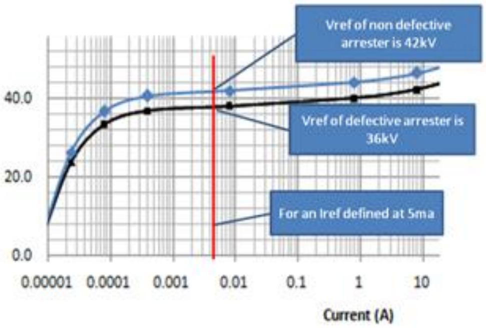
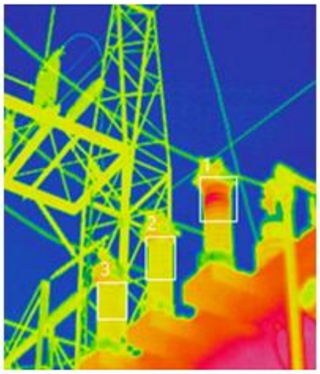
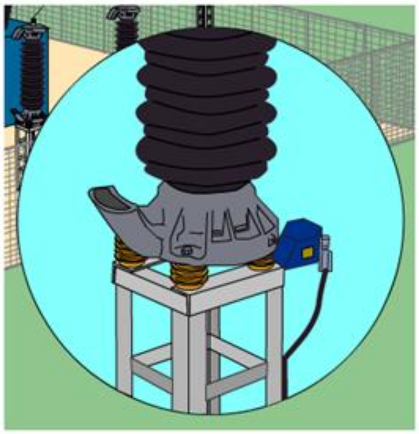
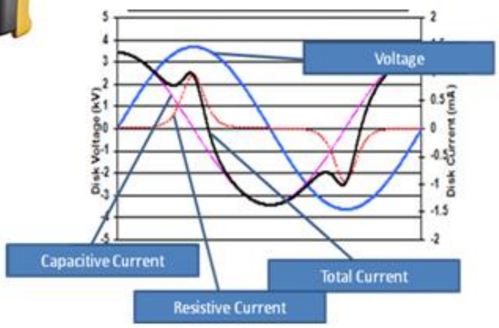
ArresterWorks





Guide for Selecting an Arrester Field Test Method





2/23/2013

Jonathan Woodworth

Introduction

A vital aspect of asset management on power systems is understanding the remaining life of a critical component. Predicting the life of these components while on-line or off-line is an onerous task at best. This document offers guidance when selecting the method to test surge arresters away from the lab environment. Testing surge arresters in the field is important on both transmission systems and distribution systems since they are extensively applied in both. The various field test methods of assessing the life of arresters are reviewed. The positive and negative attributes are discussed for all test methods. A table that clearly contrasts the benefits of each test type based on the situation is presented.

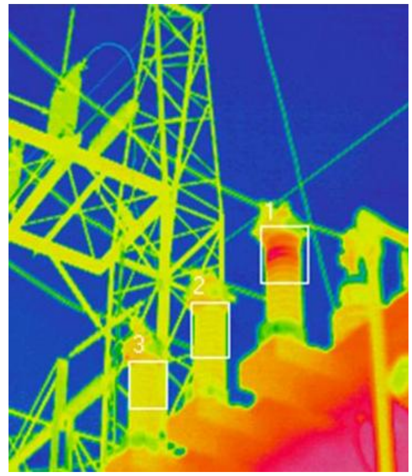
Comparative Table

Definition of Terms	Sensitivity to Arrester Health	Informative	Versatility	Speed of use	Ease of use	Reliable Predictor of Life	Initial Cost	Maintenance Cost	Use energized	Test while installed	Test while Un-installed	Remote Sensing
Infrared Imaging	High	High	High	Fast	Easy	High	Medium	Low	Yes	Yes	No	Can be
Infrared Thermometer	High	Mediu m	High	Fast	Very Easy	High	Very Low	Low	Yes	Yes	No	Can be
Partial Discharge Detection	Low	Low	Medi um	Slow	Difficult	Low	High	High	Yes	Yes	No	No
Acoustic Partial Discharge	Low	Low	High	Fast	Easy	Low	Medium	Low	Yes	Yes	No	No
Resistive or 3rd Harmonic Leakage Current	Very High	High	High	Slow	Difficult	Can be very High	High	Low	Yes	Yes	Can be	Yes
Reference Voltage Deviation or Turn On Voltage	High	High	Low	Medi um	Difficult	High	High	Low	No	Maybe	Yes	No
Watts Loss at Uc or MCOV	Can be Very High	High	Low	Slow	Difficult	High	High	Low	Yes	Yes	No	Yes
Watts Loss @ <50% Uc or MCOV	Can be High	Can be High	High	Fast	Easy	Can be Good	Medium	Low	No	No	Yes	No
Ohmic	Very Low	Very Low	High	Fast	Easy	Very Low	Medium	Low	No	No	Yes	No
Surge Counting	Very Low	Low	Low	Fast	Easy	Very Low	Low	Low	Yes	Yes	No	Yes
Leakage Current on 1-30 ma Scale	Very Low	Very Low	Low	Fast	Easy	Very Low	Low	Low	Yes	Yes	No	Yes
Sparkover	Very Low	Low	Low	Slow	Medium	Very Low	Low	Low	No	No	Yes	No

