

Figure 1 MIL-STD-2042 Reference Power Measurement.

Enclosure (1)

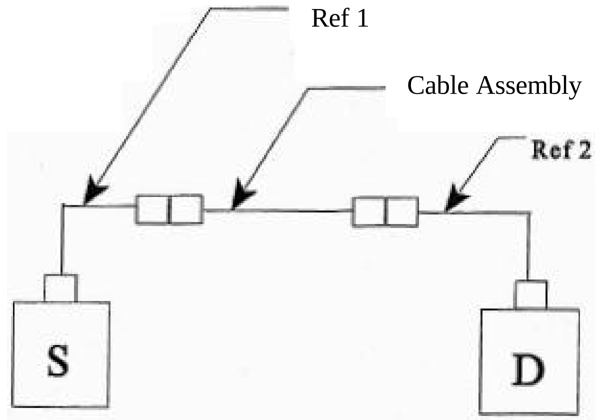

Figure 2 MIL-STD-2042 Cable Assembly Power Measurement

b. Alternate Loss Method:

(1) Obtain reference power measurement (see Figure 3).

(a) Attach one end of the first reference jumper (Ref 1) to the source (light source).

(b) Attach one end of a second reference jumper (Ref 2) to the detector (power meter or test set).

(c) Attach the free end of each reference jumper together (via an ST-to-ST adapter).

(d) Record the output power measurement (P_1) in dBm.

(2) Obtain cable assembly power measurement (see Figure 4).

(a) Disconnect the reference jumpers (Ref 1 and Ref 2) from each other.

(b) Attach this end of the reference jumper (Ref 2) to one end of the cable assembly.

(c) Attach the other reference jumper (Ref 1) to the other end of the cable assembly.

(d) Record the output power measurement (P_2) in dBm.

(3) Calculate the measurement loss.

(a) Subtract the output power measurements P_2-P_1 to obtain the measurement loss ($L_{ca}= P_2 - P_1$).

(b) Record the measurement loss (L_{ca}).

Note: This method determines the loss for the one connector on the cable assembly closer to the source end. The loss for the connector on the cable assembly closer to the detector end was measured for both P_1 and P_2. The calculation of $P_2 - P_1$ effectively subtracted out the loss at this connector. The need to use measurement quality jumpers (mqj ‘s) for the reference jumpers must still be addressed.

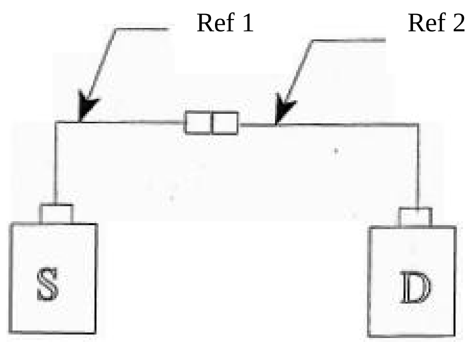

Figure 3 Alternate Method Reference Power Measurement

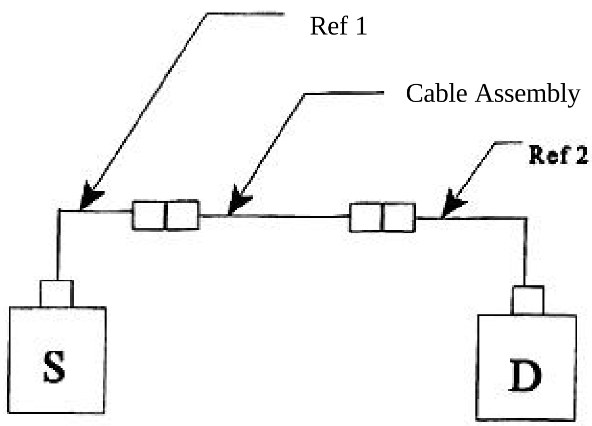

Figure 4 Alternate Method Cable Assembly Power Measurement

2. Selection and development of MIL-STD-2042 cable assembly loss procedure.
   a. Background. Field measurements for fiber optic cable assembly loss being performed on an ongoing basis were analyzed. This analysis showed highly variable data and little, if any, correlation. These field measurements were being performed using the alternative method listed in paragraph 2 or a bidirectional measurement method. The Naval Surface Warfare Center, Dahlgren Division (NSWC DD) was tasked to investigate the problem and determine the corrective action required.
   b. Measurement methods being used.
      (1) Alternative method listed in paragraph 2. This method does not measure the entire cable assembly loss and can vary greatly in the measurement loss determined. Losses that exceeded 1.0 dB were not uncommon. This was attributed to variability in the two reference jumpers, variability in the mating of the reference jumpers and changing the reference jumpers for measurements taken at different times/by different personnel. The alternative method provides an estimate of one connector mated pair loss plus the cable loss.

