7900 INTERNATIONAL DRIVE, SUITE 200, BLOOMINGTON, MN 55425 // 612-928-5546
www.ArcSuppressionTechnologies.com

ARC SUPPRESSION TECHNOLOGIES

Building a Better Interlock

"Wet / Dry" Switching for Superior Performance

Application Note #105 — rev C

INTRODUCTION

The purpose of an interlock is to prevent undesired states in a device or system, especially those states that create unsafe operating conditions for users and/or operating personnel. In most applications, interlocks are either relays or contactors.

Because it is a safety mechanism, the interlock must work. In this application note, we consider high power interlock applications that have low cycle times, high dielectric isolation and low leakage current. For example:

- Power Disconnect
- Battery Disconnect
- Emergency Disconnect
- Safety Disconnect
- Full Load Current Disconnect

The importance of interlock has lead product designers, technicians, and engineers to employ a heavy duty contactor to both carry the operational work load and act as the safety shut-off.

Unfortunately, contact current arcing causes significant deterioration of the contacts during normal operation. This deterioration can cause the contacts to fail when it really counts ... in a safety situation.

DEFINING PROBLEMS

Product designers, technicians and engineers are trained to accept manufacturer 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. This is especially true in high power (over 2Amp) applications.

Many high power interlock applications use a single contactor as a safety shut-off. Over time, however, contact deterioration from contact current arcing can lead to failure of this switch.

Relay and Contactor State Table		CONTACT STATE (NO) OFF		CONTACT STATE (NO) ON
COIL STATE	Energized	MAKE ↑	⇆ Make Bounce	CLOSED ↓
COIL STATE	De-energized	OPEN	⇆ Break Bounce	BREAK

Fig. 1

During normal relay operation, contacts move through four distinct states during each cycle: OPEN → MAKE → CLOSED → BREAK → OPEN, as shown in figure 1. The make and break states are generally transitional and are of generally short duration. The open and closed states are generally non-transitional and are of generally longer duration. A general switch cycle may start with the OPEN state. As part of the MAKE state, the contact may bounce multiple times until it achieves the CLOSED state. A general switch cycle may remain a certain amount of time in the CLOSED state. As part of the BREAK state, the contact may bounce multiple times until it re-enters the OPEN state.

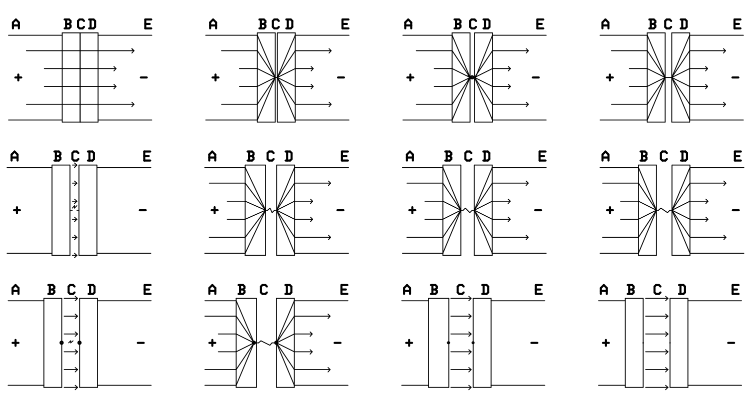

Fig. 2

The most deleterious arcing occurs during the contact break, as the contacts pull apart from CLOSED to OPEN.

Figure 2 shows the stages of a contact breaking event, showing how conditions are created for arc formation in the gap (C) between two contacts (B and D) as current flows from A to E.

Detailed description of figure 2:
Current flowing, current constricting and contact heating, metal melting and pooling, molten wire bridge forming, wire bridge ripping followed by a first dielectric (low voltage) breakdown (spark), ignition of the primary break arc between 9 and 15V, primary break arc burning, primary break arc lengthening, primary break arc extinguishing followed by a secondary (high voltage) dielectric breakdown (spark), ignition of the secondary break arc via a high voltage spike, secondary break arc burning, secondary break arc extinguishing, contact travels to its open position.

SOLUTION

A proper safety interlock design ensure better performance during normal operation, while better guaranteeing successful operation of safety shut-off switches.

