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Standard Guide for Measuring Ionizing Radiation-Induced Spectral Changes in Optical Fibers and Cables for Use in Remote Raman FiberOptic Spectroscopy[1]

This standard is issued under the fixed designation E 1654; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers the method for measuring the real time, in situ radiation-induced alterations to the Raman spectral signal transmitted by a multimode, step index, silica optical fiber. This guide specifically addresses steady-state ionizing radiation (that is, alpha, beta, gamma, protons, etc.) with appropriate changes in dosimetry, and shielding considerations, depending upon the irradiation source.

1.2 The test procedure given in this guide is not intended to test the other optical and non-optical components of an optical fiber-based Raman sensor system, but may be modified to test other components in a continuous irradiation environment.

1.3 The values in SI units are to be regarded as standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 1614 Guide for Procedure for Measuring Ionizing Radiation-Induced Attenuation in Silica-Based Optical Fibers and Cables for Use in Remote Fiber-Optic Spectroscopy and Broadband Systems[2]

2.2 *EIA Standards:*

2.2.1 Test or inspection requirements include the following references:

EIA-455-57 Optical Fiber End Preparation and Examination[3]

EIA-455-64 Procedure for Measuring Radiation-Induced Attenuation in Optical Fibers and Cables[3]

2.3 *Military Standard:*

MIL-STD-2196-(SH) Glossary of Fiber Optic Terms[4]

3. Terminology

3.1 *Definitions*—Refer to the following documents for the definition of terms used in this guide: MIL-STD-2196-(SH) and E1614.

4. Significance and Use

4.1 Ionizing environments will affect the performance of optical fibers/cables being used to transmit spectroscopic information from a remote location. Determination of the type and magnitude of the spectral variations or interferences produced by the ionizing radiation in the fiber, or both, is necessary for evaluating the performance of an optical fiber sensor system.

4.2 The results of the test can be utilized as a selection criteria for optical fibers used in optical fiber Raman spectroscopic sensor systems.

NOTE 1—The attenuation of optical fibers generally increases when they are exposed to ionizing radiation. This is due primarily to the trapping of radiolytic electrons and holes at defect sites in the optical materials, that is, the formation of color centers. The depopulation of these color centers by thermal or optical (photobleaching) processes, or both, causes recovery, usually resulting in a decrease in radiationinduced attenuation. Recovery of the attenuation after irradiation depends on many variables, including the temperature of the test sample, the composition of the sample, the spectrum and type of radiation employed, the total dose applied to the test sample, the light level used to measure the attenuation, and the operating spectrum. Under some continuous conditions, recovery is never complete.

5. Apparatus

5.1 The test schematic is shown in Fig. 1. The following list identifies the equipment necessary to accomplish this test procedure.

5.2 *Light Source*—A laser source shall be used for the Raman analysis, and the wavelength must be chosen so that the fluorescent signals from the optical components (especially the spectral activator sample and optical fibers) are minimized, and

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[2] *Annual Book of ASTM Standards*, Vol 03.06.

[3] Available from Electronic Industry Association, Engineering Dept., 2001 Pennsylvania Ave., NW, Washington, DC 20006.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

