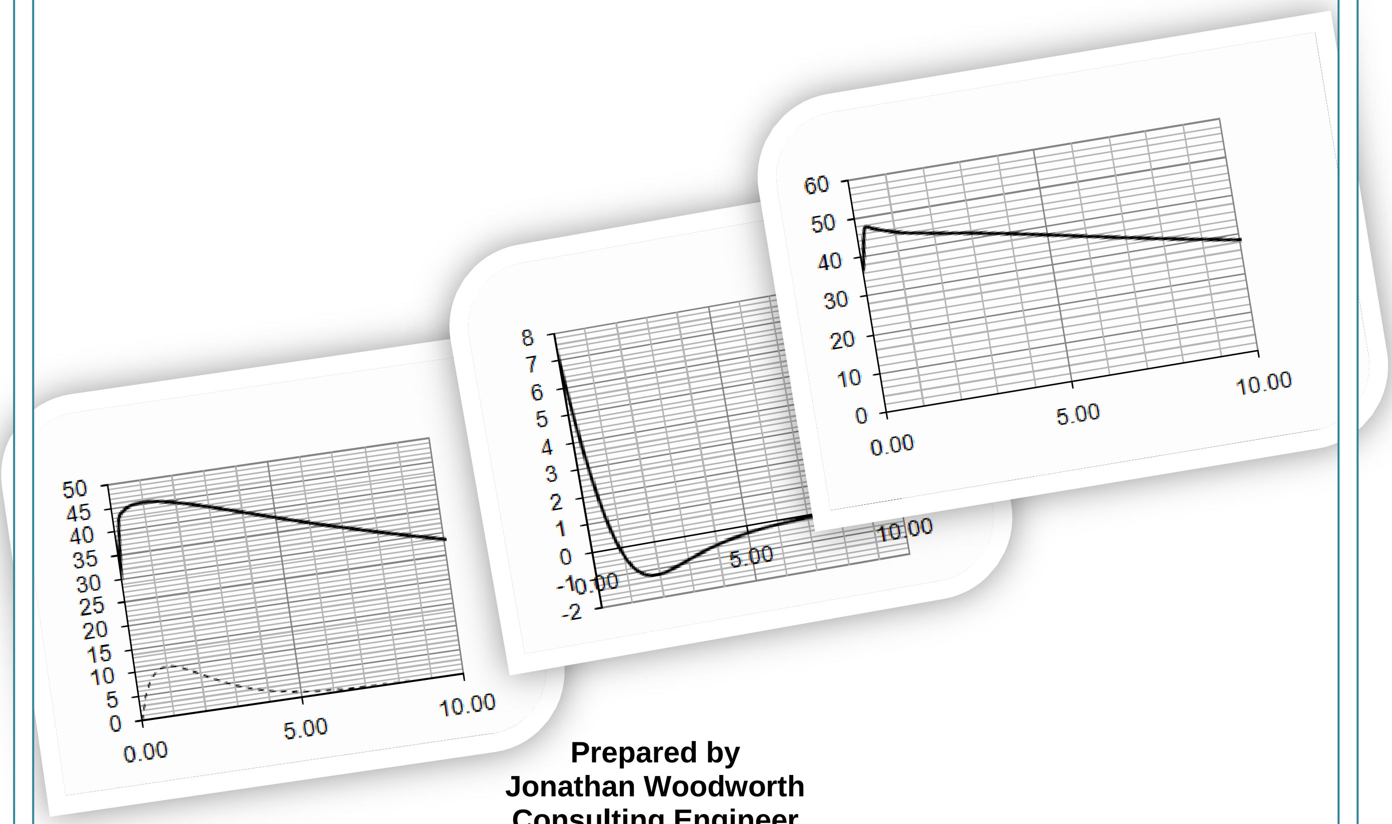
ArresterWorks

Understanding New Discharge Voltage Test Methods for Fast Rising Surges



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Introduction

The fundamental purpose of an arrester is to clamp voltage surges on power systems. The surge arrester is a fast responding device that can clamp surges that appears across its terminals, but the response of the arrester can be different depending on the steepness of the surge.

