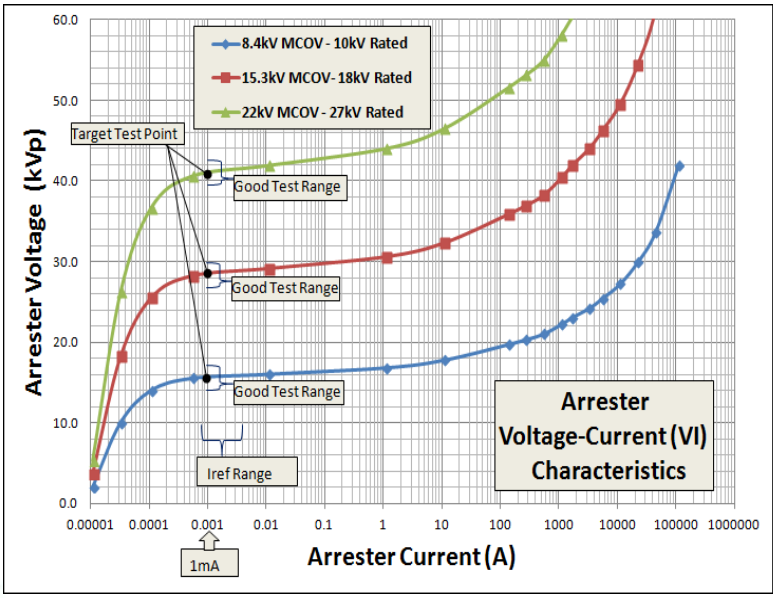
ArresterWorks

Field Testing Non-gapped MOV Type Arresters with a Hipot Tester



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Introduction

There are several ways to effectively test an arrester in the field without highly sophisticated equipment. This article is about using an AC Hipot or DC Hipot (both also known as a Dielectric Tester) to determine the health of an arrester. Using this simple test method, you can determine if an arrester is safe to install or reinstall. Another option with a Hipot tester is to determine if an arrester has experienced a high current impulse during its time on the line. This test method can be used on any MOV type arrester with any voltage rating as long as you have an adequate voltage supply. While this test method does not appear in any IEC or IEEE Standard/Application guide, it has been used for more than 30 years by arrester designers and manufacturers.

How It Works

This test method is only applicable to non-gapped MOV type arresters. It cannot be used on gapped silicon carbide arresters or, in general, on arresters with a manufacturing date before 1980.

Every MOV type arrester has a VI Characteristic, similar to what is shown in Figure 1. During steady state operation, an arrester operates at levels well below the start of heavy conduction (>1ma). The basis of this test method is to force conduction of the arrester up to approximately 1mA (DC or Peak or RMS) and then record the voltage at that point. The voltage across the arrester that results in 1 ma conduction through the arrester is often called the 1mA voltage or reference voltage of the arrester. This point on the VI characteristic curve is very consistent from arrester to arrester of the same manufacturer and vintage over a wide temperature range. Figure 4 can be referenced for the range of 1 mA voltages to be expected for various arresters.

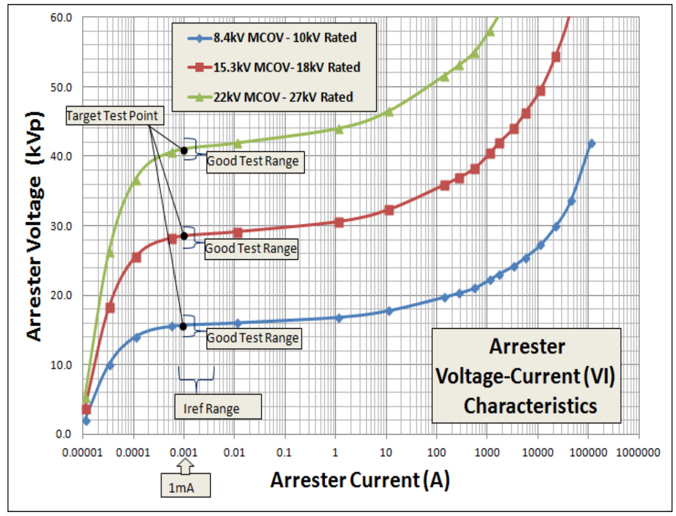

Figure 1: VI Characteristic Curve and Test Points for Typical Distribution Arresters