Infrared Imaging

Return to Comparison Table

This is a fast growing test method in power systems. The main reason is that the relative temperature of a device is highly informative. An image can give the user significant amounts of data about the test sample at that exact point in time. It cannot show temperatures through time unless the camera has been recording it through time which is often an option. With regard to arresters, the only negative attribute of this test method is that it cannot be used if the arrester has been de-energized for more than a few minutes. Since it is not a standard piece of toolbox gear, sometimes the output is not readily available at the test site by non imaging personnel.



Sensitivity to Arrester Health:
This method accurately measures the temperature of the device and devices nearby for a relative comparison. The accuracy of measuring the health of an arrester is excellent if the arrester is nearing end of life which is generally the time it exhibits excess heat. Most units can differentiate .5deg C temperatures which is adequate resolution to compare to other similar nearby energized arresters.

Informative:
The output of IR images is abundant with information about the arresters temperature but little else. It can tell the user the distribution of the temperature. It cannot tell anything about the history before the image. It can tell about the future if subsequent images are taken and compared.

Versatility:
This is a highly versatile test method since it can be used on any type of arrester, any rating of arrester and almost any configuration. It can be difficult in the heat of the mid-day when all parts are hot.

Speed of Use:
Upon entering a substation, approaching a tower or approaching a pole, the imaging device is easily switched on and the output is rapid. Within seconds a thermal image can give the status of the arrester temperatures.

Ease of Use: Late model units are quite easy to use, but may still require some training or practice.

Remote Sensing:
Since the image is digital, it can be transmitted to different locations using customary broad band methods.

Reliable Predictor of End of Life:
It is generally understood that arresters that are hotter than similar nearby units are near the end of life. However it is not possible to accurately predict the rate of failure from this type of testing.

Use Energized:
This test method must be completed while the unit is energized. Since this test method uses the temperature (or difference in temperature between similar units) to predict the health of the arrester, it must be energized either by the system or similar source for several hours prior to the evaluation.

Test While Installed:
This is the preferred state when performing a survey of a set of arresters using this test method.

Test While Uninstalled:
This testing can be done when uninstalled as long as it is energized by a source capable of supplying enough power to heat the unit if it is in an end of life mode.

Initial Cost:
500-5000 USD

Maintenance Cost: No maintenance is necessary, only standard handling similar to a computer.

Infrared Thermometer

Return to Comparison Table

Do not confuse this method with Infrared Imaging, This method only offers the user a temperature at the point to which it is aimed. The thermometer must be pointed at several locations on the arrester to assess the full health of the unit. This is an underutilized test method that should be adopted for its safety attribute alone.

Infrared Thermometers have become a piece of standard toolbox gear for many electrical workers because of their rapid deployment capability and noncontact application method. If an arrester is within the last few months of its life, this test method is most valuable. If the arrester is very hot, above 30-50C hotter than other similar arresters, this device can flag the problem rapidly.

Sensitivity to Arrester Health:
This method accurately measures the temperature of the device and devices nearby for a relative comparison. The accuracy of measuring the health of an arrester is excellent if the arrester is nearing end of life since that is generally the only time it exhibits significant heat. Most units can differentiate .5°C temperatures which is acceptable resolution to compare to similar nearby energized arresters

Informative:
The output is a temperature at the location where the thermometer is pointed. It can tell the user the temperature distribution as the thermometer is pointed at several locations on the sample. It cannot tell anything about the history before the measurement.

