Selecting Gas-Filled Contactors For High-Voltage DC Switching
By TDK Electronics
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As more of our world becomes reliant on high-capacity rechargeable battery power and renewable energy storage, there is a growing need for faster and more powerful DC Switches. Switching high voltages and high currents is a significant challenge when designing equipment with switching functions.

Contactors provide switching capabilities to such equipment. Contactors are required in applications where power needs to be accessed from stored energy, or where power needs to recharge or renew stored energy. This may include electrical and battery-powered vehicles, solar and wind inverters, energy storage systems, aircraft and marine vehicles, personal transportation devices and more.

Contactors are simple, yet heavy-duty mechanical switching relays that are used to switch high voltages and high currents.

For example, every time the ignition is activated in a traditional automobile to start the engine, 12 V from the battery is applied to a contactor that that applies current to a starter motor which starts the vehicle. This starter motor must have approximately 100 A to create the torque required to start the engine. The contactor must then quickly close to preserve the operating life of the starter motor.

The Fundamentals of Contactors
Contactors are relays that provide switching capabilities. They consist of an electromagnetic coil that activate and deactivate switching contacts into different configurations including closed, open and single pole, double throw.

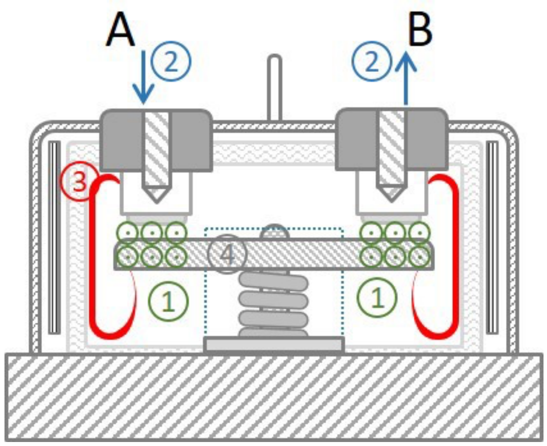
The most significant challenge with contactor contacts is that caused by arcing of high currents within the contactor. When a high current comes in contact with a contactor that opens to allow the current, arcing occurs. Arcing reduces the contactor's operating life as it subjects the contacts to high temperatures, resulting in many issues from melting and burning to loss of reliability. As a result, the contacts within contactors may become derelict, worn or destroyed quickly.

However, arcing can be reduced through the use of a chamber containing the contacts filled with a hermetically-sealed hydrogen gas mixture that quenches the arc. Gas-filled contactors also reduce arcing by optimizing the spacing, size and arrangement of the contacts.

Gas-Filled Contactors
The traditional method has been to use fuses. Fuses simply do not disconnect fast enough and many cannot survive disconnection under a load more than once. While now used as an additional safety measure against high short-circuit currents, fuses have given way to high-voltage, high-current, gas-filled contactors in an increasing number of direct current (DC) applications. Another alternative are solid-state solutions; however, they tend to be too expensive and difficult for practical use in a design.

In alternating current (AC) applications there is no burst-firing (zero-crossing) of voltage and currents that prevents arcing and facilitates quenching. High-power switch such as gas contactors are the only solution available to quench the arc that is created by a DC source.

The design of gas-filled contactors comprises of a moveable armature inside a hermetically sealed, gas-filled chamber. An electromagnet moves the armature and opens the contact to prevent the flow of current. Due to the physics of electricity, an arc always occurs during disconnection from a high DC voltage. As a result, the gas filling in these contactors is used to extinguish and quench arcs, which increases their reliability, durability and arc-quenching capabilities over a longer service life than other contactors. Fig 1. General principle of gas-filled contactor - inside view



1. Direction of Magnetic Field B of permanent magnets used to deflect the arc
2. Direction of Current I
3. Electric Arc
4. Moving Contact Bridge

Gas-filled contactors can solve even the toughest of high-speed switching problems. Not only do they have excellent arc-quenching capabilities, but are known for their increased performance. This is because the reliability and service life of the gas-filled contactor is most often determined by the amount of power dissipated within the contactor.

Applications for Gas-Filled Contactors
The two most basic categories where gas-filled contactors are used include electric vehicle operation and energy production, transmission and storage.

Gas-filled contactors are ideal for application within electric and hybrid-electric vehicles (xEVs). This is because of the need of high-speed, high-voltage battery switching within xEVs. Most xEVs contain at least one contactor that connects and disconnects power from the battery. They are used during startup, when the battery is accessed by any system, and when onboard charging occurs during operation.

Not only are they used during vehicle operation, but also during the charging of vehicles' battery. Fast chargers utilize a high-voltage direct current with heavy current flow to reduce charging time. Gas-filled contactors automatically cutoff current safely, as a fuse or solid-state cutoff would.

High-voltage gas-filled contactors may also be used in solar-panel and wind-power arrays that supply at least 400V of high current to an inverter or group of inverters that convert DC into AC. Such arrays often require significant battery storage with inverters that provide power to transmission lines. Gas-filled contactors may be utilized for any of these switching applications, and, in addition, cutoff the supplied current when actuated, thereby protecting equipment.

Selecting Gas-Filled Contactors
Understanding what features and specifications are required for the application is crucial to selecting the best gas-filled contactor for any application.

The first consideration is size. Newer, more recently designed gas-filled contactors, such as TDK's HVC200a high-voltage contactors, are known for their small size and reduced weight while providing the same reliable high performance switching of larger contactors.

Second, the gas-filled contactor must have the ability to dissipative power in the interior to an absolute minimum when switching high DC voltages and currents. This is especially critical during emergency switch off under heavy load, where they contactor must not fail. If the contactor has this characteristic, the wearing out of contacts will be minimized and the contactor will achieve a long service life.

Third, gas-filled contactors should be hermetically sealed in order to improve both reliability and for use in harsh environments that require fast and reliable high-voltage and/or high-current dc switching. A hermetically-sealed, gas-filled, contactor may be used in a wide range of applications, not just automotive and power/energy. They may be used in industrial equipment and factory automation systems that need contactors to active and deactivate heavy-duty equipment. Such contactors typically exhibit excellent arc quenching properties, and can push the contactors arc cooling mechanism to a maximum, making it safter and more reliable to operate.

Fourth, gas-filled contactors should contain Integrated sensors focused on temperature, voltage and stuck detection.

An integrated temperature sensor not only ensures the safe operation of the device, it identifies and indicates increased temperatures in real-time. In addition, an integrated temperature sensor can help operators identify problematic issues within the system including loose cables or busbars, which may lead to an increase of contact resistance and increased heat.

An integrated voltage sensor allows direct measurement of voltage-drop at the main contact, and stuck detection monitoring will tell the operator if the contactor is stuck.

Each of the solutions in TDK's High-Voltage Contactor (HVC) Series contactors exhibit all of these characteristics and can be used in a wide range of applications where fast and reliable disconnection of high DC voltages is required. For more information, visit https://www.tdk-electronics.tdk.com/en/hvc_presentation