Since the MOV arrester was introduced in the late 1970's, the method of determining the arrester's response to very fast rising surges has remained the same. This was accomplished by to measuring the arrester's response at slower rates of rise, and extrapolate back to establish the actual discharge voltage at .5us. which was faster than most test equipment could measure accurately at that time. Today with vastly improved response time test equipment, the need for extrapolation is no longer needed so direct measurement methods have been developed and will be covered in IEEE C62.11 – 2013. Also explained in the ArresterFacts is how the data will be published in the near future.

This ArresterFacts explains in detail how this measurement is specified in the current IEC 60099-4 and in the next edition of IEEE C62.11. "ArresterFacts 013 Understanding Discharge Voltage" is a recommended prerequisite read to this Arresterfacts.

Definitions

The definitions related to discharge voltage as published in section 3 of IEEE C62.11:

- **Discharge Voltage:** The voltage that appears across the terminals of an arrester during passage of discharge current.
- **Discharge Current:** The surge current that flows through an arrester.
- **Equivalent Front-of-Wave discharge voltage (EFOW):** the 10kA discharge voltage of an arrester using 1us to crest surge current

The IEC definitions related to residual voltage in section 3 of IEC 60099-4 are:

- **Residual Voltage of an Arrester - *U*res** peak value of voltage that appears between the terminals of an arrester during the passage of discharge current
- **Discharge current of an arrester:** impulse current which flows through the arrester
- **Steep Current Residual Voltage:** the 10kA discharge voltage of an arrester using 1us to crest surge current

Background

After an arresters MCOV voltage, its discharge voltage (also known as residual voltage) is inarguably the most important characteristic of the arrester. The name "discharge voltage" or "residual voltage " however doesn't effectively describes the characteristic in any way, so many users prefer to use the term "clamping voltage", since this term explains in one word the essence of the characteristic "clamps the voltage". When a surge of any type travels along a conductor and reaches the arrester, the arrester changes its impedance, conducting the surge to ground, and effectively clamps the peak voltage of the surge to lower levels according to its residual voltage characteristic curve. In other words, the clamping voltage is the peak voltage across the terminals of an arrester at any peak current in the range of a few hundred amps to thousands of amps. Since the clamping voltage is an ever changing function of the current passing

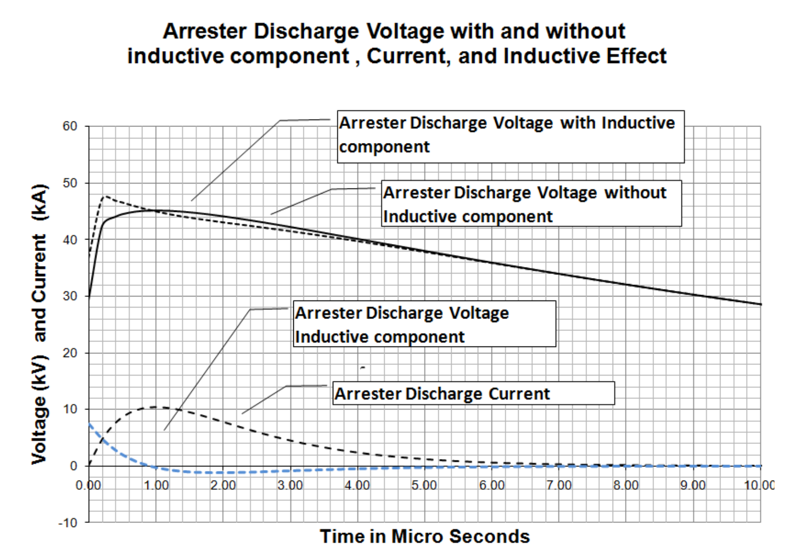

Figure 1: Fast Rising Discharge Voltage

through the arrester, it must be described as a table or curve as shown in Figure 1

The Inductive Component

The inductive component of an arrester is derived entirely from its length as it is with all electrical condutors. As long as the diameter is a is less than 25% of the length, all inductance effect is due to length.