Versatility:
This is a highly versatile test method since it can be used on any type of arrester, any rating of arrester and almost in any configuration. It can be difficult in the heat of the mid day when all parts are hot.

Speed of Use:
Upon entering a substation, approaching a tower or pole, the thermometer is easily switched on and the output is available. Within seconds a temperature on the surface of the arrester can be read.

Ease of Use:
This is the easiest of all arrester test methods. Just point and read.

Reliable Predictor of End of Life:
It is generally understood that arresters that are hot with similar nearby units measuring cooler are near their end of life. However it is not possible to accurately predict the rate of failure from this type of testing.

Use Energized:
This test method must be completed while the unit is energized. Since this method uses the temperature (or difference in temperature between similar units) to predict the health of the arrester, it must be energized either by the system or similar test set for several hours prior to the evaluation.

Test While Installed:
This is the preferred state when performing a survey of a set of arresters using this test method.

Test While Uninstalled:
This testing can be done when uninstalled as long as it is energized by a source capable of supplying enough power to heat the unit if it is in an end of life failure mode.

Remote Sensing:
These are generally hand held devices, but the data is digital and can be downloaded to other devices which means it can be remotely read. Broadband communications is not necessary.

Initial Cost:
100-500 USD

Maintenance Cost:
Maintenance is not necessary, only standard handling similar to a computer.

Partial Discharge Detection

Return to Comparison Table

Partial discharge (PD) or Corona as it is often called is may be prevalent in arresters nearing their end of life, but not guaranteed to be present. If PD is present and originates from the external surface of the arrester or on a sharp point, it could be harmless to the arrester. The uncertainty of the PD location for this type of method to assess the health of an arrester makes it a less valuable test option..

Sensitivity to Arrester Health:
This is an inaccurate test method due to the fact that PD does not necessarily imply the end of life is near for an arrester. If the PD originates on an external part of the arrester and is not emanating from an organic part, it is probably harmless and not an issue in the life of the arrester.

Informative:
The level of information regarding the status of the life of an arrester from internal or external partial discharge is minimal.

Versatility:
This can be a versatile method of testing arresters. The arrester rating and type do not increase or decrease the amount of PD that may be created. However the equipment is different for different system voltages. This test can only be done with the power applied to the arrester as it would be on the system.

Speed of Use:
Equipment used to make this measurement is quite sophisticated. It takes training and time to set this equipment up correctly to measure PD in a substation or on lines.

Ease of Use:
Filtering out ambient PD is a major challenge making this test method very difficult.

Reliable Predictor of End of Life:
As stated above, this is an unreliable predictor of life of an arrester since partial discharge is not always present in a failing arresters and PD can be present externally causing no harm to an arrester.

Use Energized:
This test method must be completed while the unit is energized. Partial discharge can only occur when the voltage stress on a point exceeds the electrical strength of the air.

Test While Installed:
This is the preferred state when performing a survey of a set of arresters using this test method.

Test While Uninstalled:
This testing can be done when uninstalled as long as it is energized by a source capable of supplying enough voltage to reach the Uc or MCOV of the arrester.

Remote Sensing:
Since the data is digital, this can be transmitted to a remote location.

Initial Cost:
10,000- 50,000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Acoustic Partial Discharge Detection

Return to Comparison Table

This is referred to as acoustic since this method uses acoustic transducers to detect and amplify the sound of the corona and then converted it to a more suitable audio range for the human ear. Transducers are available to listen to partial discharge within a transformer that has a grounded tank, but this method does not work on arresters unless they are of the GIS or liquid immersed type.

Sensitivity to Arrester Health:
This is an inaccurate test method due to the fact that PD does not necessarily mean end of life is near for an arrester. If the PD is external to the arrester and not emanating from an organic part it is probably harmless and not an issue in the life of the arrester.

Informative:
The level of information regarding the status of the life of an arrester from internal or external partial discharge is minimal.

Versatility:
This is a very versatile method of testing arresters. The arrester rating and type do not increase of decrease the amount of PD that might be generated. This test can only be done with the power applied to the arrester as it would be on the system.

Speed of Use:
The equipment for this test method is simple and generally hand held. It is very fast to setup and run.
Ease of Use:
It is still hard to filter out the ambient noise, so using this method takes training and experience to do it easily.

Reliable Predictor of End of Life:
As stated above, this is an unreliable predictor of life of the arrester since partial discharge is not always present in a failing arresters. Also if the PD is externally generated it can be harmless to an arrester.

