



DEPARTMENT OF THE NAVY
NAVAL SURFACE WARFARE CENTER
CARDEROCK DIVISION

NAVAL SHIP SYSTEMS
ENGINEERING STATION
PHILADELPHIA, PA 19112-5083

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From: Commanding Officer, Naval Ship Systems Engineering Station,
Carderock Division, Naval Surface Warfare Center

To: Commander, Space and Naval Warfare Systems Command
Headquarters San Diego (Code PD 15Q)

Subj: LASER SAFETY CONTROL MEASURE GUIDELINES FOR FIBER OPTIC APPLICATIONS

Encl: (1) Laser Safety Control Measure Guidelines For Fiber Optic Applications Ancillary Hazards of 22 April 2000
(2) Fiber Optic Laser Safety Service Group Classifications For End Of Fiber Viewing of 27 April 1995

1. Purpose

This letter addresses guidelines to be used for laser safety measures when installing and servicing optical fiber communication systems (OFCS). Exposure to emitted optical power occurs only during installation and servicing where the optical path is not completely enclosed. When a connector is removed for visual inspection of the end face under magnification, using an eye-loupe, magnifier or microscope (optically aided viewing), then all of the emitted optical power can be focused on the eye. ANSI Standard Z136.2 defines four Service Group (SG) hazard classifications to cover the viewing conditions when fiber optic cables are disconnected. Fiber optic ancillary hazards with guidance for control measures are briefly addressed in enclosure (1). This letter provides guidance that is general and appropriate for most, if not all applications. This guidance is not meant to be all-inclusive and must be augmented/tailored for each site. Consult your activities Safety and Health Office for further guidance.

2. Guidance while inspecting the end face under magnification.

a. Optically-aided viewing.

(1) Verify that no optical power is emitted at the other end.

(a) De-energize system. This option may not be feasible when servicing a large network in operation.

(b) Disconnect at other end.

Note: This is not preferred from a reliability perspective. Greater number of disconnections, or disturbances to the cabling in general, decrease system reliability.

(2) Control measures.

(a) Optical power measurement. Use an optical power meter or other suitable device to verify there is no emission of optical power prior to using an optically-aided viewing device.

(b) Implement tag-out procedure. This control measure may be implemented as warranted. Note: Use of a video inspection system may negate the need to implement control measures for connector end face inspection.

b. Video inspection system. No special measures need to be addressed for end face inspection.

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3. Guidance during period of disconnection without viewing.

If no tag-out procedure is in effect, do not view the fiber end/connector end face directly prior to performing an optical power measurement. Do not expose other personnel in the area directly to the emitted optical power.

4. Ancillary hazards and control measures.

Fiber optic ancillary hazards are identified with guidance for control measures provided in enclosure (1). Ancillary hazards with control measures identified are those applicable for all fiber optic applications and should be augmented as required.

5. Other considerations for optically aided viewing.

a. End of fiber viewing while optical power present. End of fiber viewing (including the connector end face) is to be done with the source de-energized. Use a power meter to verify that no optical power is being emitted. When a microscope, or other magnifier or optically aided viewing, is used while optical power is present, then it must be determined if the resulting exposure exceeds the maximum permissible irradiance. At sites where the maximum optical power levels may not be known/available to installation/service personnel or when new systems are added constantly with different optical power levels, end of fiber viewing should be done only with the source de-energized. If the source cannot be de-energized while the end of fiber viewing occurs, then an alternative is to use a video inspection system.

Summary: The practice of end of fiber viewing while optical power is present is never recommended and should be avoided altogether. When the source cannot be de-energized, an alternative inspection technique, such as video inspection system should be employed.

b. Microscopes with filters. Some microscopes contain filters. The degree of filter effectiveness varies greatly with wavelength, optical power level and filter type. A microscope with an adequate degree of filter effectiveness may be determined in a situation where the wavelength, optical power level, etc. are known. Most systems do not remain static and see equipment change out as part of periodic upgrades. A greater degree of filter effectiveness required by an upgrade would most likely be overlooked. It is recommended that filters be employed as a safe guard against an accidental mishap and not to encourage viewing while optical power is present.

c. Tailoring of Service Group classifications. Enclosure (2) is one example of guidance prepared for end of fiber viewing (or other servicing/installation situations) where the source wavelength, pulse rate and approximate optical power levels were known to test personnel. This enclosure was developed as a laser safety control measure and to help related classifications with power levels. Personnel performing inspections for end of fiber viewing do so with no presence of optical power. If a microscope, or other magnifier or optically aided viewing, is used while optical power is present, then the maximum permissible irradiance must still be determined for each system/source emission. Personnel must be aware of the limited set of constraints under which viewing is permitted while optical power is present.


