Coax Troubles

W2OZ Skip

Tuners, Power & Coax

The purpose of this discussion is to refresh everyone's recognition of a somewhat forgotten parameter of Coax Cable Specifications that are not being watched and possibly casually dismissed by many operators. This is the Dielectric Strength of the insulating material between the coax center conductor and the braid. Essentially what is keeping your transmitted signal from leaking to the braid and delivering full potential to the antenna load? The type of dielectric material causes a trade off in the selection of the proper coax for a particular method of operating that seems to be misunderstood at the very least by most Hams. The trade off is Loss vs Dielectric Strength, and is not being regarded by most leading to blown dielectric in some very expensive Low Loss cables. What is possibly adding to the confusion are a few other factors: 1 the use of PE [Poly Ethylene] and FPE [Foam Poly Ethylene] almost interchangeably by many vendors. 2 The omission of the Dielectric Strength from the selection tables. 3 The misunderstanding of what a Tuner or Transmatch is doing in terms of the antenna feed line. We will take up these topics in the same order and try to clarify how to select the correct coax for your station's longevity of operation. Also we will look at the voltages occurring in a barefoot 100W,a medium 500W and a full 1000 W station at normal 50-ohm loads and at elevated loads [high SWR as with a Tuner]. We will show how to calculate using basic Ohm's Law the voltages present. And suggest one more item a safety factor between the voltages being run and the rated Breakdown of the Dielectric material.

Topic I Poly Ethylene PE vs Foam Poly Ethylene FPE Dielectric

They sound the same but what a difference in DB loss vs Dielectric Strength! The Foam F PE has tremendously low loss especially at VHF & UHF frequencies a very desirable characteristic at these high frequencies since the more traditional coaxes have much higher loss in these regions. However the trade off you are making is for Dielectric Strength whether you realize it or not! The Dielectric Strength of F PE insulation according to Belden and other reputable cable manufacturers is 300 to 350 volts rms, whether the cable is the small dimension RG-58 and RG-8X or whether it is the large dimension RG8 & 9913 cables. Yet the true PE Poly Ethylene is a solid medium [has no gas or air injection] therefore it has much better Dielectric ratings, near 1700 volts rms for the smaller dimension cables and near 3700 volts [almost 10 times it's FPE counterpart!] for the larger 0.405 cables. Once again the trade off is the higher loss of the solid PE dielectric.

Topic II, Dielectric Designator & Strength

As we go on with this discussion it will become more evident why these differences exist and exactly how to pick the best Dielectric material for your operation.

Most reputable cable manufacturers give the Dielectric strength as one of the parameters in the cable description tables, however lately it has been noticed that distributors and vendors are leaving out this data. It is important to have at least one of the two Dielectric data items if not both the material designator and the Dielectric Strength. If only the material designator is given [PE or F PE, sometimes Foam PE] then the Dielectric strength follows from this data. Any Foam PE, or Foam PE is the lower 300-volt rms dielectric strength. Only plain PE [solid dielectric] has the high dielectric strength 1700 v rms for the small diameter cables and 3700 v rms for the larger diameter cables. Now that you are aware, watch for the Dielectric designator and strength Belden has a downloadable PDF file of all their coax specifications which is a handy reference, many other manufacturers also offer similar data tables. Many times it's the vendors and distributors that are abridging the specification tables and as Hams we should be pointing out to them that dielectric designators and or strength are omitted from their information. It is more preferable to select a cable from a Reputable Manufacturer's Data that suits your application, use the manufacturer's number when searching or

buying the item. Another helpful item is to look for the Military ratings, MIL C-17 or JAN C-17, these will only appear on cables with 1 solid copper center conductor, or tinned stranded copper center conductor 2 PE Dielectric [NEVER any type of Foam] 3 95% tinned copper braid or better and an outdoor rated outer jacket. Be wary of non technical vendors claiming they have a certain type of cable, they most likely are going to say 'Yes' to all your questions to get you to buy what they have in stock, demand the cable that meets [or exceeds] your requirements.

Topic III Tuners

In most VHF and UHF operations the antennas being relatively small compared to HF antennas they are usually easily permanently tuned via mechanical adjustment of their elements thus presenting a good 50Ohm match and therefore low SWR less than 1.8 or so over most of their operating bandwidth. Also on VHF & UHF it is very desirable to keep coax losses to a minimum and so this leads naturally to F PE Dielectric. On HF operation the mechanical adjustment of an antenna for low SWR is not always practical especially for Multiband antennas and a Tuner or Transmatch is used to transform the high Antenna Line SWR to a safe value for the transmitting equipment. While Tuners are very good at accomplishing this match on the Transmitter line, they are in fact not changing or eliminating the high SWR on the Antenna Line. This is an important fact overlooked by many Ham Operators and a little further on we will realize why it can be trouble with the wrong Dielectric.

