

VACUUM BOTTLE CIRCUIT BREAKER

Application and Testing Guide



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Vacuum Technology Introduction

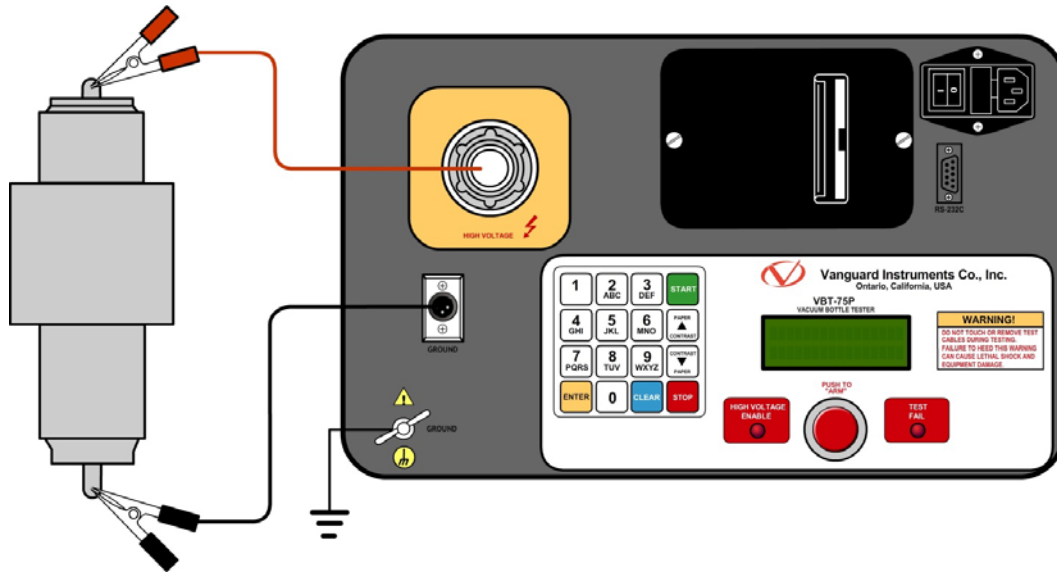
Vacuum technology has been in existence for over 60 years but has only become common since 1965 when Eaton and Toshiba introduced the first vacuum interrupters for commercial service. These interrupters, or bottles as they are commonly called, are employed by manufacturers such as Eaton Cutler Hammer, Square D, GE, ABB, and Rheinhausen. They are used in everything from motor starters to circuit switchers. In the utility industry, the most common applications are circuit breakers, re-closers, capacitors, and line switches. Their main features are high reliability, excellent switching capabilities with long electrical and mechanical life, short contact operating stroke, very low contact resistance, no arc, flash or noise, and low current chopping characteristics.

The Importance of Vacuum Interrupter Testing

The vacuum interrupters in vacuum breakers do not last forever. Leakage starts after years or decades and the air finds its way in the interrupter, making the breaker unreliable. In most cases, the leakage process is rapid once it has started. In addition to leakage, dirt on the poles and on the exterior surface of the interrupter can make it unsafe during operation. Both AC and DC vacuum interrupter testers can be used to test the integrity of vacuum breakers. The electrical resistance of the vacuum in a breaker has an identical behavior for AC and DC high voltages. AC testing of a vacuum interrupter requires high current due to the capacitance of the breaker. An AC high pot tester for the vacuum interrupter should be able to deliver up to 8-10 mA of current per interrupter. This makes AC test instruments quite bulky and heavy. The resistive component of DC current is very small compared to AC component which makes DC test instrument very light and field portable. DC testing of a vacuum interrupter is suitable for diagnostics of all potential sources of dielectric malfunction of a vacuum breaker in the field where using AC did not add any additional information. Vanguard offers two instruments, VBT-75 and VBT-75P for testing vacuum interrupters. Both instruments are lightweight and test vacuum interrupters by applying DC high voltage.



