OVERVIEW

To increase the bandwidth of cable TV systems beyond their present bandwidth, many factors must be considered. Obviously, amplifiers designed and built for the wider bandwidth must be installed. Taps and directional couplers with wider bandwidth must also be used, but is it necessary to replace the cable? Not only should factors such as the cable's electrical performance, age and maintenance be considered, but recent advances in cable design technology should also be considered to make the optimum economic decision.

ELECTRICAL

A few electrical characteristics of the cable affecting how the system will ultimately perform are of key concern to those upgrading and rebuilding a plant. They are:

- Structural Return Loss
- Attenuation
- Impedance
- Transfer Impedance

Structural Return Loss

The Structural Return Loss (SRL) of the cable is measured in a specific frequency band at the time of manufacture. The measurement band changed several times in the past twenty years to reflect advances in manufacturing technology. Times Fiber Communications began SRL testing from 50 to 108 and 173 to 216 MHz in the mid 1960's with 26 dB as an acceptable level. The band increased to 5 to 300 MHz (which included the midband) in 1972, 5 to 450 MHz in 1980, 5 to 600 MHz in 1988 and 5MHz to 1GHz in 1989 with 30 dB as the current industry standard. Now a question arises: Can older cable which was tested in the lower frequency bands be used at higher frequencies?

Unfortunately, it is not possible to predict cable SRL performance at higher frequencies based on the SRL at lower frequencies. For example, a cable manufactured in 1972 with 30 dB SRL from 5 to 300 MHz could have 12 dB SRL between 300 and 450 MHz, perhaps even worse. In general SRL spikes cause additional narrow bandwidth signal loss. Depending on the severity of the SRL spike, TV channels can be attenuated below acceptable limits through very short lengths of cable. It is necessary to know the SRL of the cable in the frequency that it will be used to assure proper signal transmission. As cascade lengths are decreased, SRL performance requirements are relaxed.

Attenuation

The next factor that affects system performance is attenuation. Although attenuation is more predictable than SRL, many cable designs of the past were susceptible to moisture ingress and absorption which caused their attenuation to increase sharply. Present cables are designed with excellent moisture blocking characteristics and resistance to moisture absorption so that the attenuation will remain stable over time. Cables currently being manufactured are also designed with lower attenuation than many of the previous designs to minimize active equipment and their associated maintenance costs. Drop cable also is now available with the low loss gas injected dielectric. Previous designs with chemically expanded dielectrics are 12% higher in attenuation while solid dielectrics are 36% higher. The problem is compounded by using older cable: higher levels at the taps are required to overcome the higher losses of the cable itself plus the higher losses due to the higher frequency. It may be more economical based on attenuation alone to replace the older cable with the newer, more stable, lower loss cable.

Impedance

Characteristic impedance is another property that should not be overlooked. Although past and present cable plants are designed around 75 ohms, moisture ingress can reduce the impedance of the cable dramatically and cause an impedance discontinuity. Two impedance discontinuities will cause a portion of the signal to be re-reflected which can result in echoes and ghosting. Impedance discontinuities can also be caused by dents and kinks in the cable.

Transfer Impedance

Transfer impedance is another factor that should be considered. Transfer impedance is a characteristic of the cable which describes how much energy will leak out of or into the cable. In the case of drop cable, significant improvements in shielding have been made in recent years. Aside from shielding improvements, a new product, lifeTime™ floodant, is now available which provides continuous longitudinal protection of the outer conductor if there is a minor jacket rupture and minimizes corrosion at the connector junction.

The drop cable to connector junction is the source of most leakage problems in the cable TV industry today. Repair is quite costly and time consuming. Even when the connector is properly tightened, the crimp area can degrade over time due to corrosion. Now with the FCC's

CLI (cumulative leakage index) requirements, the industry is required to repair excessive point source leakage and keep the total system leakage below a specified limit. Serious consideration must be given to leakage before additional frequency bands can be used.

MECHANICAL

Mechanically, the outer conductor of trunk and feeder cable becomes more brittle over time due to cyclic stress. Cyclic stress can be caused by repeated bending of the cable during connector installation and equipment replacement. The more times the cable is bent, the more likely it is to fracture. How long the cable will last depends on the number of times the cable was bent and the radius of the bend.

In expansion loops, cyclic stress is caused by changes in temperature and load conditions. Generally, the age of the cable is one indicator of the total cyclic stress. The expansion loops also have a projected life which depends on the type and shape of the loop and the cable size. Although a good loop in a normal span is expected to last 20 years or more, many factors degrade its life and it can fracture after as few as 1 or 2 years in service.

Repair of expansion loop fractures with splices is time consuming and costly. If the splice is placed at the bottom of the loop, the cable adjacent to the splice is under much higher cyclic stress and will fracture much sooner than the original loop. The reliability of plant becomes more questionable with each splice that is installed. Expansion loop cracks can cause RF leakage and interruption of service. The cracks can also allow moisture ingress and subsequent electrical degradation.