An ideal way to address the shortcomings of a single contactor is to replace it with dual contactors or relays: one a “wet” contact switch, the other a “dry” contact switch. During turn off, the wet contact breaks first, the dry contact breaks last (keeping the dry contact free of load current). During turn on, the dry contact makes first, the wet contact makes last (again, keeping the dry contact free of load current).

> ***Dry Contact Switching***
> *The contact is only carrying load current when closed. The contact will not switch the load. The contact will not Make or Break under load current.*
>
> ***Wet Contact Switching:***
> *The contact is carrying load current when closed but in addition/also switching load current during the Make and Break transitions.*

More specifically, the dry contact will provide the high dielectric isolation during the open state of the contact as is required for such safety interlock applications. The dry contact will remain in nearly pristine contact metal surface conditions because it is not experiencing contact arcing due to its dry switching function only.

Single Phase Interlock Contact Arrangement (option A)

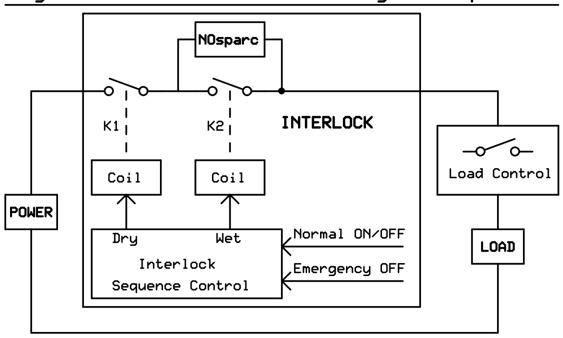

Fig. 3a

Single Phase Interlock Contact Arrangement (option B)

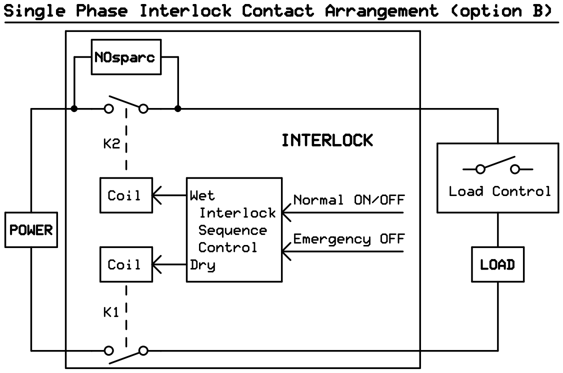

Fig. 3b

The wet contact will have the arc suppressor across it. The wet contact is the heavy lifter in this case. Without an arc suppressor, the wet contact will see deleterious effects from contact arcing. The arc suppressor will protect the wet contact from arcing during the Make and Break transitions.

The Interlock Arrangement consists of two sets of contacts, one wet and one dry (as defined above). The two interlock contacts are sequenced to make sure that:

- The dry contact transitions from Open to Close state (Make) or Close to Open state (Break) without load current flowing through it.
- The wet contact transitions from Open to Close state (Make) or Close to Open state (Break) with load current flowing through it.

The wet contact is not the sacrificial lamb. It just has to work harder and that's why the wet contact has a Two-Port Contact Arc Suppressor connected across it (as shown in figure 2). The wet/dry contact sequencing is as following:

- The wet relay/contactor is K1
- The dry relay/contactor is K2

Interlock transitioning from CLOSED to OPEN => Open K1, wait about 100ms, then Open K2

Interlock transitioning from OPEN to CLOSED => Close K2, wait about 100ms, then Close K1

An interlock sequencing control mechanism must be in place in order to enable this (see figures 3a and 3b)

Note: As per the relay/contactor industry, a contact is not considered failed if it opens (frees itself from the micro-weld) within 999 milliseconds of the de-energization of the relay or contactor coil.

An added safety feature/benefit of this Interlock contact arrangement is that since the dry contact is kept in pristine condition, the dry contact can be used as an emergency interrupt carrying the full load current if needed for it is the more reliable contact since it has been running current free during contact transitions and is thus not subjected to arcing and excessive micro-welding. For the emergency shut-off feature to be implemented an additional "emergency shut-off" signal lead will have to be fed/brought/connected to the electronic or mechanical Interlock Contact Sequence Control.

NOTE: This Interlock Contact Arrangement can be scaled as per the specific requirements of an application.