



**Vacuum Interrupter Testing
Using
Magnetron Atmospheric Condition (MAC)
Test Equipment**

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Reasons for Testing with MAC Test Equipment

History

- The majority of vacuum interrupters were installed in the 1980's and given an original life expectancy of 20 years.
- Vacuum interrupters installed in this period have far exceeded their manufacturer specified life expectancy.
- Failure of a vacuum interrupter could result in unnecessary downtime and damage to surrounding equipment.

Traditional testing methods

- Vacuum integrity Pass or Fail test using high voltage ac test set.
- Not capable of determining level of vacuum inside interrupter.
- Not capable of determining the life expectancy of vacuum interrupters

MAC Testing Overview

- Until recently, lubricating and preventative maintenance were the only means of preserving breaker life.
- The current accepted field service test for vacuum interrupters is a simple Go/No-Go AC Potential Test.
- Vacuum interrupters can catastrophically fail at any time taking many days to clean, repair, and get the switchgear back online.
- MAC testing can prevent unnecessary damage to breaker by predicting usable life of vacuum interrupter.
- This testing has only been available in the assembly plant until now.
- With new flexible magnetic field coils, vacuum interrupters can be tested in place.
- By taking all parameters into consideration, trend to failure can be predicted.

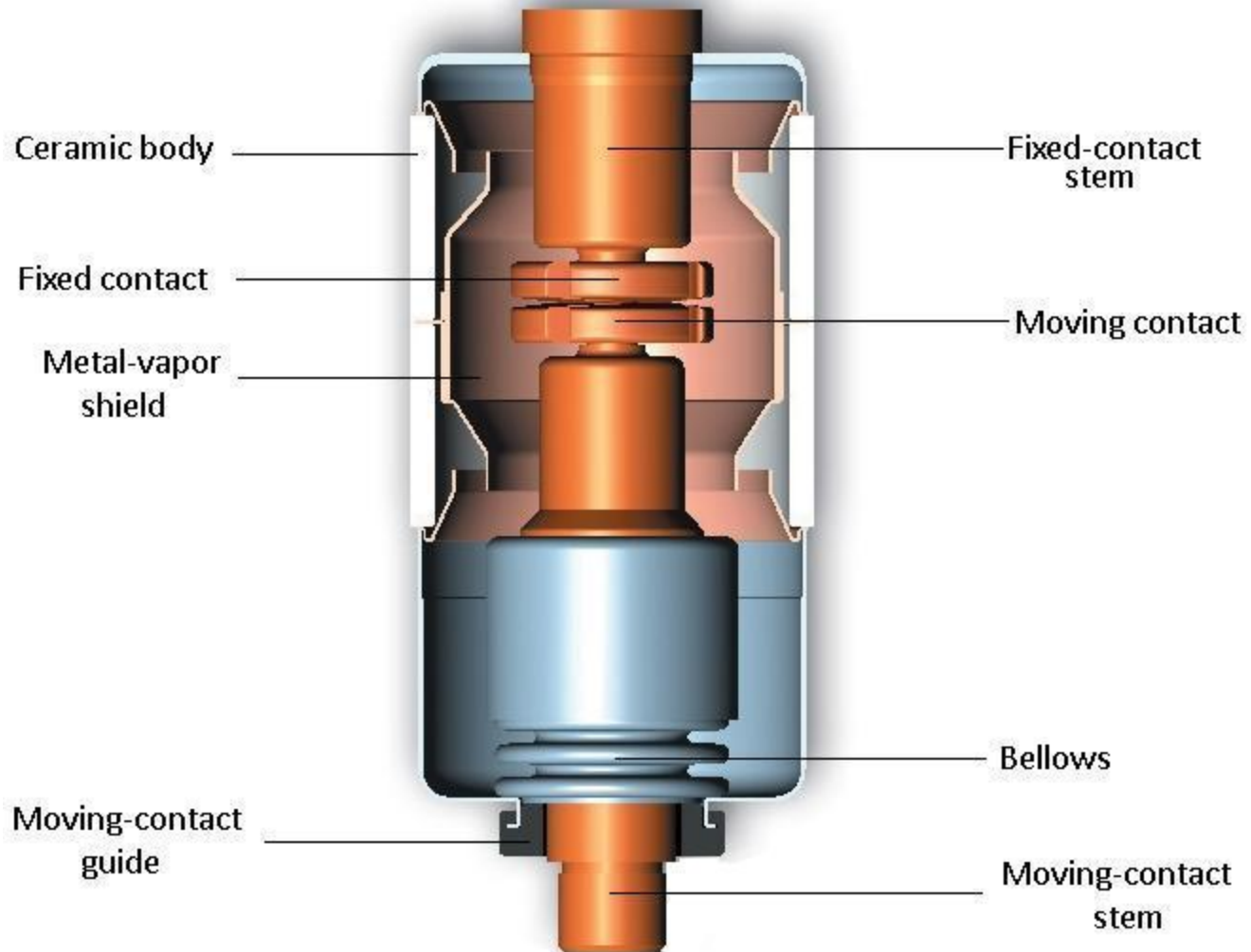
MAC Testing Technology

- MAC vacuum interrupter testers use the Penning discharge principle to determine the level of vacuum inside a vacuum interrupter
- The test results obtained are compared to an "ionization current - pressure curve" that we have determined in our lab for that particular type of vacuum interrupter using a vacuum test system
- The test results are compared to the lab generated curve
- Using this data together with other parameters, trend to failure can be predicted using condition based predictive maintenance

Conditioned Based Predictive Maintenance

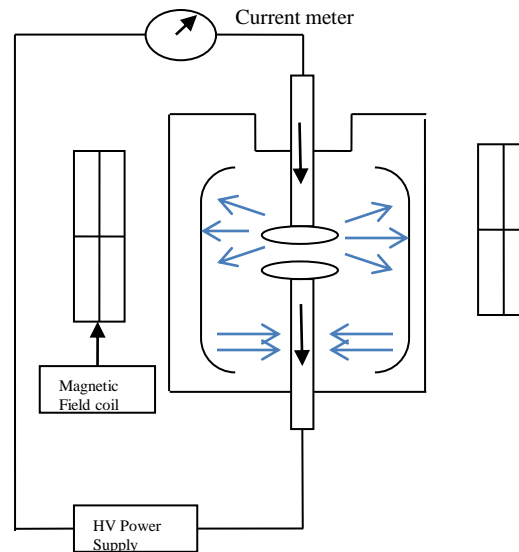
- Breaker type and serial number
- Breaker date of manufacture
- Breaker condition and atmosphere
- Breaker operating conditions
- Number of operations
- Known vacuum interrupter batch or type strengths or deficiencies
- Vacuum interrupter part number and serial number
- Vacuum interrupter wear indication
- Vacuum interrupter contact resistance
- MAC test data
- MAC database trend information.
- Circuit criticality