Use Energized:
This test method must be completed while the unit is energized. Partial discharge can only occur when the voltage stress on a point exceeds the electrical strength of the air.

Test While Installed:
This is the preferred state when performing a survey of a set of arresters using this test method.

Test While Uninstalled:
This testing can be done when uninstalled as long as it is energized by a source capable of supplying voltage at Uc or MCOV of the arrester.

Remote Sensing:
Since the data is digital, this can be transmitted to a remote location.

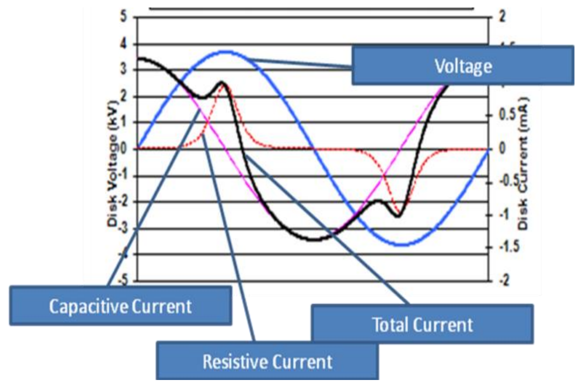
Initial Cost:
500-2000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Resistive or 3rd Harmonic Leakage Current

Return to Comparison Table

This is rapidly becoming the method of choice for arrester users interested in excellent long term maintenance of arresters. This method has been developed for the current generation of Metal Oxide Arresters. This method is the most accurate in predicting the life of an arrester and offers the most relevant data with regard to the past and present status of the arrester. IEC Standard 60099-5 has an annex devoted to this type of field testing of arresters. Numerous manufacturers of this equipment are offering many models and capabilities. This leakage current method should not be confused with simple capacitive current meters often found on surge counters. See entry on Leakage current meters below.



Sensitivity to Arrester Health:
With the proper equipment, this is a highly accurate means of measuring the present and past state of an arrester's health. Arresters that are in short or long term failure mode will exhibit some increase in resistive current long before any other characteristic shows changes.

Informative:
As stated above, the resistive current is a definitive characteristic of an arrester's health. This data coupled with an historic set of data is the best means possible in assessing the health of an arrester.

Versatility:
Using this type of test method must be planned long in advance of its use because the earthed end of the arrester must be electrically insulated from ground to make this reading. In most cases the sensors need to be installed on the arrester for them to operate properly.

Speed of Use:
If the sensors are previously installed, this method is very rapid. If the data is not automatically transmitted to a central point via some method, it can be rapidly collected with special equipment.

Ease of Use:
With the proper training any line personnel can use this type of equipment.

Reliable Predictor of End of Life:
This is the most reliable means of predicting the end of life of an arrester if historical data is kept on the unit. A long term change in the resistive current of an arrester is one of the most sensitive characteristic of an arrester's health.

Use Energized:
If the test equipment has memory, the data from this type of transducer can be downloaded even if the arrester is de-energized.

Test While Installed:
This is the preferred state when performing a survey of a set of arresters using this test method.

Test While Uninstalled:
This testing can be done when the arrester is uninstalled as long as it is energized by a source capable of supplying enough voltage to reach the Uc or MCOV of the arrester.

Remote Sensing:
Since the data is digital, this can be transmitted to a remote location.

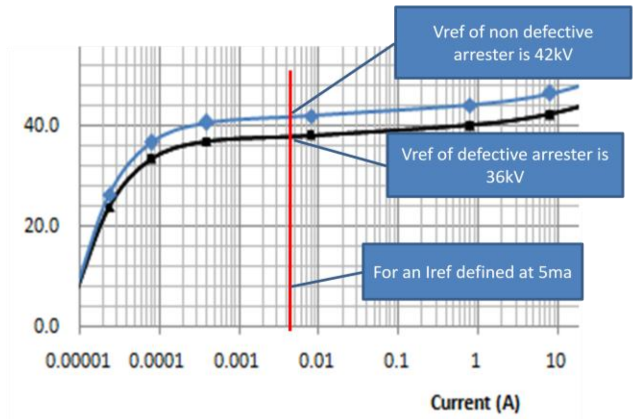
Initial Cost:
500-20,000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Vref or Turn on Voltage Deviation

Return to Comparison Table

This is a seldom used test method in the field because of its difficulty to setup and execute. It is difficult to use on higher voltage arrester without significant test equipment capabilities. For arresters 3-36kV, there are suppliers of equipment that use this test method of uninstalled arresters. Some variations of this test method are done with the arresters semi removed from the circuit. This method can be used to assess the health of oil immersed or GIS arresters with circuit modifications.