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6. Feedback on implementation.

Please inform us of the control measures implemented or being considered for implementation at your site.

7. Point of contact.

Please direct questions or comments to the Naval Surface Warfare Center Carderock Division, Ship Systems Engineering Station (NSWCCD-SSES) assistant Laser Systems Safety Officer (LSSO) and point of contact for fiber optic component testing, E. Bluebond. He can be contacted by FAX: (215) 897-8509 or E-mail: bluebond@spawar.navy.mil.


M. STUSNICK
By direction

Copy to:

NAVSEA 05JB (J. Moschopoulos)
NAVSEA 05J2 (H. Lewis)
NSWC DD B35 (G. Brown)
SPAWAR PMW-158 (CDR Ziegler)
SPAWAR PMW-152 (R. Evans)
SPAWAR PD 15Q2 (J. Bachrach)
SPAWAR D632 (A. Maldonado)
SPAWAR 04N-43A (D. Zsutty)
SPAWAR 051 (C. Suggs)

**Laser Safety Control Measure Guidelines
For Fiber Optic Applications Ancillary Hazards**

1. Eye protection control measure.

a. Connector terminations. Minimum period that eye wear should be worn is from the time the cable is stripped down to the fiber until the fiber has been cleaved from the connector end face and safely discarded.

(1) Fiber handling. Eye protection should be worn as a precaution from a glass fragment/splinter from penetrating the eye during fiber optic cable preparation and connector terminations.

(2) Epoxy handling. When epoxy is placed into a syringe and injected into the connector, an uncontrolled discharge of epoxy may occur (epoxy may squirt between syringe and needle tip into the eye).

b. UV curing. Eyewear providing UV protection should be worn during the curing process (when UV lamp is energized) when fibers are terminated in connectors/splices using UV adhesive.

c. Solvents. Eyewear should be worn while handling solvents (including isopropyl alcohol) during fiber stripping and fiber/connector cleaning operations.

2. Work area control measures.

a. Eating, drinking or smoking control measures.

(1) Fiber handling. Do not eat or drink in an area in which connector terminations occurred or other operations that may result in generating fiber fragments/splinters (including cable removal). Wash hands after handling fiber.

(2) Solvents handling. Do not eat, drink or smoke in an area in which stripping or cleaning solvents were used.

b. Work surface. Where feasible, perform connector terminations on a dark, non-reflective, chemically resistant work surface with proper lighting.

c. Floor surface. Where feasible, perform connector terminations on a tiled floor or other type of smooth, continuous surface where fiber fragments can be swept up easily.

d. Chairs. Surfaces of chairs used in the work area should be of a continuous, plastic material. Cloth surfaces tend to trap fibers causing penetration into the skin when seated.

e. Tools. Ensure that tools are free of sticky contaminants that can collect fiber fragments.

f. Ventilation. Use epoxy and solvents in well ventilated areas. In situations where solvent vapors may lead to a fire, alcohol pads may be considered as an alternative to reduce the chance of fire.

3. Work clothes control measure.

a. Coverage and fit. Tighter fit clothing in which the coverage includes the arms and legs are preferred. A laboratory jacket or coveralls over other attire may be used as an alternative measure.

b. Cuffs. Rolled up shirt cuffs and cuffs on pants should be discouraged since it may serve as a trap for fiber fragments.

4. Hazardous material waste disposal control measure.

a. Two-part epoxy. Two-part epoxies on the Navy fiber optic recommended components parts list come in packets separated into two parts, hardener and resin. The hardener is a corrosive material. The gelled epoxy becomes a piece of thermoset plastic and may be disposed of as a non-hazardous material. Leftover epoxy, that has been mixed, may be disposed of with the non-hazardous waste once it is hardened. Expired epoxy should be mixed and allowed to cure (gel or solidify) prior to disposal. Some types of two-part epoxies may need to be heated in order to cure. If the hardener goes bad, then the epoxy will not gel and must be disposed of as a hazardous material.

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b. Fiber ends. Preferred disposal for cleaved ends of optical fiber is to place them in a plastic bottle. An alternate means is to wrap the fiber in a layer of tape. The placement of fiber ends in a bottle is preferred since tape wrapped fiber usually is deposited into local, trashcans. Personnel emptying these trash cans are not aware of the potential fiber hazard to their hands and may compress trash or remove stuck tape by hand. The plastic bottle should have a small neck (so fiber ends do not spill out easily if tipped over) and should not have a snap-off cap or cover (so don't launch fibers out of the bottle in the jerking motion of opening the bottle cap).

c. Isopropyl alcohol. This is a landfill banned item. Non-used alcohol, such as contaminated bottles, must be disposed of as a hazardous material.

