PRESSURIZATION AND THE USE OF AIR DIELECTRIC CABLES

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Since the use of pressurized air dielectric cables has never become popular for use in cable television systems people are usually amazed when I tell them I have used it for eight years and my experience with it has convinced me to plan a system rebuild which includes the use of air dielectric cable for trunk line.

All the figures and experiences which I will use are derived from the system located in Altoona, Pennsylvania. The trunk line is one half inch Spirofil which was installed in 1962. There are four major branches on the trunk line, the first branch occurring about seven miles from the antenna site. We have in use about 70 miles of cable with the longest single run being 17.6 miles. The entire system is pressurized from one point located at our engineering offices eight miles from the antenna site. Incidentally, we use air dielectric cables as down leads from all our antennas and we pressurize these lines from the system. The antennas are located about 800 feet from our head end building so they cannot be seen from the building in order to prevent any possible re-radiation pick-up. I realize that cable with higher losses may be advisable for use as down leads because of reflections from poor match at the receiving ends and we pad the lines as heavily as possible to improve match and use the gas filled cable primarily because of the indication we have if any structural damage, such as stray bullets in hunting season, should occur.

We use certified dry, oil pumped, nitrogen to pressurize the cable and use a pressure of ten pounds as standard. Several ounces above atmospheric pressure is all that is really needed to keep out moisture but the ten pounds gives us a better method for monitoring the performance of the pressure system. Another advantage of the higher pressure is that the cable is storing a larger volume of gas and in the event of a break in the system it takes much longer for the entire system to lose pressure. The system is broken up into 9 areas. The input of each of these grids is furnished with a gauge and shut off valve. Gas pressure and consumption are recorded at the engineering office at 8:30 A.M. and 4:30 P.M. daily and any difficulties in the system become apparent from these measurements. The employee who normally maintains the gas system, from experience, has learned what he should expect from temperature variations and has become quite expert at evaluating the

variables of pressure, consumption and weather conditions.

In the event a problem occurs all the input valves to the networks are closed and the gauges monitored at three hour intervals until it can be determined which area is going flat. As soon as this is determined, usually a matter of a few hours, as much of the system is reactivated as possible. Naturally any area beyond the point of trouble will have to maintain its own pressure as a closed system until gas can be fed through the area of trouble. This presents no problem as most of the areas will lose only several pounds over a two week period due to the minute leaks which are always present in a system this size. We have had areas we have tested for thirty days and lost less than a pound in this period.

In order to pinpoint the trouble spot in a given section the section is broken up at each trunk amplifier. Each trunk segment is then pressurized to sixty pounds, a gauge installed, and sealed off. Very shortly the faulty segment can be spotted. Then a tank and regulator is installed at that amplifier location and the sixty pounds pressure maintained. In nearly every case merely walking along the trunk in this section will allow you to hear the leak if your ears do not cut off at high frequencies. We own equipment for soaping the cable in a very scientific manner with a tank, rollers and a maze of gadgets, also a supersonic detector, both of which we use in extremely stubborn cases but for day to day operation, sixty pounds of pressure and a man with good ears is much faster and a lot less bother. We were concerned in the early days about using high pressure on the cable but to date we have never been able to trace any trouble to the use of high pressure in leak detecting.

In a gas system it is necessary to by-pass the gas around every amplifier location. We use bulkhead fittings with a gas barrier and a hole in the side with a female three eighths pipe thread. The jumpers consist of Imperial Hydraulic fittings and Imperial Eastman Poly-Flo quarter inch tubing. This tubing weathers very well and requires replacement about every four years. In a solid state system I intend to block the gas at the input and output fitting of each trunk amplifier and then install a tee fitting in the by-pass tubing. I will then feed gas into the amplifier housing with a small shut off at the housing so that it may be opened without depressurizing the system. When the housing is closed the valve is opened to allow gas into the housing before the bolts are tightened to assure a nitrogen atmosphere in the housing. We are presently engaged in engineering tests and design for the necessary gas tight fittings to be used on the amplifier housings.