(2) Bidirectional measurement method. This measurement method uses one reference jumper to “zero the meter”. The cable assembly is then attached between the reference jumper and the detector. The output power is obtained. The cable assembly is reversed between the reference jumper and detector. The output power is then obtained. Each measurement provides the connector mated pair loss on the cable assembly closest to the source plus the cable loss. The addition of the two output.power measurements obtained is a measure of the two individual connector mated pair losses plus twice the cable loss. In general, this method does not provide the measurement of the entire cable assembly loss.

(3) MIL-STD-2042 measurement method. This measurement method was selected to be used in MIL-STD-2042 since the measurement loss of the cable assembly is obtained. Concern remained in the variability of the reference jumpers being used. This lead to the development and requirement to use measurement quality jumpers (mqj) for the reference jumpers.

c. Measurement quality jumpers.

(1) Jumper quality. Poor reference jumper quality leads to higher loss measurements for some methods, lower loss measurements for others. Measurement loss are found to increase using either the bidirectional or MIL-STD-2042 method with poorer reference jumpers. The measurement loss is found to increase or decrease, depending upon circumstances, using the alternate method with poorer reference jumpers. Variability in the mating characteristics of different jumpers leads to highly variable loss measurements (greater than 1.0 dB variation). In general, use of reference jumpers with other than verified/certified low losses and low variability, leads to unknown results. Installer use of any jumpers or uncontrolled use of reference jumpers are situations that can produce measurements with erroneous results.

(2) Advantage of using a low loss reference jumper. Erroneous measurements will result in a high loss value (one outside the specified tolerance). The installer will be alerted that there is a problem. Troubleshooting can be done to determine if the problem is the cable assembly or the reference jumper.

(3) The measurement quality jumper. The measurement quality jumper is a low loss, low variability (as verified with the standard deviation of multiple measurements) jumper that has been tested in accordance with method 6F1 of MIL-STD-2042. A measurement quality jumper can be purchased or fabricated by the installer. If fabricated, it must be certified using method of 6F1 of MIL-STD-2042.

3. Maximum acceptable loss (L_{MA}) of the cable assembly.

a. Criteria.

(1) The cable assembly is acceptable if the measured loss in each direction is less than or equal to the maximum acceptable loss (L_{MA}).

(2) If the measured loss in either direction is less than 0.5 dB above L_{MA}, disconnect and clean all the connectors and retest. If the measured loss remains above L_{MA}, proceed to the next step.

(3) If the measured loss in either direction is 0.5 dB or more above L_{MA} disconnect, clean and re-polish the connectors. If the measured loss remains 0.5 dB or more above L_{MA} reject the cable assembly.

b. Calculation of L_{MA}.

(1) $L_{MA}=(A_{CA})(L)+L_{co}$

(2) Formula parameters:

A_{CA}= maximum attenuation of the cable

Use A_{CA} = 1.0 dB/km for single mode cable at 1310 nm.

Use A_{CA} = 2.0 dB/km for multimode cable at 1300 nm.

L = length of the cable.

L_{CO}= maximum loss of the connector mated pair.

Use L_{CO} = 1.0 dB for single mode connectors.

Use L_{CO} = 1.0 dB for multimode connectors.

c. Pass/fail criteria for 850 nm versus 1300 nm for multimode.

(1) The formula parameters listed above pertain to the 1300 nm wavelength.

(2) Use the following formula parameters for the 850 nm wavelength:

A_{CA}.= maximum attenuation of the cable.

Use A_{CA} = 4.5 dB/km for multimode cable.

L_{CO} = maximum loss of the connector mated pair.

Use L_{CO} = 1.0 dB for multimode connectors.

d. Tightening of maximum acceptable loss of each connector mated pair.

(1) Risk considerations. A risk factor is associated with the determination to tighten the limit for maximum acceptable loss. This risk involves the the actual value of the cable attenuation.

(a) Low cable attenuation mask high connector loss (if don't tighten tolerance). If the loss of the cable is consistently less than the specified attenuation value, worst case cable loss criteria may be inappropriate for use. The use of worst case cable loss criteria may allow poor quality components/fabrications to be inadvertently accepted for a loss measurement during acceptance testing. For example, if a cable assembly is 300 meters in length and the cable loss is known to be 3.6 dB/km, the use of worst case loss criteria would allow an additional 0.3 dB of loss for other link components.

(b) Installed cable attenuation higher than vendor provided value (if tighten tolerance). Cable attenuation value may increase after installation, but remain the cable specification. Cable assembly could then fail the measurement loss if use the lower cable attenuation value provided by vendor or obtained during incoming inspection. Acceptable connector loss can be misinterpreted as a failure due to increased, but not accounted for, cable attenuation.

(2) Recommendations for measurements in lower acceptable loss cable assemblies.

(a) Lower cable attenuation value provided by the vendor or obtained during incoming inspection may be used instead of worst case cable loss values.

(b) Higher cable attenuation after installation may be suspected if repeated efforts at acceptable connector loss are unsuccessful. When this situation occurs, use the cable attenuation (A_{CA}) and not the value of the cable attenuation provided by the vendor or obtained during incoming inspection.