When Safety Matters Most, Monitored Redundant Valves Are the Solution

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A safe manufacturing environment must include a healthy respect for the sometimes dangerous interactions between humans and machinery. This is reflected in the fact that once simple devices such as safety-related valves have evolved and advanced to an amazing level of sophistication.

In pneumatic and hydraulic circuits where the primary concern is the removal of pneumatic or hydraulic energy from a device or system, additional dump or exhaust valves typically are incorporated specifically for this function. Just how critical this valve function is within the circuit, meaning the hazard level, is determined by a risk assessment of the machine.

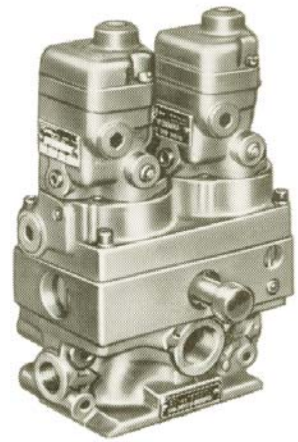
Decades ago, simple electrically-operated, 3/2, normally-closed (non-passing) valves were routinely utilized to help minimize risk during machine operation and servicing. These valves were generally a poppet valve construction (instead of a spool valve) because poppet valves are less apt to stick in the open position due to the poppet's spring and inlet pressure bias to the closed position. Even considering these more robust performance characteristics, however, it is still possible that a poppet valve element could become sluggish or stuck in the partially-open (passing) position. Depending on the machine circuit design, it is possible that such a condition might not be detected during normal machine operation. For instance, if a poppet valve was used as both a dump valve and to supply other control valves, then so long as those other control valves continued to function properly, the machine will function normally even though the dump valve did not remove the stored energy as expected. The exhausting portion of the circuit would not be functioning as it should, yet the operators or maintenance personnel may not be aware of this abnormal condition.


3/2 NC Sensing Valve

To overcome this phenomenon, there were two common approaches. One approach added a monitoring device to the valve, to detect if it functioned improperly. This would typically be a limit, proximity, or pressure switch. Such monitoring devices need to be integral to the valve, designed for safety-related applications, and thoroughly tested. An add-on monitoring device such as this would indeed indicate improper valve function, but still would not help detect or predict an impending valve failure. The valve could still breakdown, thus possibly removing the fail-safe aspects of the circuit, and the monitor would merely indicate that the valve had failed. This may still be an acceptable fail-safe outcome if the risk is minimal but is not generally considered acceptable in high risk situations.

The second approach, then, involves adding a second "redundant" valve in series or parallel to the first valve. The concept of redundancy is that a single valve breakdown would not eliminate the normal operation of the circuit because the redundant valve would perform the required function and maintain the normal operation of the equipment. The potential problem with this approach is that, again, the loss of functionality of a single valve could result in the redundancy being removed from the circuit. Despite having redundancy, the system remains dependant on a single functioning device to perform normal operation and redundancy alone provides no assurance that anyone would be made aware of the loss of redundancy within the circuit, should it occur.

Thus, the next evolution in valve safeguarding practices involved combining these two earlier approaches, and practiced monitoring of the redundant valves. In this case, the loss of functionality of one of the valves would be detected, while the second valve continued to permit normal operation, and the detected abnormality could be addressed and corrected by responsible personnel. Once the failed redundant valve was returned to normal functionality, the redundancy of the circuit would be restored. Despite this benefit, however, there are still other considerations that should be taken into account when conducting a machine safe-guarding risk assessment to determine if monitored redundancy will provide the necessary level of machine safe-guarding.



There are three other considerations to make when conducting a machine safe-guarding risk assessment. The first consideration involves a proper understanding of the flow paths through the valves themselves. If the desired result is to remove the stored energy in a specific time frame, it is important to assure any valve malfunction would not increase this exhausting time. This is especially important when used for stop functions. If the internal components of the valves (in series or in parallel) stop in any open position or slow down during their normal stroke range, the exhausting capability of the valves may be compromised. Compressed air may not be fully exhausted and may continue to be supplied to the system. These modes and crossover conditions within the valves must be known when selecting a valve for a safety-related application. In an effort to address these risk modes, valves with two sets of independent yet integrated elements and crossing flow paths were developed. These double valves have the inlets in series but the exhausts in parallel. This provides an “and” function to the supply portion of the valve elements and an “or” function to the exhaust portion of the valve, which is the optimal situation in a redundant circuit.

The second consideration for a machine safe-guarding assessment is to determine the response time of the valves. A properly-functioning machine safe-guarding system removes stored energy quickly in order to continue normal stopping operation and to avoid a potentially hazardous situation in a timely manner. If stopping time of the machine can be adversely affected by any particular valve malfunction, then it is critical that abnormal valve operation does not increase the machine stopping time. The types of valve malfunctions here can include a slowed valve response time which may result in an increase in the stored energy removal time and an increase in the stopping time of the machine. An increase in stopping time could also reduce the effectiveness of electrical safety devices, such as light curtains, whose correct mounting positions are dependent upon the machine stopping time. If this time is increased, these devices may now be too close to the point of operation creating increased risk to the operator.

Given that valves typically exhibit slower response times prior to outright breakdown, it is advantageous to monitor the response timing of the valves or of the independent valve elements. Furthermore, the response timing must be monitored during energy activation and, even more important, during energy deactivation because that is when the stored energy is actually being exhausted from the system. If a specified response time is exceeded, then the valve has not performed as it was expected to perform in the application. Such a “diminished performance” condition has occurred and should ideally be detected by the valve monitoring system. This monitoring can be internally integrated into the valve or can employ monitoring devices external to the valve. It is important that any external monitoring device’s response timing be taken into consideration during control circuit design.

The final question to consider during a machine safe-guarding assessment is, what happens when an abnormality is detected? For example, the monitor, whether internal or external, has detected that a single element has not worked properly yet the overall system worked properly because of the redundancy of the valves. During the time that the abnormality occurred, however, the control circuit was depending on a single valve or valve element to operate properly. Even though the system was still functional, the benefit of redundancy was not there and as such, the monitoring system should require the valve or equipment's control system to inhibit further operation of the equipment and require an overt act to reset the valve and system.

Through the requirement of an overt act to reset, the abnormal condition is acknowledged by responsible on site personnel, who have the ability to investigate and correct any deficiencies. A valve abnormality that occurs and is automatically reset is un-acknowledged. Re-occurring un-acknowledged abnormalities may be happening with every cycle of the control circuit and remain unknown to operators and maintenance personnel. If this is due to an abnormality in one of the valve elements, the system gradually becomes dependant on a single element functioning properly and the valve redundancy has effectively been removed. It is possible that the machine operation is not affected because the removal of stored energy is occurring as expected due to the single element functioning properly, e.g., we have a normally-functioning machine with a sluggish valve element occurring repeatedly and being automatically reset on every cycle of the valve. This results in the circuit being dependent upon a single element repeatedly. This is unacceptable result for a higher-level safety-related system where accumulation of undetected abnormalities must not lead to the loss of the safety function. The inhibition of equipment's function and the requirement of an overt act to correct the circuit abnormality bring circuit issues to the attention of personnel responsible for investigation, correction and human welfare in the manufacturing environment.

DM2® Series E
Control Reliable Valve

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