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TITLE: PREPARATION, INSTALLATION, AND CALIBRATION OF A
152-FIBER IMAGING EXPERIMENT AT THE NEVADA TEST SITE

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Preparation, Installation, and Calibration of a 152-Fiber Imaging Experiment at the Nevada Test Site

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Abstract

Fiber-optic transmission lines are being used with increasing frequency in the demanding environment of nuclear device diagnostic tests at the Nevada Test Site. Previous reports have described diagnostic experiments that utilize properties of fiber-optic cables to provide capabilities that are extremely difficult to obtain with coaxial cable systems.¹ This paper describes an imaging experiment conducted during the last quarter of 1980 at the Nevada Test Site involving 152 ~0.6-km long GI fibers in 18 cables. An imager cell sensitive to neutron and gamma radiation was located at ~8 m from the source. Individual elements of the fluor were coupled by ~10 m PCS fibers (for radiation damage resistance) to the GI fibers used for the uphole and surface lines to the detector station. Light from the imager cell in a 9-nm band, centered at 540 nm, was detected by photomultipliers and the electrical signals then recorded on oscilloscopes. Overall system bandwidth, including the fluor, was ~80 MHz. Due to the complexity of the experiment and the conditions associated with field testing, the PCS and GI fibers were cut and terminated under laboratory shop conditions prior to installation at the field site. Procedures used for quality assurance of the fiber assemblies as well as procedures used in checking fiber throughput during installation are described. The application of a large star coupler (5 input x 200 output fibers) used for system time and amplitude calibration and an attempt to "shutter" fibers with neutrons for a multiplexing application are also discussed.

Introduction

A neutron imaging experiment using 152 fiber optic transmission was performed at the Nevada Test Site in the fall of 1980. The experiment was similar in design to one carried out approximately a year and a half earlier involving ~100 fibers.¹ In addition to the larger number of fibers, several innovations were included in the experiment:

- o Fiber preparation and quality control testing in a laboratory type environment;
- o Field assembly of completed sub-assemblies permitting system throughput monitoring as the fiber system was installed;
- o Use of a 5 x 200 star coupler as part of the calibration sub-system which permitted imager-to-oscilloscope time calibration and system throughput monitoring;
- o Use of neutrons delayed by time-of-flight for a "fiber shutter" to permit recording two image points on one recorder.

The fiber preparation and quality control testing and the testing and use of the 5 x 200 star coupler will be presented in separate papers.

Experiment Overview

A diagram detailing the conceptual parts of the experiment is shown in Fig. 1. The neutron line-of-sight was 7.8 m with a pinhole at 3.9 m giving a unity magnification ratio. The imager cell was 4 cm thick and used the same liquid fluor material as the previous experiment. This fluor (8 g/l of PBD and 8 g/l of tetraphenylbutadiene in trimethylbenzene) has an impulse FWHM of ~1.9 ns and provides linear response to $\sim 10^{12}$ rads.² The fluor-fiber-photomultiplier system peaks at ~540 nm. Overall system bandwidth was ~80 MHz; the contribution from fiber material dispersion was limited by filters between the fibers and photomultipliers with $\lambda_c = 540$ nm, $\Delta\lambda = 8.5$ nm and transmission factor of 0.65.

The fiber transmission system consisted of ~10 m of single 125 μ m dia. core, 0.3 NA PCS fibers coupled to ~385 m long graded index fibers. The graded index fiber was cabled into 18 ruggedized cables of 8 fibers each.

Figure 1. Diagram detailing the conceptual parts of the experiment.

Other features shown in the schematic overview are the calibration subsystem with the 5 x 200 star coupler and the neutron driven "fiber shutter."

Imager/Fiber System

Figure 2 is a view of the imager installed in the rack used to contain the downhole diagnostic experiments. The PCS fibers are terminated in ferrules which are inserted in a mask to determine the spatial pattern. The PCS fibers are used in this region because of their greater resistance to radiation damage. Also visible is the housing for the 5 x 200 star coupler and the coupler output fibers.

Figure 2. View of the imager.

Figure 3. Junction box.

Figure 3 shows one of the junction boxes used to house the PCS to graded index connections. Each connection was monitored as the connection was made to optimize throughput. The swing-out shelves provided support and organization for the finished connections.

Figure 4 shows the loss data obtained at 800 nm for the PCS fibers. Mean loss for the 149 PCS fibers was 1.63 db with a standard deviation of 0.88 db.

Figure 4. Loss data for pcs fibers.

Figure 5. Loss data for graded index fibers.

Figure 5 shows similar data for the graded index fibers. Mean loss at 800 nm for 134 fibers was 4.42 db with a standard deviation of 1.05 db.

The loss data for the PCS/graded index lines after connection is shown in Fig. 6. Measurement wavelength was 800 nm. The mean loss for 123 fibers was 13.9 db with a standard deviation of 1.20 db.

Figure 6. Loss data for PCS/Graded index lines after connection.

Figure 7. Amplitude calibration.

The relative amplitude calibration for the system including imager and photomultiplier is shown in Fig. 7. Most of the channels are within a factor of 1.5 of the mean.

A view of the "fiber shutter" is shown in Fig. 8. Approximately 0.5 m of the cabled fibers was exposed to the neutron flux in an attempt to provide ~20 db of radiation induced attenuation. Although this attempt was unsuccessful, the technique appears promising and will be pursued in future experiments.

Figure 8. View of "fiber shutter."

Conclusions

The ability to prepare and test the over 600 terminations and 32 graded index to graded index fiber fusion splices in a relatively benign environment greatly facilitated the fielding of this system. Installation of the fiber system in the downhole equipment rack could be easily monitored to maximize fiber system throughput, leading to reduced variation of the channel relative amplitudes compared to the previous experience.

Although the "fiber shutter" did not perform as calculated, the concept appears to merit further testing.

The fielding techniques developed for this test at the NTS have proved their value and will find use on similar large experiments and other fiber application in future.

References

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