Risks

1. If the voltage from the test is allowed to remain energized for minutes, it can heat the arrester and cause it to fail internally, rendering the arrester unusable. If the arrester turn-on voltage is in the range that is expected, it has not been failed.
2. There is no risk of explosive failure of the arrester during this test. However, if an arrester is failed during this test and subsequently energized on the system, an explosive failure could then occur.
3. This is a high voltage test therefore standard high voltage test safety procedures should be observed.
4. If testing through the ground lead disconnector check the manufacturer's Time Current curve for the disconnector before applying 1 mA (note: a 1mA design however is a very rare case). If it is a fast disconnector, it could activate during the test. If possible, do not test through the disconnector.

Figure 2: Common HiPot Testers

Equipment Requirements

This test can be conducted either with an AC or DC Hipot tester. At a minimum, the Hipot tester maximum voltage rating needs to be high enough to push the arrester to the 500 uA-1 mA conduction level. This 1 mA level of the arrester is dependent on the voltage rating of the arrester. Figure 4 offers guidance as to the minimum voltage rating of the Hipot tester for the common arrester ratings. It is also preferred that the tester have a voltage and current meter, otherwise separate metering instruments will be required.

The maximum output current of the tester should be 1 mA if possible. If only .5 mA is possible, this will work, but it will not be as accurate.

Test Circuit

The test circuit in its simplest form consists of the tester and sample. In some cases, as in Figure 3, the tester comes in two parts. Follow the recommended setup procedures from the hipot tester manual. The goal is to electrically stress the full arrester or part thereof with the voltage of the test set. If a separate voltage divider or current sensor needs to be used, ensure that they do not allow the current to bypass the current meter to ground

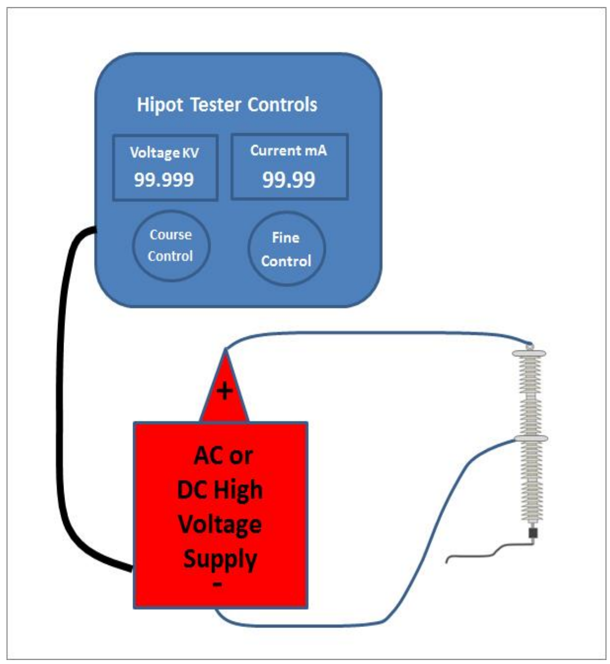

Figure 3: Test Circuit

Arrester Preparation

This test cannot be done while the arrester is in service. At least one end of the arrester needs to be isolated and the voltage source for the test must be the Hipot test set. The test should be conducted on a dry sample, but not necessarily clean. However, if test results appear to be erratic, cleaning of the sample may be beneficial. The temperature of the arrester is not relevant for this test as long as >500uA of current is available from the voltage source. This test can be conducted if less than 500uA is available, however if tested numerous times at that current, and the temperature of the arrester increases, it becomes a factor and the data is less trust worthy.