Vacuum Interrupter Testing Methodology



For testing personnel, the design of the bottle is of little concern until it is time to test or replace one. At that time, understanding vacuum interrupter technology becomes more important. Two reference sources are ANSI/IEEE C37.60 for production testing and C37.61 for maintenance testing. NETA uses these standards as a reference in MTS-2005 in the specifications for in-service testing of vacuum interrupters installed in electrical equipment. The industry guide for selecting the test voltage for testing vacuum bottles is shown in the table below:

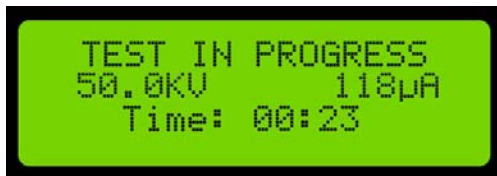
Vacuum Integrity test voltages				
ANSI C37.60	IEC 60694	Rated Power frequency withstand voltage	Field test voltage. 75% of rated power frequency withsatnd voltage AC or DC	
Rated Voltage	Rated Voltage		AC kV RMS	DC kV
	12	28	21	30
	17.5	38	29	40
15.5		50	38	53
	24	50	38	53
27		60	45	64
	36	70	53	74
38		80	60	85

TEST RESULTS	
DATE: 01/09/15	TIME: 07:39:01
COMPANY:	VANGUARD
STATION:	SHOP
CIRCUIT:	15KV
MFR:	ABB
MODEL:	681A308H24
S/N:	9809I82201
KVA RATING:	
OPERATOR:	
TEST VOLTAGE:	75 KV
TEST LIMIT:	300 μ A
TEST TIME:	0:10
LAST MEAS CUR:	98.08 μ A
LAST MEAS VTG:	80.2 KV
TEST PASSED!!	
NOTES:	_____
TEST VOLTAGE:	75 KV
TEST LIMIT:	300 μ A
TEST TIME:	0:10
TEST FAILED!!	
NOTES:	_____
DATE: 01/09/15	TIME: 07:39:43

If DC voltage of equal magnitude to the peak of the AC voltage whose magnitude is 75% of the Power Frequency Withstand Voltage Rating of the circuit breaker is applied and withstood for 1 minute, then the vacuum interrupter has an acceptable level of vacuum and is therefore good.

The DC high pot test voltage is equivalent to an AC test voltage if $V_{dc} = V_{ac} \times 1.414$. When a DC test voltage is used, a high field emission current from a microscopic sharp spot on one contact can be misinterpreted as a sign of a vacuum interrupter filled with air. To avoid a misinterpretation of the test result, the vacuum interrupter should always be subjected to both DC voltage polarities. This means the test should be carried out by reversing polarities. A bad interrupter filled with air will have a similarly high leakage current in both polarities. A good interrupter with a good vacuum level may still have a high leakage current, but this will generally be in only one polarity. An interrupter with a tiny sharp spot on the contact produces a high field emission current only when it is a cathode, not an anode. So repeating the test by reversing the

polarities will avoid any misinterpretation of the result. The test voltage to be used for testing a vacuum interrupter is recommended by the manufacturers of vacuum interrupters.



The VBT-75 and VBT-75P offered by Vanguard instruments can test vacuum interrupters using a pure DC voltage at 10-75 kV in 5 kV steps. The leakage current limit can be set to 100, 200, or 300 μ A. If the interrupter leakage current is less than the set limit

current on the instruments for one minute, then the vacuum bottle is in good condition.

Flashover across the external portion of the VI is commonly due to dirt and contamination and should not be mistaken for a failed bottle. If this should occur, clean the external surfaces and repeat the test. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application, the test specimen is considered to have passed the test.

Safety Notes

Vacuum integrity tests should be performed on each bottle in the open position in strict accordance with the manufacturer's specifications. Do not exceed the voltage stipulated for this test. Do not perform this test unless the contact separation of each interrupter is within the manufacturer's tolerance. Be aware that some high potential test sets use half wave rectifiers to create DC voltage. Such test instruments will stress the vacuum interrupters at a much higher voltage which may lead to the wrong interpretation of the results. The Vanguard VBT-75 and VBT 75P do not use half wave rectifier technology. They produce pure DC output for vacuum interrupter testing.

Vacuum interrupters manufactured in compliance with applicable ANSI standards do not produce X-rays at normal operating voltages. When a high DC test voltage is applied to a vacuum interrupter (above 35 kV) with the main contacts open, there is a possibility that X-rays may be produced. The intensity of the X-rays reduces rapidly with distance from the source, becoming nearly indistinguishable from the background level when a distance of 3 meters or more is reached. Therefore, for all high voltage tests, all personnel should stand at a safe distance from Vacuum Interrupter being tested to minimize the risk of X-ray exposure.

Additional Information Sources

For further information on Vanguard's VBT-75 and VBT-75P vacuum bottle testers, please contact your local authorized Vanguard channel partner or visit our web site at www.vanguard-instruments.com.



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