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ARC SUPPRESSION TECHNOLOGIES

Relay Life

Unsuppressed vs. Suppressed Arcing

Lab Note #107 — rev A

ABSTRACT

Electric current arcing causes significant degradation of the contacts in electromechanical relays and contactors. This contact degradation drastically limits the overall operating life of a relay or contactor to a range of perhaps 100,000 operations … a level representing 1% or less than the mechanical life expectancy of the same device, which can be 10 million, 20 million, or more operations. Arc suppression drastically limits contact destruction caused by electric current arcing. Because the contacts last longer, the operating life of the relay or contactor can be extended much closer to its mechanical life expectancy.

PROBLEM

Product designers, technicians and engineers are all trained to accept specifications when selecting electromechanical relays and contactors. None of these specifications, however, indicate the very serious impact of electrical contact arcing on relay life expectancy.

TESTS

Operate a CIT J115F1 "T9A-style" sealed, non-vented relay switching a resistive load at 240Vac, 5kW, 4 second cycle time, 50% duty cycle, under three separate test conditions:

I. 100,000 cycles with no suppression element
II. 100,000 cycles with a NOsparc arc suppressor* (ASF ≈ 1250**) connected across the relay contacts
III. 1 million cycles with a NOsparc arc suppressor* (ASF ≈ 1250**) connected across the relay contacts

* *A NOsparc MMXac™*

***ASF stands for "Arc Suppression Factor." An ASF = 1 means no effect; an ASF > 1 means reduced arc energy. See Lab Note #103: www.arcsuppressiontechnologies.com/LabNotes.aspx*

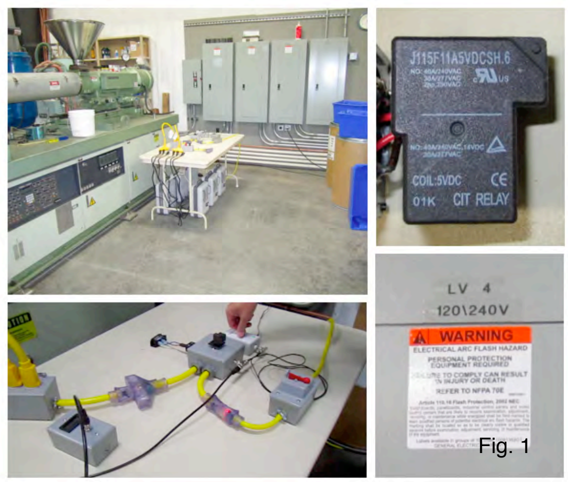

Fig. 1

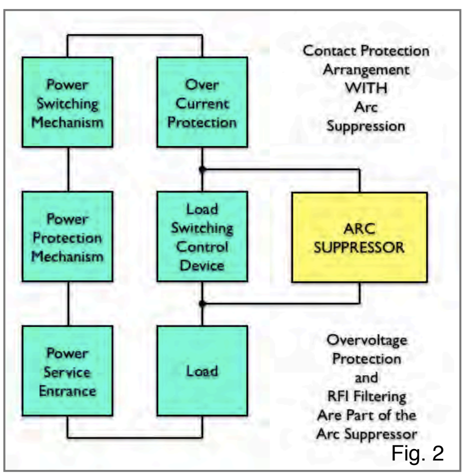

Fig. 2

In the first two tests, relays were run at the above duty cycle up to 100,000 cycles.
In the third test, the relay was run at the above duty cycle to 1 million cycles.

Fig 2. is a diagram of a contact protection arrangement with arc suppression. The box labeled "Load Switching Control Device" represents a process control relay whose arc is being suppressed.

The relay contacts move from open to closed and back in 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)

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. We refer to this arc as the "break arc" and the test specifically measures this arc under the three test conditions.

Relay Contact State Table

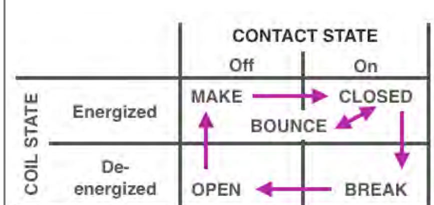

Fig. 3

Testing was performed at Performance Plastics LLC, Amery, WI (Figure 1).