Test Procedure

1. **Identify the Arrester:** Ensure that the arrester is a non-gapped MOV type arrester. If it is not, this test will not work, as stated earlier in this article.
2. **Connect the Arrester:** Follow safety precautions as suggested by the Hipot Tester manual. Ensure that the high voltage terminal is out of reach of all personnel. Connect the high voltage test lead to the top of the arrester, and the ground terminal to the bottom of the arrester. If the arrester is a multi-section arrester, each section may be tested separately, in this case, connect the tester terminals across the section of arrester being tested. If this is the method used, take care to keep the open end of the arrester isolated from personnel and/or ground.
3. **Adjust the Voltage:** Slowly increase the voltage applied to the arrester (1-2 minutes to test voltage) until current begins to flow. When the current reaches 1 mA, record the voltage on the voltage readout. If the current trip on the tester

Typical Current and Voltage Values for HiPot Testing of Arresters

Arrester MCOV or Uc	Target AC Test Voltage	Minimum AC Voltage at 1 mA (kV RMS)	Typical Maximum AC 1 mA voltage (kV RMS)	Suggested AC HiPot Tester Rating (kV RMS)	Target DC Test Voltage	Minimum DC Voltage at 1 mA (kV)	Typical Maximum DC 1 mA voltage (kV)	Suggested DC HiPot Tester Rating (kV)
2.55	4.55	4.33	4.78	5kV	6.38	6.06	6.69	10kV
8.4	15.0	14.3	15.8	20kV	21.0	20.0	22.1	25kV
10.2	18.2	17.3	19.1	20kV	25.5	24.2	26.8	30kV
12.7	22.7	21.5	23.8	25kV	31.8	30.2	33.3	50kV
15.3	27.3	26.0	28.7	30kV	38.3	36.3	40.2	50kV
19.5	34.8	33.1	36.6	40kV	48.8	46.3	51.2	75kV
22	39.3	37.3	41.3	50kV	55.0	52.3	57.8	75kV
29	51.8	49.2	54.4	75kV	72.5	68.9	76.1	100kV
42	75.0	71.3	78.8	100kV	105	100	110	125kV
84	150	143	158	200kV	210	200	221	250kV
98	175	166	184	200kV	245	233	257	300kV

Figure 4: Typical Test Value

trips before reaching 1 mA and it cannot be increased, then record the voltage at which the current tripped. This test can be ran numerous times on an arrester and will not damage the arrester as long as the arrester remains at or is allowed to return to ambient temperature between tests. If the voltage is allowed to remain on the arrester for several minutes (>5) at 1 mA, it may however, damage the arrester.

4. **Evaluation:** If more than one arrester of the same vintage and manufacturer is available, compare the resulting V1 mA voltage of each arrester. If the voltage levels are within a few percent of each, the arresters are ok. If only one arrester is available for test, the resulting tests can be compared to typical values shown in Figure 4. Note, it is acceptable for the 1 mA voltage to be higher than the values in Figure 4, but voltages lower than that in Figure 4 are not recommended.

If, however, numerous arresters test exactly the same with this test, then the absolute value is not as important as the consistency.

Detecting High Current Impulse History

High current impulse history is another arrester characteristic that can be determined when testing with a DC Hipot test set. If an arrester is stressed within 25% of its maximum design impulse current, it often undergoes a small VI characteristic change. The change is subtle, but detectable with a DC Hipot tester.