An inductance value of .32/ft or 1uh/m has been adopted as a general value that gives a reasonable approximation of the actual inductance of an arrester. If an arrester had no length, there would be no inductive voltage across its terminals. As seen in Fig 1, the inductance of a 2 foot 15kV MCOV arrester results in a peak inductive voltage at T_0 of about 7kV when impulsed with 10kA cresting at 1us.
Note that the inductive component becomes irrelevant when the surge current crests in 8-10 micro-seconds. For this reason, the inductive component is only of concern for discharge voltage measurement where the surge current is in the 1-2us range.

Test Procedures Past, Present, and Future

In the past and present IEEE standard C62.11, the inductive component has only been accounted for indirectly. It is stated in the discharge voltage test procedure to include inductive components in the prorated section that represented the full arrester. This very loose specification allowed less than optimum test results. Further, the IEEE test procedure required that the sample be impulsed with three surge currents with 2, 4, and 8us crest currents, and then extrapolating the resulting voltage back to a voltage cresting in .5 us. This antiquated method was not only inaccurate, but unnecessary in light of new test equipment that can easily measure a surge cresting in .5us. This test method and procedure could also lead to measurement error exceeding that allowable in the standard.

The present IEC test procedure in 60099-4 specifies a clean and clear means of accounting for the inductive effect by impulsing a conductor of equal length and diameter to the arrester and subtracting the resultant inductive component from the arrester curve. (Note this can be completed on a disk only if desired) This results in a very accurate characterization of the arrester if it were to have zero length or no inductive effect. In figure 1, if the inductive component is subtracted from the total discharge voltage (as it would be measured in actuality) the results would be the solid line of arrester discharge voltage without inductive effect. It is also worthy to note, that this procedure also eliminates any error present in the test measurement system and therefore even more valuable as means of representing the most accurate discharge characteristic.

In the new addition of C62.11 to be released in 2013 the IEC test procedure has been adopted by the IEEE standards groups as a more accurate representation of the actual arrester discharge voltage characteristic.

New Method of Calculating the Discharge Voltage with Inductive Component

Once the non-inductive discharge voltage is determined, it is still important to determine the inductive voltage of a complete arrester since arresters with similar MCOV ratings can have very different lengths. To determine the total discharge voltage including the inductive component a common method has been adopted. The inductive component is calculated per equation below and then added to the non-inductive discharge voltage as follows:

V_{ind} = L * arrester length * di/dt

- L= .32uh/ft
- Arrester Length in feet
- di/dt for 10kA rise in 1us = 10kA/us

Example 1: For a 2 ft arrester the Inductive voltage to add to the non-inductive discharge voltage is - V_{ind} = .32 * 2.0 * 10 = 6.4kV

A value of 6.4kV would be added to the non-inductive discharge voltage to represent the total discharge voltage of the arrester.

If the arrester was an extra creep model and was 4 feet instead of 2 feet, then a value of 12.8kV would be added to the non-inductive discharge voltage. The implication here is that all extra creep arresters used in highly contaminated areas will have higher total discharge voltages, effectively not protect as well as the shorter arrester.

Using the Right Discharge Voltage Characteristic

Because the discharge voltage of an arrester is a competitive characteristic, it is often times used to compare one manufacturer and/or model with another. The arrester with the lower discharge voltage is generally considered the better arrester. When comparing arrester discharge voltages, it is important that the non-inductive discharge voltage not be compared to the total (inductive component include) discharge voltage.

Until the 2013 IEEE St. C62.11 is published, all IEEE tested arresters include the inductive component in the published data. Arresters tested per IEC methods as outlined in 60099-4 may or may not have the inductive voltage included. It is best to consult the manufacturer if it is not clear.

Because arrester modeling is becoming a more utilized analysis tool, it is desirable to have an arresters discharge voltage without the inductive component so that it can be more accurately modeled.

Summary

In 2013 both IEC 60099-4 and IEEE C62.11 will be published with new calculation methods and data publication requirements for discharge voltage. The new calculation methods will result in more precise discharge voltage values which will be be reflected in the new requirements for published tables. These tables will include two columns of data for the EFOW and Steep Front discharge voltages. One will include the inductive component and one will not. As a result in the future it will be easier to make accurate comparisons.

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If you ever have any questions about this or other arrester issues, contact Jonathan Woodworth at jonathan.woodworth@arresterworks.com

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