Sensitivity to Arrester Health:
The turn on voltage or reference voltage of an arrester is an extremely sensitive characteristic related to the health of an arrester. If high resolution equipment is used, this can be the best possible way to evaluate an arrester.

Informative:
The only information measured on this test is the voltage level at which an arrester starts to conduct. If several similar arresters are measured, this level is all that is needed to ascertain the health of the arrester.

Versatility:
This method is not highly versatile since the voltage rating of the arrester will modify the results of the test. The higher the rating, the higher the turn on voltage and Vref of an arrester. This needs to be taken into account when using this method.

Speed of Use:
If performing this test in the field, the arrester needs to be removed or at least disconnected at one end. This makes the speed of this test slow.

Ease of Use:
If a portable tester is being used for this test and the arrester is already uninstalled, this is an easy test to perform. If the arrester is tested in place, wiring can be difficult.

Reliable Predictor of End of Life:
This can be a highly effective in assessing the health of an arrester if the original values known. If this test is done routinely, and the data stored it could be use as a better predictor. If several arresters are tested of the same vintage and model, this test method becomes more predictive.

Use Energized:
This test can only be done when the arrester is energized.

Test While Installed:
This test method requires at least partial removal from the circuit.

Test While Uninstalled:
This is the preferred method.

Remote Sensing:
Not likely.

Initial Cost:
500-30,000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Watts Loss at Uc or MCOV

Return to Comparison Table

All metal oxide arresters without gaps demonstrate some level of losses at their operating voltage Uc or MCOV. This loss is relatively low and constant over the life of an arrester. If the arrester is unhealthy and near end of life due to some internal or external failure in process, this measurement will reflect that. The major issue with this method is that the arrester needs to be energized at its operating voltage to be most useful. If previous values have been measured and recorded, this data is highly valuable.

Sensitivity to Arrester Health:
Since this characteristic of an arrester is directly related to its resistive leakage current, it is highly accurate method to assess the health of an arrester. It is best if previous values are known and can be used to compare to the present values.

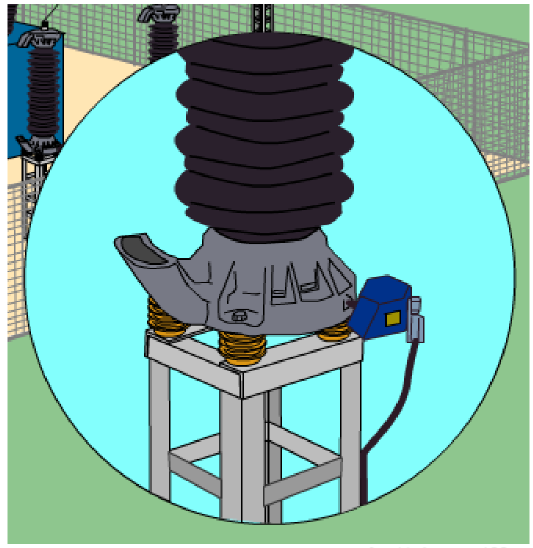
Informative:
Since this is related to resistive leakage current, this measurement is highly informative as is the leakage current.

Versatility:
This is not a versatile test because it needs preplanning to perform, needs a high voltage source, and needs special equipment installed in some cases.

Speed of Use:
If the sensors are previously installed, this method is very rapid. If the data is not automatically transmitted to a central point via some method, it can be rapidly collected with special equipment.

Ease of Use:
With the proper training any line personnel can use this type of equipment.

Reliable Predictor of End of Life:
This is the most reliable means of predicting the end of life of an arrester if historical data is kept on the unit. A long term change in the watts loss of an arrester is one of the most sensitive characteristics of an arrester's health



Graphic Courtesy ABB

Use Energized:
If the test equipment has memory, then the data from this type of transducer can be downloaded even if the arrester is de-energized.

Test While Installed:
This is the preferred state when performing a survey of a set of arresters using this test method.

Test While Uninstalled:
This testing can be done when uninstalled as long as it is energized by a source capable of supplying enough voltage to reach the Uc or MCOV of the arrester.

