A RURAL INSTALLATION OF FIBER OPTICS

CRAIG M. SWINN

COMMONWEALTH TELEPHONE TECHNOLOGIES CORP.

GENERAL:

Construction of the outside plant of Commonwealth Telephon Company's T3 digital fiber optic system which began on October 26, 1978 was recently completed. The cable installation took place over an 8 week period. This project is one of two similar commercial fiber optic field trials currently taking place in Pennsylvania to test two different approaches in the design of fiber cables. The Commonwealth system, which is the more ambitious of the two lengthwise, spans a distance of 22 km utilizing four intermediate repeaters between the north central Pennsylvania communities of Wellsboro and Mansfield. The system, which was purchased from ITT Telecommunications Division in Raleigh, N.C., is being installed in conjunction with the REA. It serves as the first commercial field trial of fiber optics in an operating company environment for all three parties. When the entire system is completed in early 1979, it will carry toll connecting, intertoll, operator and special service traffic. With the installation of cable, associated splicing and repeater housings completed, this report will deal primarily with specific techniques used during the installation.

The optical cable was installed using four methods of construction: direct buried (plowed), underground (duct), aerial lashed to existing cable, and aerial lashed to a new messenger. The following list shows the approximate length of the four types of construction.

Direct Buried	10.0 km
Underground	1.0 km
Lashed to Existing Cable	3.0 km
Lashed to 6M Strand	8.0 km

Two types of cable construction were used. For the aerial portion a totally dielectric cable rated at 6db/km was used consisting of five graded index fibers individually coated with a colored Hytrel polyester buffer laid up with Kevlar strength members and impregnated with a filing compound to form a central core. The core, jacketed with polyurethan jacket. Polyurethane was chosen over polyethylene for this application because of the added resistance to tear and abrasion, crush resistance, and the flexibility it imparts to the fiber cable. The outside diameter of this cable is .265 inches.

The aerial cable was adapted for direct burial by adding a 12 mil coated aluminum tape longitudinally applied and an extruded jacket of low density polyethylene. This type of protective sheathing meets existing REA specifications for conventional telephone (copper) cables. The outside diameter of this cable is .370 inches. Both types of cable construction utilized sequential markings on the outer jacket. These markings were recorded at various pole locations, splice points, manholes, repeater housing locations, etc. This information will prove invaluable in quickly locating cable damage using a TDR test set.

DIRECT BURIED INSTALLATION

Because of the impending weather conditions, the buried portion was installed first. Installation started near the Wellsboro exchange in an open field. The cable was plowed to a depth of approximately one meter using an International Harvester TD15B identical to that used by Commonwealth Telephone Company in installation of conventional copper cables. The plowing operation varied from very easy to difficult due to varying weather, geological and topographical conditions along the 13.7 mile route. All fiber optic cable installation was performed by Commonwealth construction personnel.

To monitor possible cable damage during plowing, an optical time domain reflectormeter (TDR) was connected to the cable. This instrument consists of an oscilloscope with a special plug-in-module housing for the required TDR electronics. On the first day of construction the test set was damaged by an unregulated A.C. generator. While starting a search, which might have taken days, to obtain a replacement for the failed oscilloscope, a decision was made to start the plowing operation using two alternate techniques to monitor the cable installation.

An ohmmeter was connected between the aluminum cable shield at the starting point of the reel and a ground rod driven nearby. A reading on the meter could indicate a break in the polyethylene jacket, grounding of the shield and possible fiber damage. If a grounded reading was encounted or if the plow stopped for any other reason, each of the five fibers was tested for continuity by shinning a flashlight into the fiber at one end and looking for received light at the other end.

Approximately 460 meters of cable on the first 1km reel was plowed when the ohmmeter jumped. Each of the fibers was tested using the flashlight technique and no loss of fiber continuity was found. The ohmmeter reading turned out to be false. It is interesting to note that the light emitted from the fiber looked red rather than white due to the bandwidth characteristics of the fiber.

The need to communicate between the plow crew and the personnel at the other end of the cable required additional consideration when the radio transceivers being utilized did not operate satisfactorily. A talk path was established using the aluminum shield and ground as a transmission medium.

The first day two 1km reels of cable were buried using these methods of checking for cable damage. However, no damage occurred. Initially, all turns were made with a large radius in comparison to conventional cable installation standards and extreme care was taken to insure the cable was fed smoothly into the shoot of the plow. Based on our experience with the first reels, we found no extra care was required and the cable could be handled the same as conventional cables. By the second day, a replacement oscilloscope was obtained and the TDR was used to confirm that no damage had occurred to the first two reels. For the remainder of the buried portion, fiber continuity and shield ground resistance were measured only after the complete reel had been installed.

Various obstacles were encountered during the plowing operations. A backhoe was used to trench across small streams and drainage ditches. For larger obstacles the cable was installed using an aerial insert. There were a number of road crossings which were accomplished by boring under the road and installing 4 inch PVC conduit or by pushing the cable through existing duct. In one case, about 450 M of cable was pulled back through the conduit to the last splice point. The cable was laid on top of the ground and the plow then buried the cable in from the splice point to the road crossing.

During the plowing operation, an unmarked gas main was cut by the plow. In addition, due to wet ground conditions, the plow got stuck a few times and had to be pulled out using a cable line truck and a backhoe. Through all of this, the cable remained intact with no detectable breaks in either the outer jacket or fibers themselves.

Since installation, the cable was damaged once by a contractor installing buried electric service to a new home. Although the route was well marked, the cable was struck by a shovel while hand digging the trench. Despite the fact the outer jacket and metal sheath were damaged, the fibers were not broken. Repair was accomplished with VM masking tape.