Let us consider 3 station power levels, 100 W, 500 W and 1000 W, and calculate the impressed voltage on a 50-Ohm load, this is a simple application of Ohm's Law. The Power formula E^2 /R = Power where the ^ means Raised to the power 2 or squared. By algebra we get E [Voltage]= SQRT {R * Power] meaning that for our 3 power levels at 50 ohm loads we get these voltages;

100W: SQRT 5000 = 70.7 vrms
For 500W: SQRT 25000 =158 v rms
For 1000 W: SQRT 50000 = 223 v rms.

These are all for perfect 1:1 SWR match of 50 Ohms at the antenna and all have less than 300 volts meaning that if you are running 1000 W and you have a perfect match you will not exceed the Dielectric Strength of Foam PE insulation. However suppose like many Hams, on a couple of bands with your multiband antenna you have a raw SWR of 4:1 or 5:1, or even a modest 2:1,and you opt to use a Tuner or Transmatch to present 50 Ohms to the transmitting equipment? The voltage on the antenna line [from the Tuner to the Antenna] will be the product of the Raw SWR and the 50 Ohm voltage depending on your power level, this is a simple scientific fact, it happens in every state, every country, you are not exempted from Ohm's Law! Notice a few items from this information, at 100W or 70.7 Vrms, with a 4:1 SWR you are just below the 300-v rms Dielectric strength of Foam PE, and at 5:1 SWR you just carbonized a track in the Foam Dielectric! Now at 500 W with a modest 2:1 SWR you are already smoking the Foam PE, and at 1000W you don't dare go over an SWR of more than 1.34:1 with Foam PE Dielectric. On the contrary worth observing that with PE insulation in even a small cable rated at 1700 v rms nothing here is a problem, you would have to go above 7.5:1 with 1000 W to blow the dielectric of even the small cable with PE Dielectric! Most operators running this power are using the larger 3700 V rms cables like RG-213 or RG-8/U, these cables will handle the 1000 W with SWRs over 16:1! No one wants their station to be so marginal that if an external factor, like ice, a tree branch, a fallen wire, etc, happens that you blow a coax cable so good engineering practice is to keep the Dielectric strength much larger then the number required for perfect circumstances. Once Foam PE or other Dielectric has been blown or Carbonized' it is extremely lossy even more than the PE alternative was to begin with, and can never be repaired, most likely will have to be scrapped. Carbonizing is the normal failure of almost all-plastic insulation when exposed to too high an electric field and it becomes a carbon semiconductor, as most plastics are hydrocarbon molecules that release their hydrogen with a dramatic sizzle and water droplets, leaving behind a conductive path of carbon.

You can many times tell if a cable blew during a transmission, when you release the PTT and the receiver signal level is way down, you hear whistling [the melted plastic cooling [and it takes a long time for the received signal to come back up in strength. In many cases too much attention is put on 'Low Loss ' or Foam Dielectric and it is applied with no regard to the issues covered here. A possible explanation of why things have gone a little in the wrong direction is due to the nature of today's Ham Radio Hobby. Most new Hams come into the hobby in the low power VHF & UHF bands with nearly perfect antenna loads and want as little loss as possible, and also tuners are not usually used on these bands, therefore they have relatively productive & peaceful enjoyment with the low loss Foam Dielectric. Trying to bring this idea of 'low loss or bust' down to HF frequencies without understanding the trade offs and Power and Tuners will lead to a lot of frustration and ruined Foam Dielectric.

Conclusions

(1) Try to understand how your station is going to grow, whether in power, use of a Tuner, or is it restricted to VHF & UHF. Then arrive at a plan that does not limit your growth direction by limiting future power or frequency coverage. You may have actually to use different Dielectric materials above and below 6 or 2 meters. Using RG-213 on 2m is not limiting at all, a good pre amp could make up for any loss on direct communications, although most Hams are just operating into a repeater with low power.

(2) Always search out the manufacturer's specifications, and read and understand what they are telling you about applying their products whether it's coax or any other technical item. Demand answers from vendors on your concerns, don't just buy because they recommend the item. Ask for the manufacturer's name and part number, then go look it up with the manufacturer. There was a time, hopefully it will return, when hams bought based on the specifications, not some wives tale they heard on a repeater.

(3) The laws of physics apply equally to everyone there are no exception. The punishment for ignoring them is self administered, not by a judge or jury, and is immediate upon power application, and sounds like
Z O S! [Zap, Oh Sh.]

73 Skip W2OZ
1972 graduate of Stevens Institute of Technology.