Typical Vacuum Interrupter

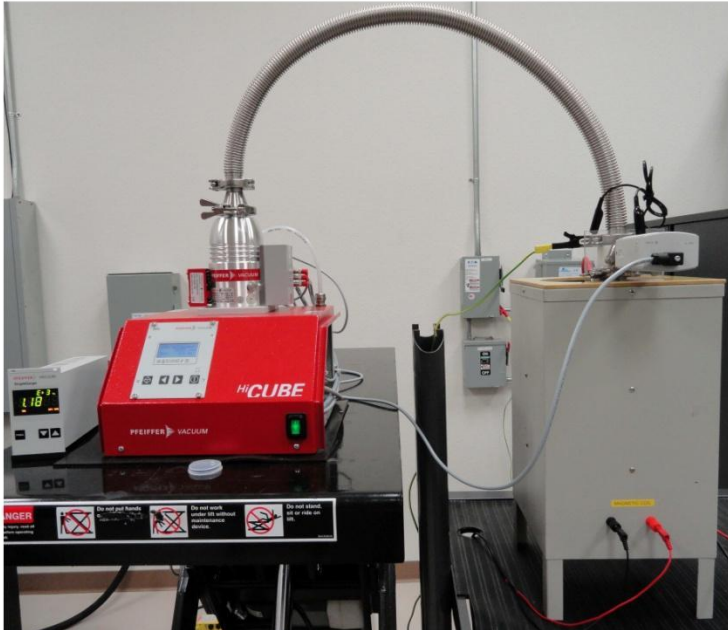


Penning Discharge Principle

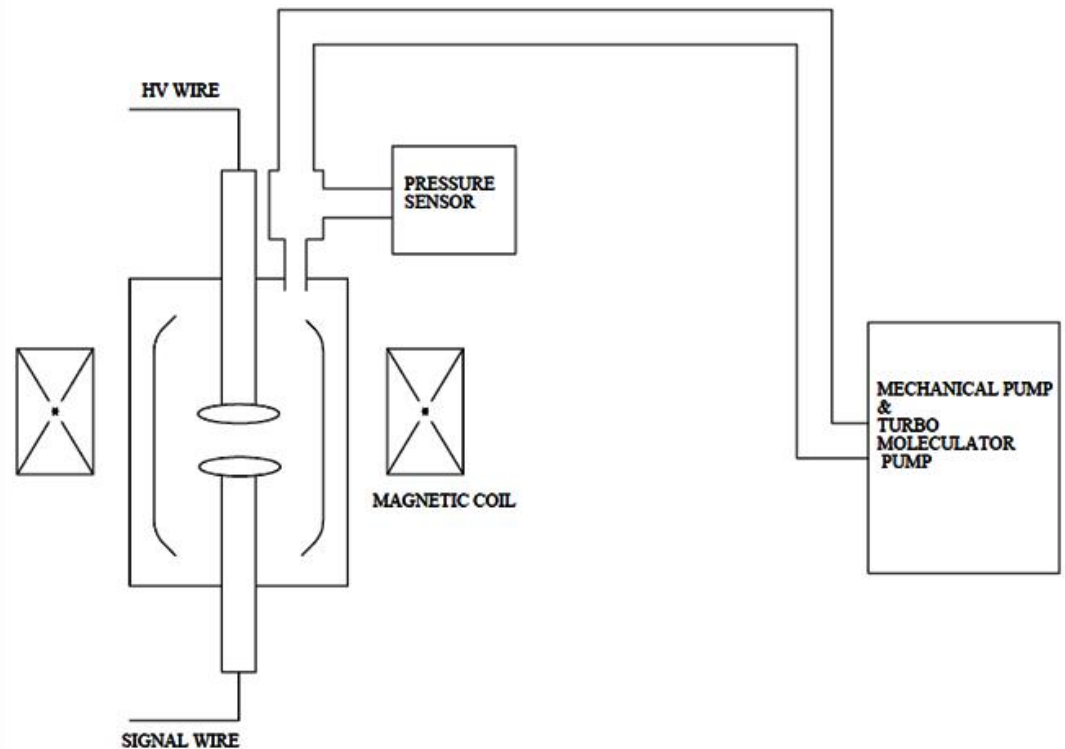
- Charged particles (ions) can be generated from high voltage supplied across an open vacuum interrupter. When a strong magnetic field is applied, these ions will move, thereby, producing a current across the open contacts. This ionization current is directly proportional to the pressure inside the vacuum interrupter. With a known pressure-ionization current curve, the pressure inside a vacuum interrupter can be easily determined through the Penning Discharge principle.