We have made no decision in regards to fittings splices, etc. on a rebuild which we are planning. We presently use the Entron SSU Splice Box and ER-851 flare fittings. When it comes

to containing gas I am from the old school and a flare fitting when properly made with flaring tools in good condition has proved, for us at least, to be the most reliable. Great care must be used in making a flare using aluminum. Too much pressure on the flaring tool will decrease the wall thickness of the tubing to the point where it will break off under slight vibration.

Many people have expressed concern about the center conductor in an air dielectric cable having more freedom to move and as a consequence have been worried about pull outs during cold weather. This factor is really no worse than in any cable. We were very fussy when our installation was made to be sure that all pole bends were uniform and of such a radius to exert pressure on the center conductor and immobilize it. We developed a bending tool which was used at all pole bends and at every splice. As a result in eight years of operation we have had two pull outs, both occurring in below zero weather in an area where construction crews knew it would be difficult to inspect and were careless in making the proper bends. At splices we use a complete letter S and insist that the fitting cross the strand at ninety degrees.

When our system was installed structural return loss measurements were strictly for the better equipped laboratories, so we really do not know it's condition when new. We are fairly certain it was good because we have made quite a few summation sweeps including over fifteen miles of the cable and the results came out to plus or minus one half Db overall. We have had occasion to make return loss measurements on this cable after repairs in the past several years and it is not unusual to come up with 35 to 40 Db over the band of 50 to 220 megahertz. I mentioned repairs to cable. This may cause some raised eyebrows. However, we have had cases where someone put a gaff through the cable in wet weather and it became literally filled with water at a low spot. This has a very simple solution. Merely break the cable at the lowest splice you can find and install a fitting temporarily with a hole in the outer wall. At the highest available spot where gas can be introduced install a tank of nitrogen and purge the cable using the entire tank of nitrogen with the pressure regulator set at about 25 or 30 pounds. At a cost of about $6.50 for nitrogen and several hours of one man's time you have, in effect, replaced several spans of cable. The effect of water in the cable is of course the same as any other cable temporarily, high losses and severe reflections but as soon as it is purged the characteristics immediately are restored to their former values. We have never been able to measure any long term detrimental effects from water.

I am sure most of you are interested in how much it costs in terms of man hours to maintain a gas filled trunk line. In

Altoona we have accurate records of the performance of all our employees over a seven year span. Each man's performance is rated in units of work produced per hour every month so from these records it is a simple matter to extract the man hours spent on maintaining the gas filled trunk system. In fact this number is included on every monthly report I get from the chief engineer. In the past 24 months, 1,011.5 man hours were charged to gas maintenance. This averages to 42.1 man hours per month. The highest month was 76 man hours and the lowest 7.5. At $3.50 per hour this comes to $147.00 per month, or $2.10 per mile per month. Our annual cost for dry nitrogen is $311.69 or $25.97 per month or 37 cents per mile per month. This gives us a total of $2.47 per mile per month for materials and labor to maintain 70 miles of gas filled trunk line which is 8 years old. Even if your going rate for labor is double ours it is still not an item of any great consequence.

In summary I would like to list what I consider to be the principal advantages of a pressurized air dielectric system:

1. RF ground continuity of the outer conductor is assured. We lose our gas pressure long before the ground connection is poor enough to cause flashing on the trunk. In other words we locate and repair the trouble before the customer knows any trouble exists.

2. Attenuation does not change with age.

3. When water does enter the cable it can be purged and restored to like new condition with only momentary interruptions in service.

4. One advantage which is sometimes overlooked is that the attenuation versus frequency curve of air dielectric cables is flatter than most foam cables which makes for less change in equalization required for temperature change.

5. The lower loss of air dielectric cable will sometimes allow the use of the next smaller size cable and this offsets the extra cost for the air dielectric; however, the introduction of the new breed of foam cables has cancelled out this factor.

