Allen-Bradley

Vacuum Technology for Motor and Pump Control

Bulletin 500 NEMA Vacuum Combination Starters and Pump Control Panels

This paper examines vacuum technology and provides guidelines that may help in selecting the appropriate contactor for your application.

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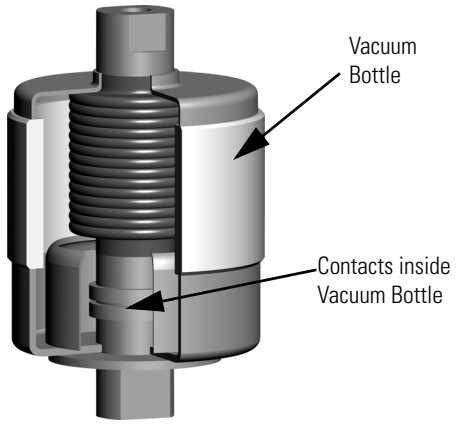
Introduction

As motor control and pump control system reliability for harsh, dirty environments becomes a greater need for End Users, Panel Builders, Contractors and manufacturers alike; many have began taking a closer look at vacuum technology. Vacuum technology is becoming an increasingly viable alternative for reducing downtime in harsh, dirty environments. This white paper will discuss the various elements of vacuum contactor technology and will help guide users towards the appropriate applications for using this product.

Technology Explanation

The most commonly used contactor for motor starter and pump control applications are “air break” contacts, meaning: the “make/break” action takes place in open air. In contrast, a vacuum contactor is a device that contains electrical contacts inside a sealed “vacuum interrupter” called a vacuum bottle. This sealed environment in which the switching takes place allows for a fast, clean “make/break” action of the contacts in harsh, dirty environments. The vacuum bottle prevents the external environment from affecting its operation.

When closed contacts carrying current are separated, the current continues to flow through space, which is observed by the eye as an arc. Any contactor must address the issue of energy dissipation. In the case of harsh, dirty environments the vacuum contactor's sealed vacuum bottle can provide a better environment than free air for breaking the arc. Within the sealed vacuum bottle, the arc burns in the metal vapor of the contact material. Without air to ionize, the arc extinguishes more quickly.



Since the arc burns on the contact, it is important that the material and construction for a set of vacuum contacts is designed to address the arc quenching. Contacts in a vacuum bottle are typically made with a harder material than with air break contacts. For low-voltage vacuum contactors (under 1500V) a dual material alloy is often used, such as WCu (Tungsten Copper) or WAg (Tungsten Silver). This material helps to reduce the possibility of welding. Additionally, the contacts are larger allowing heat to dissipate more quickly. The reduced arc time reduces contact erosion. With minimal erosion and the avoidance of contaminants, the contacts remain clean and dependable.

The speed of the contact separation can affect the contact performance. Contaminated contacts due to dirty, harsh environments may lead to “slow breaking” of air-break contacts after a number of operations. Since the vacuum tube is sealed, the arc chamber does not become exposed to impurities from the application environment.

For motor control and pump control applications in harsh, dirty environments, some manufacturers offer customers Open Type Vacuum Contactors, Vacuum Combination Starters, Vacuum Non-Combination Starters and Vacuum Pump Control Panels solutions.

Allen-Bradley Bulletin 1232V
Vacuum Pump Control Panel

Allen-Bradley Bulletin 1102C
Vacuum Contactor

Allen-Bradley Bulletin 513V
Vacuum Combination Starter

Vacuum Contactor Performance

1. Contact Reliability

The sealed contacts hardened contact material and large contact surface helps extinguish the arc quickly which leads to:

- Consistent contact performance
- Contacts sealed from harsh contamination
- Improved arc extinguishing above 600V —reduces contact wear/erosion.
- Limited re-strike with capacitive loads
- Reduction of arc to ground failure due to the low-ion environment of vacuum bottles (for power rated switching).

Additionally, the contact material and construction helps the arc extinguish quickly, and less damage is experienced.

2. Mechanical Reliability

Within the vacuum chamber, the contacts experience minimal mechanical movement, typically only 0.080 in. The harder contact material and reduced contact movement limit the mechanical wear of the contactor and leads to improved mechanical durability.

3. System Reliability

The design is suited for the specific requirements of inductive load switching for motor load applications. This helps reduce the possibility of insulation failure on downstream motors and transformers in comparison to typical air-break contactors. If a problem does occur with the contact or inside the vacuum bottle, the bottles are replaceable.

4. Voltage Capability

While 1500V is available to the contactor, most users will require a lower line voltage in their application. This can be beneficial in situations requiring a long cable run, along with an appropriate voltage under 1500V. A voltage drop due to power cable length will not affect the circuit, assuming the difference in available supply voltage and applied voltage is great enough.

5. Space Saver

When reviewing larger horsepower contactor designs, the amount of Vacuum contactor panel space is less than when compared to an air break design. The bottle design remains relatively constant throughout the increased size ranges. The vacuum bottle and switching device size hardly changes as current switching rating increases. The dimensions that most vary include the line and load terminals for handling increasing current values associated with higher horsepower. Chart A shows one example of % Panel Space savings (based on panel area footprint.)

Chart A

NEMA Size	% Space Savings*
4	>45%
5	>30%
6	15%
*When compared to a typical air break contactor or equal switching capacity	

6. Overall benefits

- Quiet operation
- Reduced maintenance and down-time
- Long service life

Consideration

- Transient voltages which have DC characteristics are not suitable for switching with a vacuum interrupter due to the shorter gap between the contacts.
- Vacuum contactors are not suitable for use as a holding contact, nor should they be used to bypass a variable frequency drive.

Applications

Whether based on system load or harsh environment with possible contaminants, the vacuum contactor is designed with tough applications in mind. The vacuum contactor design has incorporated specific requirements of inductive load switching for motor load applications. It is also appropriate to use with capacitor and transformer loads. Additionally, applications that experience continuous heavy duty cycling of motors, where reliable motor starting is critical, will likely benefit by using vacuum contactors. This is due to the quick break of the contacts. Vacuum contactors are ideal for meeting the needs of mining, pumping, and other harsh environments. These will often align with environments requiring Type 1, 3R/4/12, 3R, and 4/4X enclosures.

Typical Product Applications:

- Mining
- Oil Well Pumping
- Waste Water Treatment
- Rock Crushing/Cement
- Petrochemical
- Pulp and Paper
- Earth Movers

Conclusion

The sealed vacuum bottles provide many benefits which increase contactor performance. In the appropriate application, the vacuum contactor can be the right choice when reliability is an important factor in motor control and pump control applications located in harsh, dirty environments.

Notes:

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation, Vorstlaan/Boulevard du Souverain 36, 1170 Brussels, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

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