Vacuum Test System



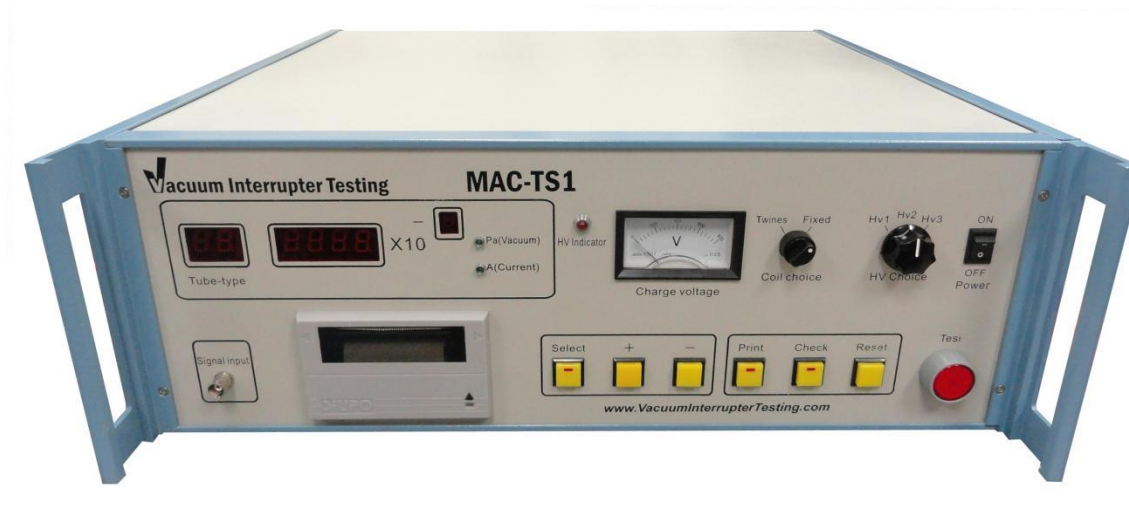
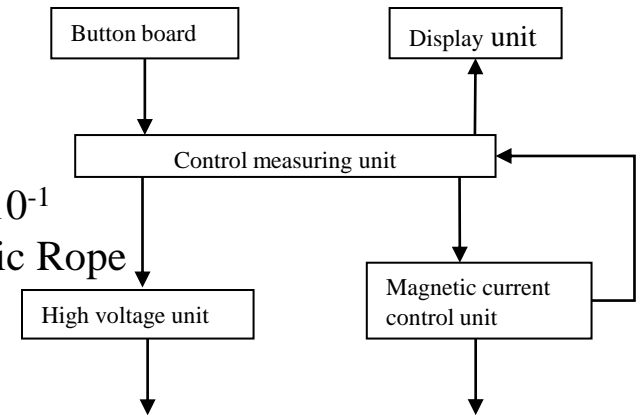
In order to create the ‘ionization current - pressure curve’ for the MAC-TS1 and MAC-TS2 Testers, 40 data points are required for each unique vacuum interrupter within the range 1×10^{-1} Pa - 1×10^{-5} Pa.



MAC-TS1 Test Set - Lab/Shop Use

Technical features

- Light weight unit for lab/shop use
- Measurement range: $1 \times 10^{-5} \text{ Pa} \sim 1 \times 10^{-1} \text{ Pa}$
- Measurement accuracy: $<10\%$ in $1 \times 10^{-4} \sim 1 \times 10^{-1}$
- Uses Fixed Magnetic Field Coil or Flexible Magnetic Rope
- Easy and safe to operate



Magnetic Field Coil

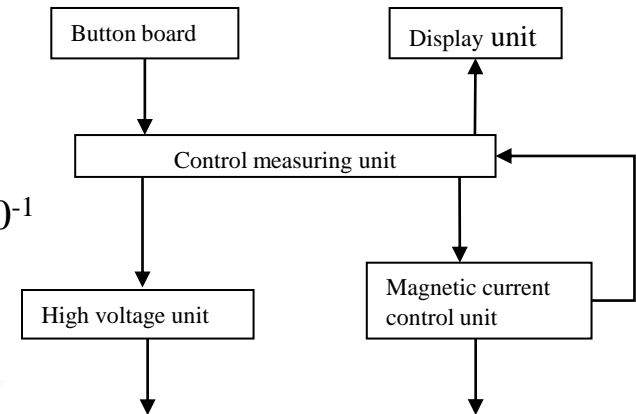
A lab-based magnetic field coil for testing individual vacuum interrupters that have been removed from a breaker or contactor. The coil allows for a consistent, uniform magnetic field and accurate vacuum interrupter condition measurement. The magnetic coils are used in conjunction with the MAC-TS1 tester. The magnetic field coil comes in various sizes to accommodate most vacuum interrupters.