Remote Sensing:
Since the data is digital, this can be transmitted to a remote location.

Initial Cost:
500-20000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Watts Loss at Less Than 50% of Uc or MCOV

Return to Comparison Table

This is a popular means of testing arresters that have been uninstalled. It achieves its popularity since it is the only convenient means to test a de-energized arrester above 25kV outside of a lab environment. However it is only useful if previous data has been collected on the same arrester or similar models of arresters. The closer the arrester Uc or MCOV is to the test voltage the more accurate the data.

Sensitivity to Arrester Health:
If the test voltage is in the 10kV range and the Uc of the arrester is 100kV this test method is highly inaccurate unless the arrester is very near end of life. If long term data has been collected on an arrester, this test method can become accurate enough to assess the health of the unit.

Informative:
The information is relatively un-useful without previously collected data to compare with. If a large sample set of similar models are tested, this data can also be very informative.

Versatility:
This type of test equipment is quite versatile and often used for measuring dielectric strength of other equipment

Speed of Use:
This is a time consuming method since the arresters need to be disconnected from the circuit at a minimum.

Ease of Use:
This type of equipment is not difficult to use, but training is necessary.

Reliable Predictor of End of Life:
This is a good end of life predictor if the unit has a long history of data collected on it.

Use Energized:
The equipment must be energized by the tester along, and not the system voltage.

Test While Installed:
Can only be tested if partially or fully uninstalled.

Test While Uninstalled:
This testing can be done when uninstalled.

Remote Sensing:
Not likely since the arrester needs partial un-installation.

Initial Cost:
Up to 20000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Ohmic or Resistance Measurement

Return to Comparison Table

This is a means of determining if an arrester is shorted or open. It cannot tell anything else about the health of the tested arrester. This is not a recommended test method by most arrester manufacturers.

Sensitivity to Arrester Health:
Highly inaccurate in offering information about the health of a functioning arrester. It can be used to determine if the arrester is a short and failed.

Informative:
This test method can only tell if the arrester is a short or open. It cannot determine the health of a functioning arrester.

Versatility:
Very versatile, but does require that at least one end of the arrester be uninstalled.

Speed of Use:
This is a time consuming method since the arresters need to be disconnected from the circuit at a minimum.

Ease of Use:
This equipment is very easy to use.

Reliable Predictor of End of Life:
Can effectively tell if the arrester has failed, but not a health predictor of a functioning arrester.

Use Energized:
Cannot be used while the arrester is energized.

Test While Installed:
Can only be tested if partially or fully uninstalled.

Test While Uninstalled:
This testing can be done when uninstalled.

Remote Sensing:
Not likely since the arrester needs partial un-installation.

Initial Cost:
Up to 1000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Surge Counters and RMS Current in mA

Return to Comparison Table

Leakage Current with mA Meter

This is a carryover from the Gapped Silicon Carbide Arrester era. It is of little value in assessing the health of a MOV type arrester. By the time current is high enough to register on the mA meters, the arrester fails rapidly thereafter.

Sensitivity to Arrester Health:
Highly inaccurate in offering information about the health of a functioning arrester. The readout is generally showing the total current which is dominated by the capacitive current. Capacitive current does not change relative to the health of an MOV type arrester.

Informative:
No information until very near the end of life.

Versatility:
Non-versatile since it needs installation into the base of the arrester.

Speed of Use:
Fast since it has to be built in.

Ease of Use:
This equipment is very easy to use.

Reliable Predictor of End of Life:
Not a predictor of a functioning arrester at all.

Use Energized:
Cannot be read if the arrester is de-energized

Test While Installed:
Can be used while the arrester is installed

Test While Uninstalled:
Cannot be read if the arrester is de-energized

Remote Sensing:
Routinely sensed remotely.

Initial Cost:
Up to 1000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Surge Counting

This test method is a carryover from the Gapped Silicon Carbide Arrester era. It is of little value in assessing the health of an MOV type arrester. MOV arresters do not have a limited number of surges before failure.

Sensitivity to Arrester Health:
Highly inaccurate in offering information about the health of a functioning arrester.

Informative:
No information regarding the life expectancy

Versatility:
Non-versatile since it needs installation into the base of the arrester.

Speed of Use:
Fast once it is installed in the arrester base.

Ease of Use:
This equipment is very easy to use.

Reliable Predictor of End of Life:
Not an end of life predictor of a functioning arrester.