If I were to have to decide what I consider to be my chief reason for recommending air dielectric cable to you it would have to be continuity of service to the customer. We all know that troubles are going to crop up in any trunk line. The difficulties are much the same regardless of the type of cable whether it be gas filled, foam, or solid dielectric, the difference is the method of locating the problem. To site a "for instance", I am sure many of you have spent hours trying to locate a faulty splice which only gave trouble when the wind

blew, usually after 10:00 P.M., when an important night football game was tied in the fourth quarter. We now have good reliable methods of locating this kind of trouble electronically and I am by no means knocking the Time Domain Reflectometer as a valuable tool. What I am saying is this, in a vast majority of cases this kind of trouble will become very evident in a properly maintained gas filled system long before the electrical integrity is destroyed plus the fact that the gas does not wait for the wind to blow to escape, ten pounds pressure takes care of this chore very nicely. In addition, electrical tests usually involve interruption of service to be properly done, which usually means night work (after 3:00 A.M. with present TV station schedules). Gas tests can be done during normal working hours with service maintained, except for the interruption for repair which can be scheduled and is usually of very short duration. I cannot remember a single customer complaint which could be traced to a trunk line problem in the past four or five years in Altoona, yet we have had many problems which we were aware of and as I said before, one of our employees spent over 1,000 man hours on these problems in the past 2 years. We feel that $2.47 per month per mile of trunk is money well spent in providing our customers with uninterrupted service.

DISCUSSION

Mr. Ken Brubaker: Thank you very much. Any questions?

Question: What about pressurization in feeder lines?

Mr. Brubaker: We don't use--I really don't think that gas filled cable has too much application in feeder lines. The advantage that you get from the gas filled cable, I believe, in a case of distribution would be offset by the amount of maintenance required on a system of that size if all your distribution lines were---remember, in a distribution line, especially in today's systems, where you have directional couplers or any kind of tap device, you can have a break in the cable at almost every customer point so that I believe you would be taking a chance of having to contend with a fitting which must be gas type at every pole. In other words, in a trunk line we're talking now 3000 feet--something like that, in that general order--between splices where in a distribution line, you're talking about a splice at every pole. And I question whether that would prove to be practical.

Question: When you start to pressurize your amplifier cases, do you still put 60 pounds on this.....

Mr. Brubaker: I think maybe I may have been misunderstood. This 60 pounds is only used in the event there is trouble. The normal pressure in a cable is 10 lbs. per sq. inch. This is what we maintain as a norm. When we experience trouble in a given section and break it up and seal it off--and this is just between trunk amplifiers--then we'll pressurize that small section to 60 lbs. We wouldn't normally, I don't think expect any amplifier or any cable system to be able to maintain this kind of pressure as a general rule. Ten lbs. per square inch is the pressure which we normally use and several ounces is really all that is required, but, as I said, the cable stores more gas under 10 lbs. and it does give you a better indication on the guage and so on. Sixty pounds is only used for testing.

Question: About how far does your pressure take?

Mr. Brubaker: We only pressurize at one point. We have 70 miles of cable all pressurized from one point. I'll tell you--the big, and this is a real headache, and there's a gentleman in the process right now near Erie somewhere who called me the other day--who is in the process of installing a gas filled

system. This is the real headache--your first go around to once get everything gas tight. Once this is achieved, maintaining it is no problem. But to get it gas tight the first time, I have to confess it's murder. But, like I say, in the eight years experience that we've had with it, this was the only bad thing that we ran up against and actually the company that installed the system for us gave up and I took one of our men and spent about three months, myself, with this man getting the thing finally gas tight and once it was gas tight, it was no problem keeping it that way.

Question: One other question--do you cover the amplifier with a piece of copper tubing?

Mr. Brubaker: Plastic tubing--right. This plastic tubing has a life of somewhere over four years.