MAC-TS2 Test Set - Field/Shop Use

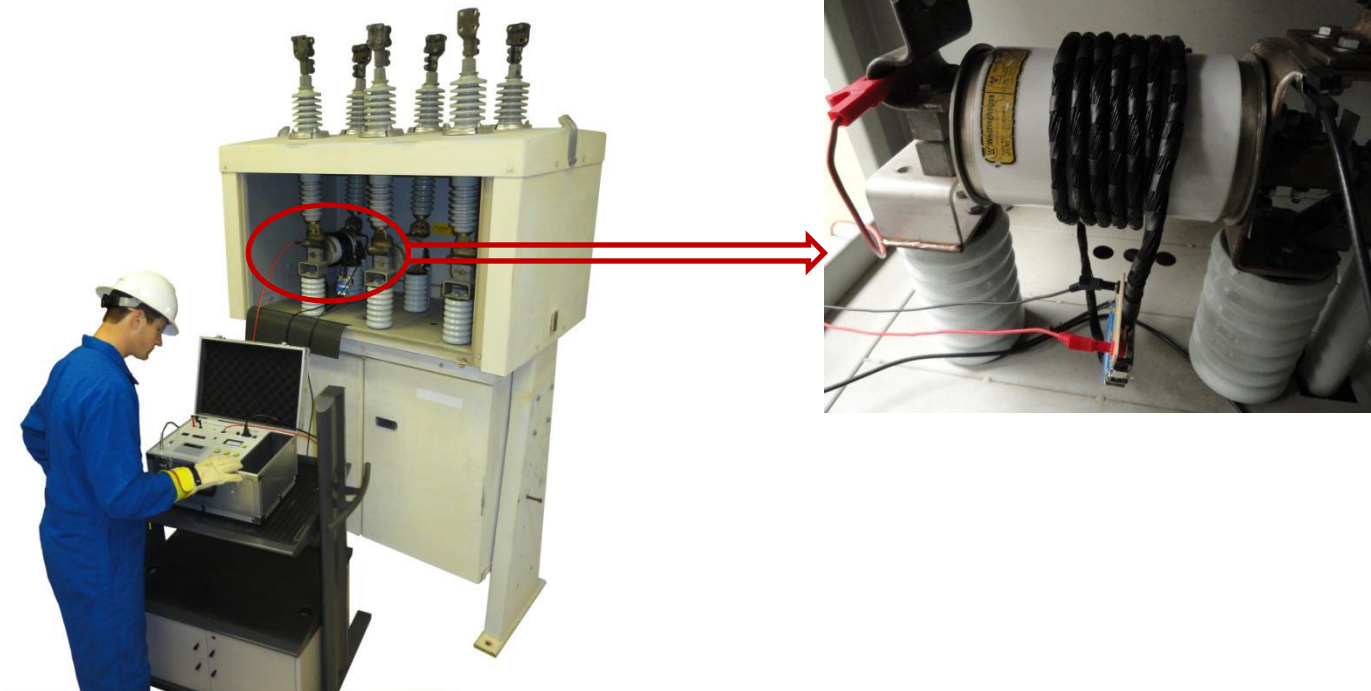
Technical features

- Light weight, portable test set for field or shop use
- Measurement range: $1 \times 10^{-5} \text{ Pa} \sim 1 \times 10^{-1} \text{ Pa}$
- Measurement accuracy: $<10\%$ in $1 \times 10^{-4} \sim 1 \times 10^{-1}$
- Easy and safe to operate
- Operates only with flexible magnetic field coils.



Flexible Magnetic Field Coils

A flexible magnetic coil for testing vacuum interrupters while installed in a breaker or contactor, making it ideal for field use. The flexible magnetic field coils are used in conjunction with the MAC-TS1 or MAC-TS2 test sets. The flexible magnetic field coil comes in various lengths to accommodate most vacuum applications.



Summary

- Vacuum interrupter testing utilizing MAC testers can provide a viable means of determining the condition of vacuum interrupters prior to failure
- When used with the patent pending, flexible magnetic field coil, vacuum interrupters can be tested in-place while installed in your circuit breaker or contactor
- Using condition based predictive maintenance in conjunction with MAC tester data, trend to failure of vacuum interrupters can be predicted