UNDERGROUND INSTALLATION

The underground construction of the cable was confined to the existing manhole entrance systems at each central office. The Wellsboro end was 490 meters long with 6 manholes and two 90 bends. So that the 4 inch duct could also be reused for a larger copper entrance cable and to insure the fiber cable would not be damaged by such an installation, a 1 inch PVC pipe was first installed through the duct system and the fiber cable was then pulled inside.

The Mansfield end was approximately 550 meters in length with six manholes and two 90 bends. The same installation technique applied at Wellsboro was used here. Because of the cable's small diameter, light weight, and tensile strength, a potentionmeter was not used to measure the pulling force on the cable.

AERIAL INSTALLATION

About 500 meters of aerial cable was installed by the manufacturer at a test site in Roanoke, Va. almost a year before the installation in Pennsylvania. In this test, the fiber cable was lashed to a 6M messenger simultaneously with a 12 pair copper cable. A standard General Machine Products lasher was used for both the test and actual cable installations with no special installation techniques or precautions. Expansion loops were not used at any pole locations.

The aerial portion was constructed over a variety of conditions. In the town of Wellsboro, the fiber cable was lashed onto existing cables that varied in diameter from 1 to 2 inches. Overlashing was necessary because not enough space was left on the existing pole line for a new cable run. Once outside the town, the cable was lashed to a new 6M steel messenger. This construction went very quickly and was performed using the standard 3 man line crew that is used to install any small telephone cable. One man climbed the poles to transfer the lashing machine, another pulled the lasher and a third man pulled on the cable to keep it from wrapping around the messenger. No problems were encountered during the aerial construction. Production was at the same rate that is experienced with the installation of any small telephone cable (approximately 2 km/day). Since the fiber optic cable follows an existing aerial cable route, only a fiber cable was installed for the entire 22 km. Copper pairs for power and order wire will be provided from the existing cables.

SPLICING

Fusion splicing was used for this project. Because electric fusion equipment was not available, a flame method was used. We spent about a half day training cable splicers plus additional training on the job under ITT supervision. Within a short time, we were able to complete about one and a half splice points a day. Because of the cold weather, a tent and heater were needed. Most of the splicing time involved stripping the cable and removal of the filling compound from the fibers. In a few cases, this process caused some fiber breakage. Extra care is recommended during this preparation period to eliminate fiber breakage. Actual splicing of two fibers took about 10 minutes.

All splicing was done above ground. The aerial splice housings were pole mounted while in the buried sections, housings were mounted in pedestals. This method allows easy access to fiber conductors in case of trouble. In all cases, slack cable was left at each splice point to allow resplicing or termination of the cable. All splicing was performed by Commonwealth Telephone Company craftsmen.

REPEATER HOUSINGS

Standard ITT T1 span line repeater housings were modified to house the optical transmitters, receivers, fault monitoring unit, physical pair protection and other apparatus associated with the normal and hot standby lines. The housings are pole mounted and come equipped with a copper cable stub for connection of powering and maintenance pairs. Because the unjection laser diode (ILD) sources used in the repeaters are not thermoelectrically cooled, a special sun shield which surrounds the housing was designed to limit high temperatures which are detrimental to laser life. The repeaters themselves are powered by a 140 ma DC constant current loop using standard T1 span line power supplies and current regulators. It should be noted that this current requirement is a standard for T1 systems.

TESTING

The cable testing will be performed in two phases. Initial testing was conducted after completion of all construction and splicing. Tests were performed between repeater locations to determine changes in cable loss due to installation and associated splicing losses. Subsequent testing of the fiber cable for survivability and performance will be conducted on a weekly basis prior to system turn-up. Apparatus used will consist of ITT's OFTS-02 portable loss measuring test sets and the TDR mentioned previously. Loss readings from section to section will be recorded and referenced to the initial acceptance test data. Any significant variations from the reference results will be investigated using the TDR. Based on the results of the ITT test cable at Roanoke, Va., no problems are anticipated.

OTHER SYSTEM CHARACTERISTICS

While this report has dealt primarily with the installation of the outside plant portion, there are other system characteristics which are pertinent to the discussion of this system. The ITT electro-optic equipment will interface existing T1 channel banks and span lines through Farinon M1-3 multiplex terminals equipped with both low and high speed protection. This system has a capacity of 672 channels over one pair of fibers. While the signal between the M1-3 equipment and the ITT terminal equipment is at the standard 45 Mb/s rate, the line rate over the cable is actually 47 Mb/s. The increased bit rate is due to parity bit addition/removal circuitry in the ITT terminal equipment. The additional bits will be used to provide in-service error monitoring and reporting functions at the repeater points, terminal and line looping for test purposes, and hand shake routine between ends to coordinate simultaneous automatic swithcheover and restoral. In addition, a microprocessor controlled alarm reporting system to reduce the possibility of system outage due to component failure and also ease troubleshooting will be provided.

SUMMARY

The conclusions drawn from our experience to date indicate that basically the same construction methods used for conventional cables also apply to fiber obtics. We feel that fiber optics will be the telecommunication medium of the near future. In certain high density applications, fiber optics now proves in economically in comparison with conventional cable and microwave systems. In addition, it offers greatly improved transmission quantities and qualities, ease of installation, reduced maintenance and the capabilities of providing the distributed broadband services of voice, data, and video to our customers. With all of this in mind, the obvious answer to the question, "Why fiber optics?", is WHY NOT!