A Furukawa Company

Emergency Cable Restoration for Fiber Optic Cable Systems

Contents ……………………………………………………………………………………………….. **Section**

1. General

1.1 As a growing number of companies move toward the use of fiber optic cable systems, the need for a well organized emergency restoration plan becomes increasingly important. With the proper equipment, system documentation, and trained personnel, cable failures can be quickly identified and repaired thus keeping network outages and downtime to an absolute minimum.

2. Pre-Construction Considerations

2.1 In aerial applications, it may be advantageous to store excess cable slack at predetermined storage locations. Slack cable can later be moved towards a cable break to eliminate the need for two restoration splices. The same method can be used in an underground conduit system. The amount of slack cable that can be stored in the network depends on the application and availability of convenient storage locations.

2.2 In a direct buried application, cable slack can be stored at splice locations or handholes; however, it is usually more difficult to retrieve this slack because the cable route must be excavated between the restoration site and the slack storage location.

3. Emergency Restoration Equipment

3.1 A fiber optic emergency restoration kit should be centrally located and readily available to the technicians responsible for maintenance and restoration of the system. Depending on the size of the system, it may be desirable to have more than one kit. Technicians can also equip their service vehicles with an emergency restoration kit.

3.2 Emergency restoration kits are commercially available and can be customized for any particular system. It is also possible to prepare the kits from spare cable and equipment leftover from the installation. The required tools and consumables are readily available from many sources. The recommended tools and equipment are listed in the following paragraphs.

3.3 ***Fiber Optic Repair Cable*****:** The fiber count of the repair cable should match the highest fiber-count cable in system. The cable length will depend on the type of installation, e.g., the aerial span lengths or manhole spacings. Typically, the repair cable should be 100-150 feet longer than the longest distance between cable access locations.

3.4 ***Splice Closures*****:** Two splice closures are required for the repair cable. The splice closures should accommodate the highest fiber-count cable in the system. Depending on the restoration plan, one or both ends of the repair cable should be prepared and secured in the closures before hand. If necessary, the closures should be pre-drilled to accept the system cable (damaged cable).

3.5 ***Splice Tray*****:** Typically the manufacturer of the splice closure can supply splice tray(s) for either mechanical or fusion splices. There should be enough splice trays in each closure to accommodate the maximum fiber count in the system. The ends of the repair cable should be prepared and the buffer tube(s) fastened to splice tray(s) beforehand. Leave adequate fiber in the trays for mechanical and/or fusion splices.

3.6 ***Mechanical Splices:*** High quality mechanical splices are available for temporary and/or permanent fiber splicing. Mechanical splices should be simple, reusable, and require a minimum amount of tools and preparation time. Fiber ends of the repair cable can be prepared and the mechanical splices installed on the fibers and fastened in the splice trays.

3.7 ***Tool Kits:*** Two tool kits are required so that both ends of the damaged cable can be prepared simultaneously. At a minimum, each kit should contain the following tools and materials. Additional tools and/or consumables may be required for your specific cable and closures.

- cable sheath knife
- snips
- seam ripper
- tube cutter
- fiber strippers
- side cutting pliers
- wrenches and screwdrivers (as required for closure prep)
- cable ties
- black vinyl tape
- fiber cleaver
- alcohol
- lint free wipes
- cable cleaner

NOTE: It is very important to replenish the tool kit consumables after each use. The tool kits should also be checked at regular intervals to ensure that all required tools and consumables are available.

3.8 ***Optical Time Domain Reflectometer (OTDR):*** The OTDR is used to measure the fiber characteristics by launching a pulse of light down the fiber and analyzing the reflected and backscattered light. The OTDR is an invaluable tool for measuring optical fiber lengths, splice and fault locations, and their associated attenuation. It is nearly impossible to locate cable damage without an OTDR.

NOTE: Smaller, less expensive "fault finders" are available that can measure the distance to a fiber fault; however, these instruments cannot replace all of the system analysis capabilities of an OTDR.

3.9 ***Optical Power Meter:*** An optical power meter is used to measure the output power from transmitters, through connectors, jumpers, and long lengths of fiber optic cable. Portable handheld meters are available with digital readouts in both decibel and watt scales. Optical power meters offer a quick way to determine if a fiber or transmitter is active and if the power levels are adequate.

3.10 ***Radios or Cell Phones:*** Radios or cell phones are invaluable for communication between technicians working in the equipment office and the emergency restoration site. Communication is needed to verify satisfactory splice results during the cable repair.