ENVIRONMENTAL

Aerial Installations

During its life the cable is exposed to environmental factors that degrade its mechanical and electrical performance. Cold temperature extremes can cause the cable to be exposed to a great deal of stress, enough in fact, to cause the center conductor to pull out of the connector. Present TFC cable designs minimize or eliminate center conductor pullouts by bonding the center conductor to the dielectric and the dielectric to the outer conductor.

Temperature cycling can cause stress which fatigues the metal components. Differential movement between the cable and the support strand can produce holes in the sheath from the rubbing action. Temperature changes can also cause differential pressure changes inside the cable and equipment housing which will in turn cause moisture to be pumped into the cable unless the connectors and housings are properly sealed. Significant cyclic loading due to trees leaning against the strand, wind, wind gusts, and ice can shorten expansion loop life by excessive cable movement and rapid cycling and vibration. Hail can cause significant damage to the cable. Squirrels can eat the aluminum outer conductor. The cable can be corroded by sea air and automotive and industrial pollution unless the proper jacket and heat shrink tubing are used.

Underground Installations

In the soil, the jacket can be ruptured by rocks and expose the aluminum to water or chemicals in the soil. The jacket may also be ruptured if care is not taken during initial cable installation or during accidental digging by shovels. Burrowing rodents, such as ground hogs and gophers, can eat through underground cable if it is not armored. Ground movement and frost heave can crush the cable. Stray ground currents can rapidly corrode exposed aluminum via galvanic action. In pedestals the cable can be exposed to moisture and condensation; it may even be submersed. The jackets used today are designed with better abrasion resistance. Present jacketed cables with a bonded dielectric can be bent tighter without kinking especially in pedestal applications where the cable may be exposed to repeated tight bends.

During a conduit pull, the jacket may be ruptured and the aluminum exposed. If an improper pulling compound is used it may damage or corrode the aluminum. Again, cables manufactured today have jackets with better abrasion resistance than their predecessors and can aid in resisting kinking during bends. They also have lower friction coefficients to reduce pulling tension.

CONSTRUCTION PRACTICES AND PLANT MAINTENANCE

The condition of the cable also depends to a great extent on how well the cable was installed initially and how well it was maintained over the years. During construction, expansion loop formation is one particularly important factor. If the loops are less than 5 inches deep (6 inch deep loops are recommended), even when it's very cold the loops are probably not deep enough to accommodate normal cable expansion and contraction. During cable installation, the cable may be pulled around a bend with too much back tension and cause the cable to be flattened. The cable may be exposed to many other adverse conditions during construction which will reduce the cable's life.

The cable may also be damaged during routine plant maintenance if care is not taken. During connector replacement, both aerially and underground in pedestals, the cable may wrinkle or kink. Replacement of the heat shrink tubing may be forgotten thus exposing the bare aluminum to the environment. Equipment covers and connectors may not be tightened properly thus allowing a path for moisture ingress. A careful examination of the existing plant (how many splices, expansion loop depth, cable kinks, shrink tubing, etc...) is very important in estimating the remaining life of the cable.

CONNECTOR INTERFACE

The cable-connector junction is another possible problem area. During its life, a cable system is continually being modified and in many instances extended. Unless care is taken in the selection of the type of cable, the system may be made up of a number of different types of cable and different types of connectors. With different connectors, maintenance and repair becomes more costly. Naturally, it costs more to have additional connectors in inventory, but the real cost disadvantage may be that the repairs become more time consuming if the technician doesn't have the right connector on his truck. He must return to the shop and find the right connector before he can return to make the repair. The problem of using existing cable may be amplified by the need for different size radiation sleeves. Obviously, having the same type cable throughout the entire system has real economic advantages for continuing maintenance.

ECONOMICS

Due to the higher attenuation of older cables, more amplifiers will be needed than for present cable designs. This problem is further compounded if the bandwidth of the system is increased because cable attenuation increases with frequency. Drop cables manufactured today also have lower losses, better shielding characteristics, and are designed to resist corrosion at the fitting. Additional cable sizes are also available to optimize overall plant cost. Cables designed today can be expected to last longer and increase the rate of return on the investment.

CONCLUSIONS

Obviously, from an electrical view point, the cable should be replaced, just like amplifiers and taps, if it does not have the proper bandwidth. Key factors in determining its bandwidth are SRL, attenuation, impedance, and transfer impedance. From a mechanical view point, factors such as where the cable is in its life cycle, how the cable was initially installed and how it was maintained must be considered. Environmental degradation of the cable should not be overlooked. Even if the cable may be electrically and mechanically acceptable and has not degraded from the environment, an economic analysis should be performed to compare the cost of maintaining the existing cable versus cable replacement.