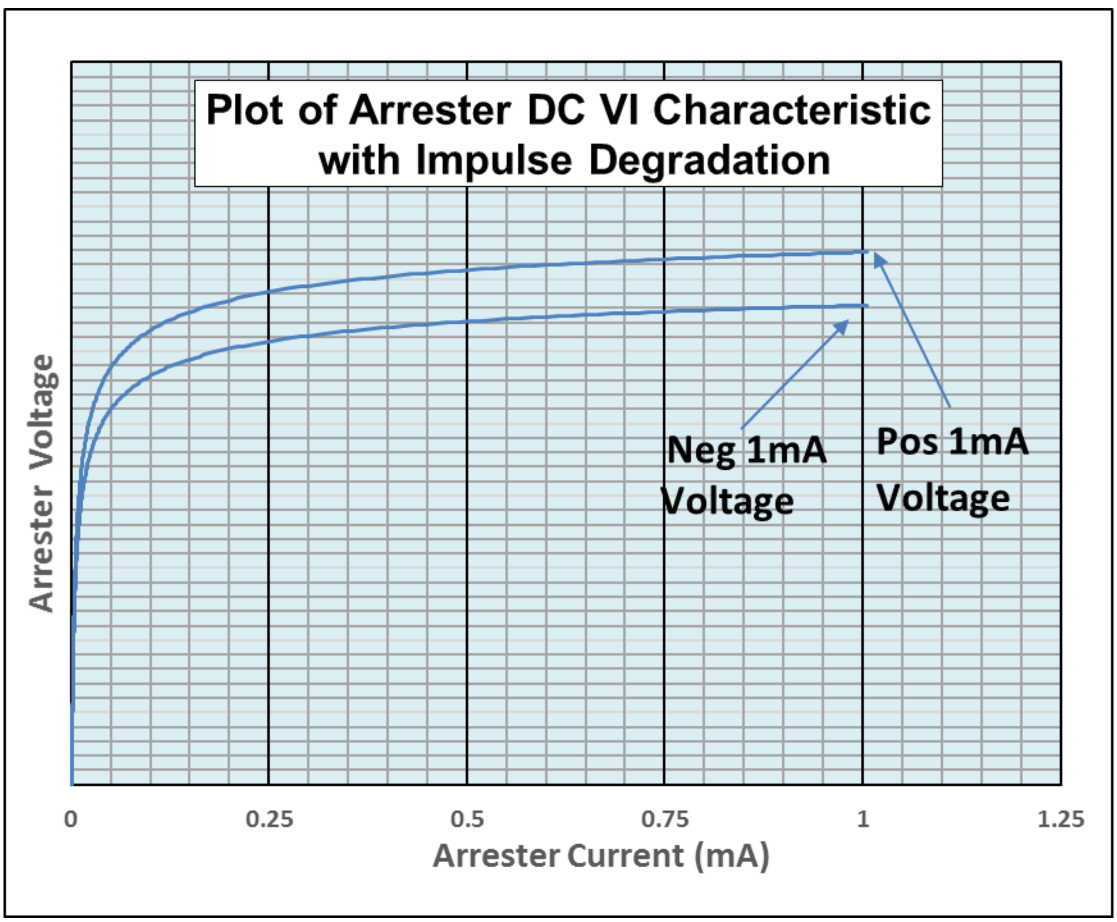

Figure 5 DC VI Curve of an Impulse Degraded Arrester

Unfortunately, the change is not easily detected with an AC Hipot test set. It should be made known that an arrester with a small change in VI characteristic in this manner is not necessarily a potential failure, but should be noted for comparison to future test data.

To execute this test in practice, the voltage is adjusted until the current is as high as possible (up to 1 mA), and then the voltage level is recorded. For the second reading reverse the direction of the current flow through the arrester and tested again. If the voltage at the same current is different in either direction, the sample has likely experienced a high current surge during its history. If more than a 20% difference in the voltages at max current is detected, then serious impulse damage has taken place. With a 20% or more difference in 1 mA voltage, the arrester should be replaced if possible. It will still protect with this impulse degradation, but the arrester has a higher chance of failure during a temporary overvoltage event. The plot in Figure 5 is from voltage and current data points taken with a Hipot tester. The current was recorded at various voltages applied across the arrester and plotted. This is just an example.

Conclusion

There are several ways to test arresters in the field once they are taken down from the system. However, most of these methods require special equipment. This test option uses existing equipment typically owned by utilities and no additional capital equipment is required. Along with very low cost, this test is also very easy to execute. Figure 6 is a favorite of mine from when I was using this test method just south of the Arctic Circle in early winter several years ago.

Figure 6: Hipot Testing Varistor Columns in a Series Capacitor Installation