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Snubbers

Are They Arc Suppressors?

Lab Note #103 — rev C

ABSTRACT

Electric current arcing causes significant degradation of the contacts in electromechanical relays and contactors. This contact degradation drastically limits the overall life of a relay or contactor to a range of perhaps 10,000 to 100,000 operations … a level far below the mechanical life of the same device, which can be in excess of 20 million operations. Product designers, technicians and engineers are all trained to believe that a snubber connected across the contacts of a relay will reduce or eliminate the arcing. While mostly true for low-power applications, they do not measure up to this claim in high-power applications (2A or more).

PROBLEM

Product designers, technicians and engineers are all trained to believe that snubbers reduce or eliminate electrical contact arcing in electromechanical relays and contactors in high-power applications (2A or more).

TESTS

Operate a Tyco T9A open-frame relay switching a Tungsten load at 277Vac, 1.4kW, under three separate test conditions:

- I. With no suppression element
- II. With a typical RC Snubber (ITW QuenchArc, 0.1μF+200Ω) connected across the relay contacts
- III. With a NOsparc MMXac™ arc suppressor connected across the relay contacts

NOTE: The QuenchArc was selected as representative of several RC snubbers used in this test, all of which yielded nearly identical results. Snubber ranges: R=15Ω to 470Ω; C=0.01μF to 0.22μF.

Data is collected using an oscilloscope connected to a differential voltage probe across the relay contacts and a high speed current probe to measure the current through the contacts during operation under load. Fig 1. is a diagram of a typical contact protection arrangement without arc suppression. Fig 2. is a diagram of a typical contact protection arrangement with arc suppression. The box labeled “Load Switching Control Device” in both Fig. 1 and Fig. 2 represents a process control relay whose arc is being measured.

The high operation speed allows the relay to act as a spark-gap generator, facilitating emissions data capture. Emissions yielding arcing occurs as the relay contacts cycle through the four distinct states shown in Fig. 3:

1. **CLOSED**
2. **BREAK** (transition state from closed to open)
3. **OPEN**
4. **MAKE** (transition state with “bounce” from open to closed state)

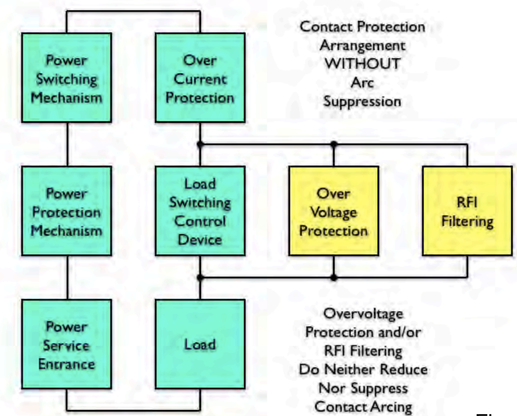

Fig. 1

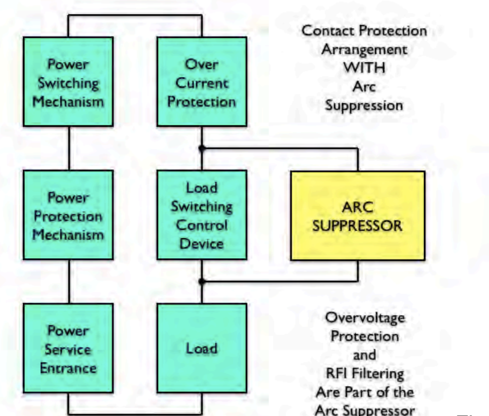

Fig. 2

Relay Contact State Table

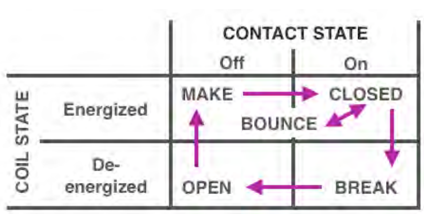

Fig. 3

There are two distinct arcs during the MAKE state: the first is the initial dielectric breakdown (Make Arc), followed-by one or more Bounce arcs until the contacts come to rest in the CLOSED state. The most damaging arc occurs during the contact BREAK state, as it is akin to the process of arc welding. The BREAK arc is measured in this test.

WARNING: Tests use high electrical power, therefore only qualified personnel should attempt to recreate them.

RESULTS

The following figures show oscilloscope data of the break arc for each of the three listed conditions.

- ***Y-axis:*** Current shown by blue line (sinusoidal wave), 2V/div = 5A/div; Voltage shown by red line,10V/div
- ***X-axis:*** Time, 1ms/div
- ***Trigger:*** Externally triggered on the falling edge of the DC coil relay control voltage

Test I

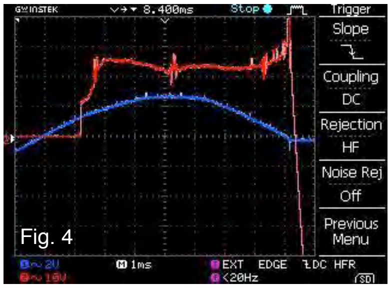

Fig. 4: Without arc suppression the break arc lasts about 7ms as shown, until the current approaches the zero-crossing.