Use Energized:
Can be read if the arrester is de-energized

Test While Installed:
Can be used while the arrester is installed

Test While Uninstalled:
This testing can be done when uninstalled.

Remote Sensing:
Routinely sensed remotely.

Initial Cost:
Up to 1000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Arrester Sparkover

Return to Comparison Table

This is a carryover from the Gapped Silicon Carbide Arrester era. It is of little value in assessing the health of an un-gapped MOV type arrester but can be used for a gapped MOV arrester. If it is used on a gapped silicon carbide arrester, it can offer good information about the arrester. This type of test is only available for arresters with Uc or MCOV less than 34kV.

Sensitivity to Arrester Health:
Can be an accurate means of assessing the health of a gapped arrester. If its sparkover has changed significantly, it may be in danger.

Informative:
Sparkover level information is indicative of the health of a gapped arrester. A larger sample set is best.

Versatility:
Not versatile since the arrester must be uninstalled to use.

Speed of Use:
Fast once the arrester is uninstalled.

Ease of Use:
This equipment is very easy to use.

Reliable Predictor of End of Life:
Cannot predict the life, but can determine if the arrester is different than others and considered for removal

Use Energized:
Cannot be used if the arrester is energized

Test While Installed:
Cannot be used while the arrester is installed

Test While Uninstalled:
This is the preferred state of the arrester when tested with this method.

Remote Sensing:
Not likely

Initial Cost:
Up to 1000 USD

Maintenance Cost:
No maintenance is necessary, but the equipment must be handled with care.

Definition of terms used in the Analysis of Test Methods

Return to Comparison Table

Sensitivity to Arrester Health:
Sensitivity refers to how accurately the specific measurement type assesses the health of the unit. A healthy unit would be as it operated when initially installed.

Informative:
When testing an arrester, many characteristics can be measured, Watts, Temperature, Difference in Watts at different voltages, third harmonic currents, how all the afore mentioned characteristics have changed recently, max temperature, min temp in last selected time period.

Versatility:
A most versatile test method would be where the same tester could be used for all voltage ratting without setup changes. A least versatile tester method would be when significant setup was required when changing type or rating of arrester to be tested. Also movement from one location to another is part of versatility

Speed of Use:
How quickly is there an output regarding the health of an arrester once it is desired?

Ease of Use:
Does this type of test require an advanced degree in testing techniques or can anyone use and understand

Reliable Predictor of End of Life:
This attribute is about predicting the probability of a failure.

Test while installed:
Can this test be performed when the arrester is still installed in the circuit. Energized or not. Answer is

Test when Uninstalled:
Does the arrester need to be disconnected from the circuit when being tested.

Tested when Energized:
Verifies if the arrester needs to be electrical energized for this particular test to be valuable.

Remote Sensing:
Can this test result be transmitted to a remote site for monitoring?

Initial Cost:
Is the basic cost of the test equipment high or low. Low is

Maintenance Cost:
If this applies, how much does it cost to keep the equipment in good operating condition? 10 is nothing, and 1 is more than 1% of initial cost. Does the test need to be carried out while the unit is energized. Weather in or out of the system

ArresterFacts are a compilation of facts about arresters to assist all stakeholders in the application and understanding of arresters. All ArresterFacts assume a base knowledge of surge protection of power systems; however, we always welcome the opportunity to assist a student in obtaining their goal, so please call if you have any questions. Visit our library of ArresterFacts for more reading on topics of interest to those involved in the protection of power system at:

About the author:

Jonathan started his career after receiving his Bachelor's degree in Electronic Engineering from The Ohio Institute of Technology, at Fermi National Accelerator Laboratory in Batavia, IL. As an Engineering Physicist at Fermi Lab, he was an integral member of the high energy particle physics team in search of the elusive quark. Wishing to return to his home state, he joined the design engineering team at McGraw Edison (later Cooper Power Systems) in Olean, New York. During his tenure at Cooper, he was involved in the design, development, and manufacturing of arresters. He served as Engineering Manager as well as Arrester Marketing Manager during that time. Jonathan has been active for the last 30 years in the IEEE and IEC standard associations. Jonathan is inventor/co-inventor on five US patents. Jonathan received his MBA from St. Bonaventure University.

Jonathan Woodworth
ArresterWorks'
Principle Engineer

www.arresterworks.com
jonathan.woodworth@arresterworks.com
+1.716.307.2431