ARC SUPPRESSION TECHNOLOGIES

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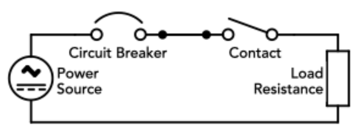
FMEA Mitigation for Electrical Contacts

With NOsparc® Arc Suppression

Application Note #108 — Rev E

Introduction

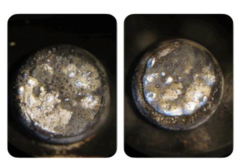
Electromechanical relays, contactors, and switches ("contacts," hereafter) all have an inevitable end of life. While failure is inevitable, it can be pushed into the future using proper mitigation methods. If desired or required, this can be accounted for in a Failure Mode and Effect Analysis (FMEA).



Typical control circuit in which the contacts of a relay, contactor, or other switch is not protected. Unprotected contacts will experience significant arc damage during normal operation.

This inevitable end-of-life is driven by contact destruction from power contact arcing. When operating mechanically (i.e., without current) contacts can operate for 10 million, 20 million or even more cycles. The electrical lifespan (i.e., the actual contact lifespan operating under its rated load current), is reduced to 100,000 operations, 5,000 operations, or even fewer depending on the application and specifications.

The most dramatic end-of-life condition for a contact is failing closed, creating a permanent closed circuit condition, i.e., creating a short. This condition is estimated to occur in less than 45% of contact failures.



Unprotected contacts, failed after operating fewer than 100,000 cycles.

What is FMEA?

Failure Mode and Effects Analysis (FMEA) is a qualitative analysis that involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes, and their causes and effects. For each component, the failure modes and their resulting effects on the rest of the system are identified and documented, allowing for the employment of appropriate mitigation measures.

Select Definitions:

Failure mode—The specific manner or way by which a failure occurs in terms of failure of the item function under investigation; it may generally describe the way the failure occurs. It shall at least clearly describe an end failure state of the item under consideration, i.e., it is the result of the failure mechanism.

Failure effect—Immediate consequences of a failure on operation, function or functionality, or status of some item.

Mitigation—Actions used to lower a risk or justify a risk level or scenario.

Relevance to this application note:

All contacts fail (reach their end-of-life) in time due to the destructive power of contact current arcing.

- *Failure mode*—The most dramatic end-of-life condition for a contact is failing closed.
- *Failure effect*—Creates a permanent, closed circuit condition.
- *Mitigation*—Add a ***NOsparc®*** arc suppressor in parallel across the contact to increase its electrical end-of-life to its mechanical end-of-life.

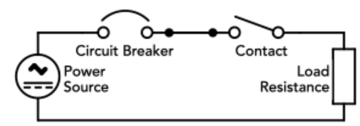
Under normal operating conditions, a ***NOsparc®*** arc suppressor has a significantly longer life than contacts. While the arc suppressor should be a sufficient mitigation for contact failure, its failure can also be mitigated.

- *Failure mode*—The most dramatic end-of-life condition for an arc suppressor is also failing closed.
- *Failure effect*—Creates a permanent closed circuit condition.
- *Mitigation*— Add a single slow blow fuse in series with the arc suppressor terminals to prevent a failure of the arc suppressor from creating a permanent short across the contacts.

Possible Contact Failure Mode (per Naval Sea Systems Command: "Relays" MIL-STD-1346)	Relative Probability
Temporary or permanently assume an open condition between the contact points	55%
Temporary or permanently assume a low, medium or high resistance between the contact points	26%
Temporary or permanently assume a closed condition between the contact points	19%

Problem:
Arc-Caused Contact Failure

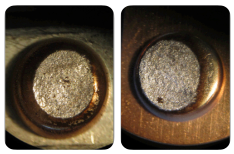
Contacts within relays, contactors, and switches are a well known source of unintentional but predictable contact current arcing (with power sources operating above 12V and 100mA). The destructive power of contact arcing significantly shortens contact life, yielding an operating life for a relay or contactor that is only a fraction of its specified mechanical life (i.e., number of cycles possible when not operating under power).



Typical control circuit in which the contacts of a relay, contactor, or other switch is not protected. Unprotected contacts will experience significant arc damage during normal operation.

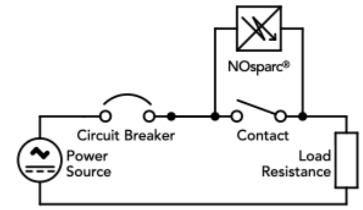
NOsparc® Solution:
Mitigation of Contact Failure

A NOsparc Electronic Power Contact Arc Suppressor connected in parallel with the contact will continuously clean and restore the contact electrodes. This extends the operating life of the relay or contactor to its specified mechanical life (a 10X, 100X, or even greater increase depending on operating conditions).



NOsparc protected contacts, like new after more than 1 million cycles.

NOsparc keeps the contact electrode surfaces in like-new condition via "metallic plasma pressure-washing" during each contact Make and Break transition (i.e., each opening and closing of the contact), reducing electrode material transfer to insignificant levels.

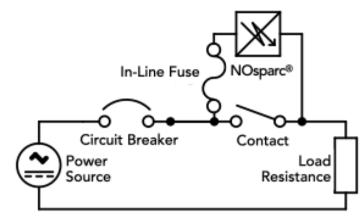


Contacts protected by a NOsparc electronic power contact arc suppressor will last to the mechanical failure of the relay or contactor.

NOsparc® + In-Line Fuse Solution:
Mitigation of NOsparc® Failure

While the likelihood of the NOsparc arc suppressor failing before the contacts is highly unlikely, an in-line fuse connected in series with the arc suppressor terminals provides yet an additional reliability element to the application and for the specific FMEA design of the application.

An in-line fuse will mitigate the failure effect of the arc suppressor by preventing it from presenting a permanent short across the contacts. The in-line fuse does this by opening when a sustained load current flows through the arc suppressor. In the case the arc suppressor fails and the in-line fuse opens, the contacts will operate without arc suppression until reaching their natural electrical end-of-life failure condition.



A delayed action ("slow blow") fuse may be added in series with the arc suppressor terminals to mitigate the unlikely event of an arc suppressor failure, and provides an additional FMEA reliability element to the system design.

Example of a typical in-line fuse.

Note: The ratings of the In-Line Fuse is application specific and must be of the delayed action type (slow blow); and fuse current rating should be 10% for low inrush current loads (e.g., 50Amp heater load @ 5Amp slow blow rated fuse) and 30% for high inrush current loads (e.g., 30Amp motor load @ 10Amp slow blow rated fuse).