5. Miscellaneous control measures.

a. Fiber handling precautions.

(1) Do not touch the end of the fiber with your hand or finger. The end of the fiber is razor sharp and will lacerate or penetrate immediately.

(2) Do not look into the end of a bare fiber. Accidental eye penetration can cause irreparable damage.

(3) Wash your hands after stripping bare fiber or performing connector terminations.

Note: This is especially important so as not to rub your eyes or digest food with the potential of fiber fragments on your hands.

Note: Plastic coated or non-metallic tweezers is found to be one effective instrument to assist in removal of fiber fragments.

b. Solvent handling precautions.

(1) Know location of Material Safety Data Sheet (MSDS) for solvents being used. Become familiar with safety instructions on the MSDS for hazards, storage and spill procedures for those solvents.

(2) Wear eye protection when handling solvents.

(3) Avoid prolonged or repeated contact with skin. Wear rubber gloves, when necessary, to prevent skin contact.

(4) Clean area and wash hands when job is completed.

(5) Avoid prolonged or repeated breathing of vapors. Do not work with these solvents in confined spaces or any area without adequate ventilation or proper respiratory protection.

(6) Do not use solvents in areas where any type of hot work is in progress.

(7) Do not use solvents in an open container. Use approved safety cans/containers.

(8) Dispose of dirty rags and wipes containing solvents by placing them in a suitable container (covered one when specified).

(9) Properly identify and safety label solvent containers.

(10) Clean up solvent spills and leaks immediately.

c. Epoxy handling precautions.

(1) Know location of Material Safety Data Sheet (MSDS) for epoxies being used. Become familiar with safety instructions on the MSDS for hazards and for those epoxies.

(2) Wear eye protection when handling epoxies.

(3) Avoid prolonged or repeated contact with skin. Wear rubber gloves, when necessary, to prevent skin contact.

(4) Clean area and wash hands when job is completed.

(5) Avoid prolonged or repeated breathing of vapors. Do not work with these solvents in confined spaces or any area without adequate ventilation or proper respiratory protection.

(6) Dispose of dirty rags and wipes containing epoxies by placing them in a waste container.

(7) Properly identify and safety label bag containing epoxy packs.

(8) Clean up epoxy spills immediately.

d. Incidental personnel safety.

(1) Optical fiber ends/fragments are accounted for, collected and disposed of in a manner that won't come in contact with incidental personnel.

(2) Spent solvents and epoxies are removed and disposed of in an approved manner.

FIBER OPTIC LASER SAFETY SERVICE GROUP CLASSIFICATIONS FOR END OF FIBER VIEWING

SG1: No risk when the end of a fiber is viewed with a microscope, eye-loupe or with the unaided eye. The total output power is less than 5 mW.

SG2: Potentially hazardous when the end of a fiber is viewed for more than 0.25 seconds using a source that emits at wavelengths between 400 nm to 700 nm.

Note: This wavelength range is in the visible region and is outside of the 1300 nm wavelength currently used in Navy sources.

SG3a: Hazardous when the end of the fiber is viewed with a microscope or eye-loupe, but is not hazardous when viewed with the unaided eye. The total output power is between 5 mW and 50 mW.

SG3b: Hazardous when the end of the fiber is viewed under any condition unless protective eye wear is worn. The total output power is between 50 mW and 500 mW.

- Notes:
1. There are four fiber optic system service group (SG) classifications. These classifications apply when the fiber optic system is not completely enclosed. This open condition can result in a risk of eye damage during exposure while viewing the end of the fiber with the source energized. The open condition occurs during installation and service.
 2. The standard laser classifications, as specified in ANSI Z136.1-2000, apply if the source light is viewed directly and not through the end of the fiber.
 3. The range of power levels listed for SG1, SG3a and SG3b are applicable for the following source conditions: 1300 nm wavelength, continuous wave or wave repetition pulse rate > 15 kHz, emission duration > 0.25 seconds, multimode fiber with NA > 0.22 and single mode fiber. The maximum values for SG1 and SG3a power levels, listed above, were obtained from ANSI Z136.2-2000 figures A6 and A7, respectively.
 4. Viewing the fiber with the unaided eye includes the used of prescription eye wear, but not protective eye wear.
 5. All control measures specified for a service group apply to both laser diode sources and LED sources.
 6. The end of the fiber (connector, splice, etc.) should only be viewed with the source de-energized. The recommended method of verifying continuity is to use a source and power meter or a test set. Verifying continuity by shining a flashlight into one end and viewing the other end is not recommended.

NSWCCD-SSES Fiber Optic Component Test Laboratory (FOCTL)
DOC: LDCLASS1.DEF 27 April 1995, revised 31 August 2000

Enclosure (2)