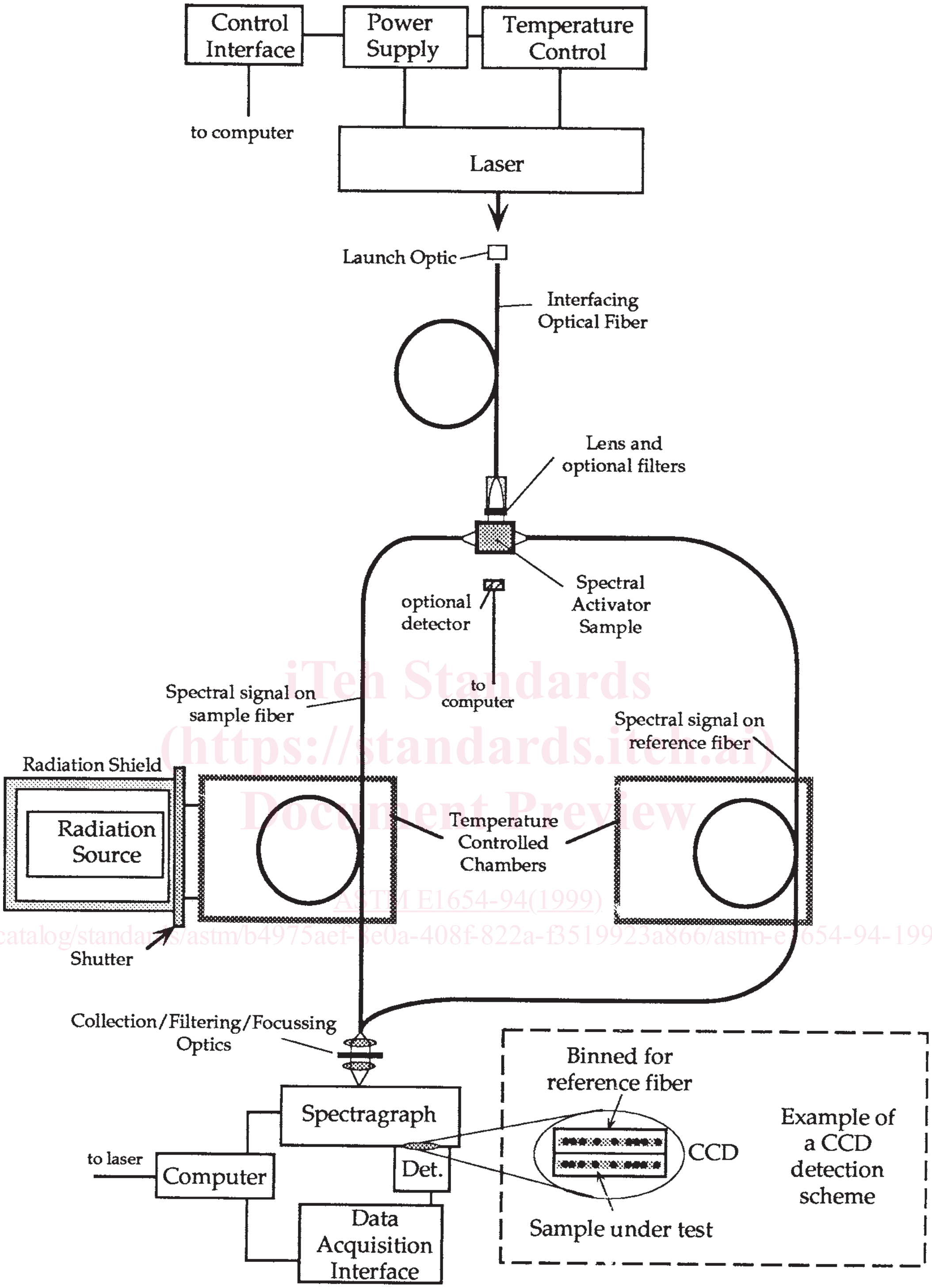

FIG. 1 Test Configuration

so that the wavelength corresponds to the spectral sensitivity of the detection scheme. Typically, the wavelength range exploited spans from 0.4 to 1.06 µm. The laser source must have sufficient power to obtain the desired minimum signal-to-noise ratio (S/N) (see 10.3).

5.3 *Focusing/Collection Optics*—A number of optical elements are needed for the launch and collection of light radiation into and from the optical fibers (interfacing, sample and reference), and other instrumentation (light source, spectrograph, detector). The minimal requirement for these elements shall be that the numerical aperture of the components are matched for efficient coupling. Optics may also be necessary to enhance the interaction of the input light with the spectral activator.

5.4 *Interfacing Optical Fiber*—The primary requirement of the interfacing optical fiber is to provide the minimum power to the activator sample at the proper wavelength(s). The fiber length may be adjusted so that the power requirements are met.