

What is DF?

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Dissipation Factor (DF) is a measure of the electrical loss through an insulation material or, in other words, how far that material is from being a perfect insulator. It has other names such as loss tangent, tan delta and percent DF (%DF). Sometimes “power factor” is used as well, especially in European testing. What does all this mean, how do you measure it and what effect does it have on insulation systems?

Why test for DF?

Dissipation factor testing is useful in analyzing an insulating material or an insulation system in a laboratory environment. Compatibility of materials, degree of cure, and contamination will all contribute to the DF of a system. DF is very sensitive to external factors, so it is not useful for completed units or for maintenance testing in the field. DF of a material will also change with temperature. Comparing DF at differing voltage stresses (depending on the voltage of the design) will provide additional evaluation information called Tip-Up where 0 is perfect; a larger number indicates other factors, the most common being voids in the system. Again, this is an

important tool in analyzing the effectiveness of an insulation system.

Are there perfect insulators?

Imagine a perfect insulator – this is represented by a capacitor. The dissipation factor is repre-

sented as a resistor in parallel with the capacitor, as shown in Figure 1. The value of that resistor is very high, infinity for a perfect insulator. But real materials have some loss as there are imperfections in the material on the molecular level. (Fun chemistry!) If voltage is applied across this system, the capacitor holds off the voltage, but a little current could flow through the resistor in the circuit. This current is so small that you can barely measure it. This measurement is translated into the dissipation factor or loss of the material. How does one measure the

DF of a material? It helps to understand more about how DF is measured. Figure 2 shows an example of a material with high losses, which is easier to illustrate. When voltage is applied across the insulator, current flows through the insulator (the arrowed line in Figure 2). The components of that current, appearing across the capacitor (capacitive current or I_c) and through the resistor (resistive current or I_r) are

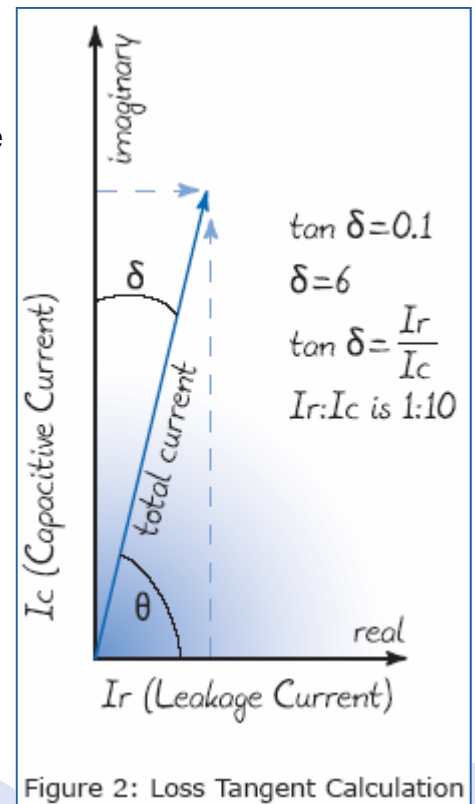
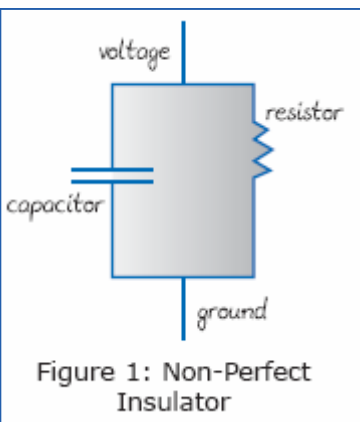


Figure 2: Loss Tangent Calculation



shown as the components of the total current. The angle, let's call it delta (d), is the tangent of the resistive current and the capacitive current. Remember trigonometry days? The tangent of an angle is the opposite side over the adjacent side. That is how we get the tangent d. So, tangent delta = tan delta = tangent d = tan d = Ir/Ic = some number. Note that DF is a unitless measurement. That's because it is a ratio. Let's look at this carefully. The tan delta is a ratio of the resistor current over the capacitor current. The resistor current is a bad thing . . . it means that the dielectric material is less than perfect. So you want the tan delta or dissipation factor to be a LOW number. This means that the material is close to perfect.

What do these different names mean?

Tan delta = tan d = dissipation factor = DF also
 %DF = DF*100%
 For example, let's say a material has a
 DF = 0.0066.
 Then %DF = 0.66 (easier to read),
 dissipation factor = 0.0066,
 tan delta = 0.0066

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TEC TALK is a quarterly publication of Technical Marketing ■ Von Roll USA, Inc.
 Kevin Alewine, Editor

What is PF?

Power Factor (PF) relates to a device (like a motor or generator) and is a measure of how efficiently electrical power is transferred. PF=1 when there are no resistive components to the system, or no loss, again a perfect system. It is measured in much the same way as tan delta, except that PF=cos q in Figure 2, or the capacitive current over the total current. This means that power factor shows how closely the system performs to perfect (without any losses). Or, simply, it describes how efficiently the device transfers power. That being said, you now have two perfect measures. For a material, as well as an insulation system, perfect means a DF equal or close to zero. For a device, perfect means a PF equal or close to one.

What is the effect of high DF?

Remember that electrical energy lost due to high DF, such as Example A in Figure 3, results in increased heat rise of the device—always a major factor in determining the service life of the design. Choosing compatible materials and paying close attention to processing are both key factors in manufacturing quality equipment.

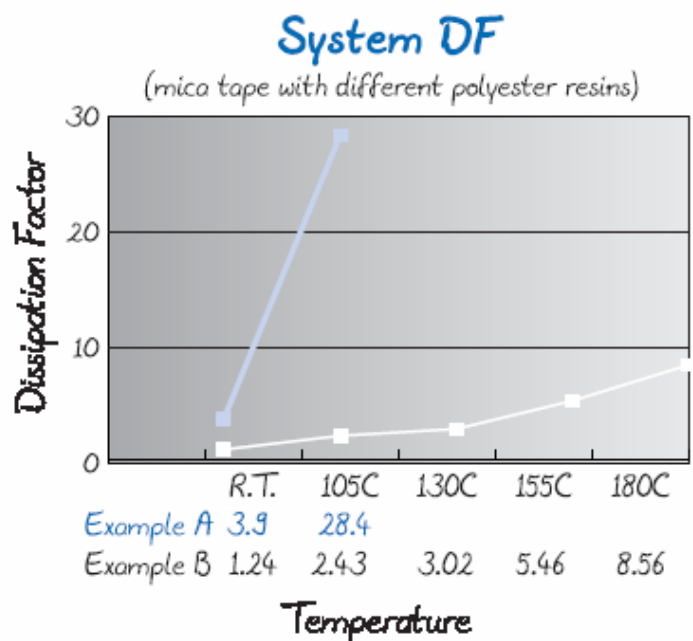


Figure 3: Sample of System DF Test Results