W_{arc0} (unsuppressed arc energy) **≈ 437mJ**

Calculation: $W_{arc0} = I_{arc0} \times V_{arc0} \times T_{arc0}$

Mean $I_{arc0} \approx 2.5A$

Mean $V_{arc0} \approx 25V$

Mean $T_{arc0} \approx 7ms$.

Test II

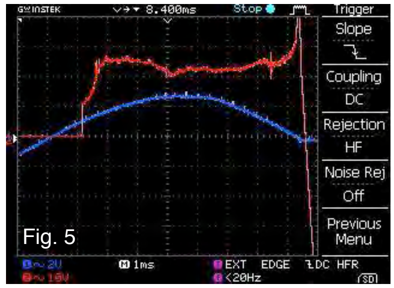

Fig. 5: With a "QuenchArc" snubber across the relay contacts, the break arc lasts about 7ms, until the current approaches the zero-crossing.

W_{arc1} ("snubber'ed" arc energy) **≈ 437mJ**

Calculation: $W_{arc1} = I_{arc1} \times V_{arc1} \times T_{arc1}$

Mean $I_{arc1} \approx 2.5A$

Mean $V_{arc1} \approx 25V$

Mean $T_{arc1} \approx 7ms$.

Test III

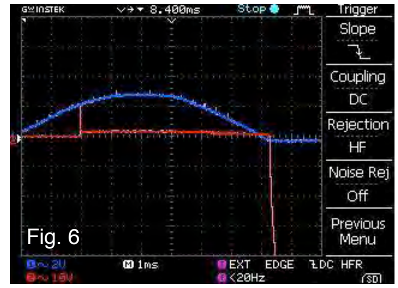

Fig. 6: With a NOsparc arc suppressor across the relay contacts, the break arc is immediately sup-pressed and held for the 7ms until the current approaches the zero-crossing.

$W_{a/s}$ (suppressed arc energy) **≈ 35mJ**

Calculation: $W_{a/s} = I_{a/s} \times V_{a/s} \times T_{a/s}$

Mean $I_{a/s} \approx 2.5A$

Mean $V_{a/s} \approx 2V$

Mean $T_{a/s} \approx 7ms$.

DISCUSSION

Looking at the unsuppressed arc's scope picture in Figure 4, you can almost "feel" the arc burn through the widening contact air gap. Again in Figure 5, you can "feel" the arc; and with the exception of a small decrease in electrical noise, the snubber suppressed arc is nearly identical to that of the unsuppressed arc in Figure 4.

The scope picture in Figure 6 stands in sharp contrast to the previous two. The suppressed arc's energy is aptly shown as a flat line after the arc suppressor detects and arrests the initial *arclet* (a term we've coined to describe the nascent arc formation). Unlike the other energy values, **$W_{a/s}$** (suppressed arc energy) refers to the energy dissipated in the arc suppressor.

"Close-Up" of Arclet

(Note scale change from above:
Y-axis: *Same as previous figures.*
X-axis: *Time, 5μs/div)*

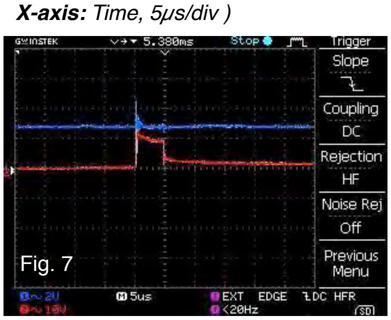

Fig. 7 is a detailed view of the initial "arclet" that triggers the arc suppressor, preventing full arc formation.

W_{arclet} (arclet energy) ≈ 350μJ

Calculation: $W_{arclet} = I_{arclet} \times V_{arclet} \times T_{arclet}$

Mean $I_{arclet} \approx 7A$

Mean $V_{arclet} \approx 10V$

Mean $T_{arclet} \approx 5\mu s$.

Arc Suppression Factor

Arc suppression methods and devices may be compared using an Arc Suppression Factor (**ASF**), measuring the ratio of the arc energy without suppression ($W_{no\ a/s}$) over the arc energy with suppression ($W_{a/s}$) as follows:

$$\mathbf{ASF = W_{no\ a/s} / W_{a/s}}$$

The **ASF** allows arc suppression devices to be compared as follows:

ASF = 1 .... No Effect

ASF > 1 .... Positive Effect (i.e., arc energy is decreased)

CONCLUSION

Snubbers are not arc suppressors! They neither reduce nor suppress the arc across relay contacts as shown in these tests, which can be consistently recreated to calculate respective Arc Suppression Factors of any claimed arc suppressor.

Snubber ASF	NOsparc Arc Suppressor ASF
ASF ≈ 1 ... No Effect	**ASF ≈ 1250 ... Very Significant Effect**
$ASF = W_{arc0} \div W_{arc1}$	$ASF = W_{arc0} \div W_{arclet}$
Mean $W_{arc0} \approx 437mJ$, Mean $W_{arc1} \approx 437mJ$	*Mean $W_{arc0} \approx 437mJ$, Mean $W_{arclet} \approx 350\mu J$*