More information on test set-up and conditions may be found in previous lab notes on our website at: www.arcsuppressiontechnologies.com/LabNotes.aspx

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

RESULTS

Results are shown in pictures taken of each relay's contacts upon conclusion of the test.
(Note: The results are best seen when this document is either printed in color or viewed online at www.ArcSuppressionTechnologies.com/labnotes.aspx)

Test I

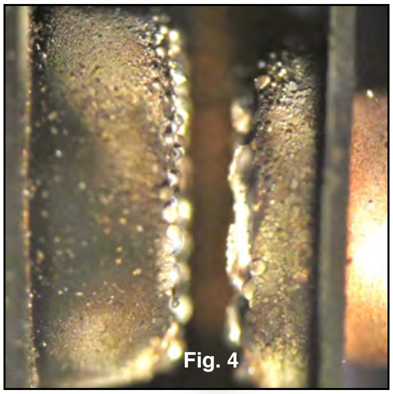

Fig. 4

Fig. 4 is a side view of contacts from a relay operated without any arc suppression element. This relay completed 100,000 cycles.

Test II

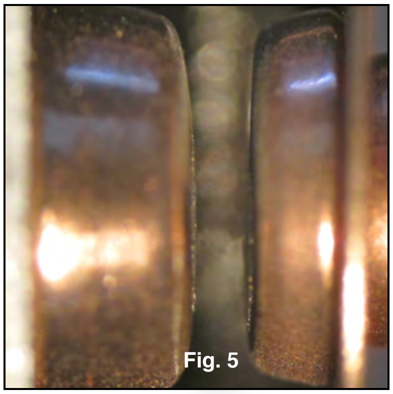

Fig. 5

Fig. 5 is a side view of contacts from a relay operated with a NOsparc arc suppressor across the contacts. This relay completed 100,000 cycles.

Test III

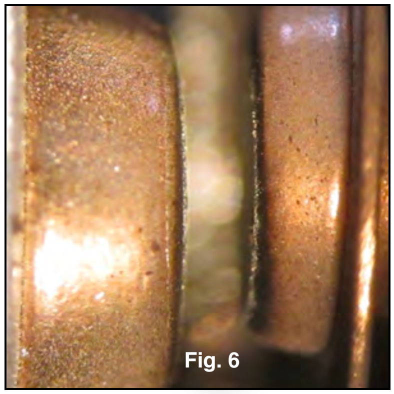

Fig. 6

Fig. 6 is a side view of contacts from a relay operated with a NOsparc arc suppressor across the contacts. This relay completed 1 million cycles.

Unused Baseline Relay Contacts

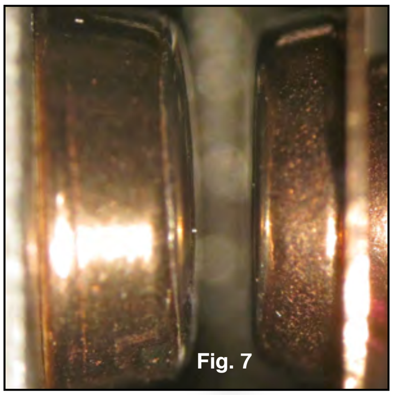

Fig. 7

Fig. 7 shows side and face views of contacts from an unused relay, for comparison with Figs 4, 5 and 6.

DISCUSSION

The unsuppressed relay in Test I completed 100,000 cycles. Figure 4 shows the clearly visible damage from both the heat and current of the electrical arc across the contacts. In addition to the physical contact damage there is also a coating of carbon and other matter that make the contacts almost unrecognizable.

It is important to note that this is the result of a test in which the relay was operated at 50% of its rated current, with only a benign, resistive load.

The relay operated with NOsparc arc suppression in Test II also completed 100,000 cycles, yet the contacts in Figure 5 show significantly less damage. Even the striations on the metal surface of the contact spring are still perfectly visible. The lack of obvious damage is indicative of the arc suppressor's ASF ≈ 1250*.

Notably, the relay in operated Test III completed 1 million cycles which is a feat in itself, as most relays typically have a rated life of only 100,000 cycles. Even more striking is that In spite of this nearly unheard of performance the contacts from Test III show about the same level of wear as those from Test II. This is again indicative of the arc suppressor's ASF ≈ 1250.

Unlike the unsuppressed relay contacts, the suppressed contacts in Figure 6 — even at 1 million cycles — show no discernible cone & crater formation from metal migration. This is a "world's first!"

In terms of operating life expectancy, note that the 4 second cycle time of the test (which is again well inside rated specs) equates to 900 cycles per hour.

Running to the relay's rated End-of-Life of 100,000 cycles in Tests I and II, therefore took just 4.6 days. In sharp contrast, in Test III the relay operated for 46 days!

CONCLUSION

We have run continuous tests over the past two years on relays and contactors both with and without arc suppression. We have also immersed ourselves in prior art patent research, studied white papers and lab notes, and discussed the topic with the brightest industry experts.

Based on all of this, the ultimate conclusion of this Lab Note is that even if one were to operate a suppressed relay to it's mechanical end of life of 10 million or more cycles, it's contacts will never resemble those of an unsuppressed relay at it's rated operating end of life of 100,000 cycles.