4. System Route Documentation and Cable Data

4.1 One of the most valuable items for troubleshooting a fiber optic system is accurate documentation. The following information should be included in the system documentation.

- Cable Route Diagram - A schematic diagram should include splice locations, slack cable locations, cable sheath sequentials, and optical lengths between splices.

- Manufacturer's cable data

- Pre-installation OTDR cable test data

- Post-installation OTDR cable test data

- OTDR traces of splice locations and splice loss
- OTDR span loss measurements
- Insertion loss test measurements
- Equipment power levels (transmit and receive)

NOTE: Copies of all documentation should be located at the transmission equipment sites and be readily available to the technicians responsible for maintaining and troubleshooting the system.

5. Personnel Training

5.1 Proper restoration planning, training, and practice are critical to a rapid system restoration. Technicians responsible for maintenance and restoration of the system should be well trained in the operation of the OTDR, optical power meter, and mechanical and/or fusion splicing. Training classes for troubleshooting and emergency restoration should be taught regularly to keep technicians well practiced in handling fiber optic cables and their components. Mock systems can be created in the cable yard where troubleshooting and restoration skills can be practiced.

5.2 A restoration plan and procedure should be established beforehand so that there is no confusion as to each technician's task. High priority fibers must be identified and repaired first.

5.3 Depending on the size and importance of the system, two or more crews should be trained for emergency cable restoration. Having two or more trained crews will provide more reliable emergency response in the event of vacations or illnesses.

6. Emergency Restoration

6.1 When a system failure is discovered, either by customer complaint or by a status monitoring system, the troubleshooting procedure should begin at the point of signal transmission (headend, central office, etc.).

6.2 The technician must first verify transmission power with an optical power meter. The measured power levels should be compared to the documented levels of transmission power. If the power levels are not acceptable, the transmission equipment must be repaired or replaced.

6.3 If the equipment is operating properly, the next step is to confirm the power levels through the transmitter jumpers and their related connectors. If the power levels through these components are not acceptable, they can be easily replaced with backup jumpers.

6.4 If the transmission equipment and its related fiber jumpers and connectors are operating properly, the next step is to test the outside plant fibers with the OTDR.

6.5 OTDR measurements should be taken on the fibers in question. The loss and lengths of the fibers can then be compared to the documented as-built data. If there are no differences between the traces, it can be assumed that the problem is at the receive end.

6.6 In CATV applications, customer complaints can help in determining which area and receiver node(s) to check first. Technicians can then measure the receive power at the node(s) to verify the status of the optical network.

6.7 When OTDR traces reflect a fault in one or more of the fibers, the location should be determined from the cable route schematic diagram. The emergency restoration crew and necessary equipment (backhoe and/or bucket truck) can then be dispatched. The time required to locate a fault varies in respect to the type of construction. For example, locating damage in a direct buried cable requires excavation which may add significant time to the overall cable restoration.

6.8 Once the crew arrives in the general vicinity of the fault, they must physically find the problem. Most cable damage occurs when some outside force comes in contact with the cable, such as a backhoe, a gunshot, rodents, etc., so some types of cable damage are more evident than others. Faults can also occur inside splice cases. For example, vibration may cause a splice to fail if the splice was not properly made. In a buried system, improper closure assembly may result in a failure.

6.9 Once the damaged cable has been found, the crew can begin the restoration. Each technician prepares an end of cable by first cutting away about 10 feet of cable to get past any damaged fibers inside the cable. An OTDR or power meter test is required to ensure that the entire length of damaged fiber has been cut out.

6.10 The cable ends are then prepared and secured in the emergency restoration closure. The buffer tube(s) are fastened to corresponding splice tray(s) in order of highest priority. Fibers can then be stripped, cleaved, and inserted into the mechanical splices. Constant communication between the splicing technicians and the technician operating the OTDR is required to verify that the system is properly restored.

6.11 Temporary mechanical splices can later be replaced with permanent fusion splices. If necessary, the restoration cable can become a permanent addition to the optical network. Alternatively, if slack cable can be later pulled towards the restoration site, the emergency restoration cable can be removed and replaced with a single splice point instead of two splice points that are required with the restoration cable.

7. CONCLUSION

7.1 It is difficult to address each situation that may arise in a particular fiber optic cable system. However, quick and reliable restoration is possible with the proper equipment and preparation. Key ingredients for successful restoration of all systems are proper equipment and materials, cable and route documentation, well trained technicians, and an adequate restoration procedure.