High-end intelligent emergency valve applications

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High-integrity pressure protection system valves

Over-pressure protection may be carried out by pressure relief valves or by depressurising systems, as considered in the previous chapter. A different approach to protecting piping and complete processes against overpressure can be provided by introducing High Integrity Pressure Protection Systems (HIPPS). HIPPS is a type of safety instrumented system (SIS), which is designed and built according to safety standards such as IEC 61508 [1] and IEC 61511 [2]. HIPPS is an independently instrumented system, which has typically higher safety integrity than normal shutdown systems. Basically, HIPPS systems act as an isolation barrier between high and low pressure sections of piping or process equipment by shutting down HIPPS valves before overpressure. Therefore, lower pressure class piping and equipment can be used on the downstream side of HIPPS system. This obviously reduces costs. In addition to the commercial aspects, HIPPS provide technical and environmental benefits by improving the availability and reliability of the plant, and minimising flare loads. The main disadvantage of HIPPS compared with pressure relief devices is its greater complexity.

The HIPPS system consists of initiators (pressure transmitters), a logic solver (eg safety PLC) and final elements (shutdown valves). Emergency shutdown ball valves are commonly used in HIPPS applications. Ball valves shown have been evaluated by a third party as being suitable for HIPPS applications up to SIL 4 using a double channel solution. The main advantage of the ball valve over other valve types is reliable operation combined with negligible pressure loss when the valve is in its normal position (fully open). Well-designed ball valves with rigid seats made of the right materials can handle fast stroking times and high pressures.
Valve requirements are basically assessed by safety standards and applications. Depressingur or pressure protection standards, such as API 521, do not indicate additional safety requirements for HIPPS valves on top of IEC safety standards. However, many times high reliability and availability are targeted in HIPPS applications due to consequences in failure on demand and the high cost of a spurious trip.

This typically leads to redundant solutions in the valve sub-system as well as with the instrumentation of single valves. Depending on the application, HIPPS valves may contain partial-stroke devices and/or solenoid(s) and additional instrumentation, such as limit switches and quick exhaust valves or volume boosters, to meet stroking-time requirements.

**Burner valves**

Economic and environmental issues are major challenges nowadays. In industrial thermal processing equipment, low fuel consumption, safety and reliability have become vital. Reliable and safe fuel-line shut-off together with accurate fuel control is essential to meet industry requirements.

A typical burner fuel line consists of two emergency shut-down valves (ESDV) and a flow control valve. In cases where the combined use of a control valve for safety and control service is accepted, voting 1oo2 using an ESDV and control valve can be used. Safety standard IEC 61511 [2] allows the use of a control valve for safety applications in cases where failure of the control valve does not compromise the safety instrumented function of the safety system. In such a case, the flow control valve would be equipped with a solenoid, which is used to provide the safety function.

A positioner controlling the valve’s operation in normal control service shall be connected to the basic process control system and shall not prevent the valve’s ability to provide the safety function. The dual role of the control valve may result in additional requirements, such as tight shut-off and fire safety, beyond standard flow control service. In general, opinions vary as to whether a control valve could be used for both safety and control.

But in practice, the only reasonable way to use a control valve in a safety system is in configurations where the control valve is used as a redundant element, and in those cases the positioner is not part of the safety system and should not be considered in safety calculations.

In order to meet these critical challenges, Metso has developed ESD burner valves that fulfil EN161 / EN ISO 23553-1 [3] as stipulated by the EN746-2 safety requirements for combustion and fuel handling systems. The automatic shut-off valves are designed not only to meet the EN161 and EN23553-1 [1] (formerly EN264) requirements, but also to provide exceptional protection against fire and explosive hazards during the operation of gas- and oil-burning equipment. When a safety function is required, these burner valves close within 1 second to isolate the gas or oil flow. The units consist of a soft-seated ball valve with an actuator, solenoid pilot valve or TÜV SIL3 certified partial-stroke device and safety valve Controller Neles ValvGuard.

The unique, flexible-lip Xtreme seat design makes soft-seated valves bubble-tight and outstandingly durable, even in applications with a high degree of thermal cycling. The ball valves have successfully passed TÜV-type approval tests according to EN161/23553-1 [3] Class A.

**What is intelligence reliability in emergency valves?**

Intelligence in emergency valves is not just putting the intelligent partial-stroke device or intelligent solenoids on top of the valve for safety action. By contrast, intelligence in emergency valves is combining correctly selected and reliable valves with adequate safety factors, together with the added value provided by intelligent valve controllers such as Neles ValvGuard, to achieve the full benefit of intelligence. Even the most inherently reliable valve may not perform well if it is selected for an application for which it is not suitable. A simple example could be the systematic failure caused by an unsuitable seat design for a polymer application that causes valve jamming due to a medium build-up between the seat and the valve body. Such a systematic failure cannot be considered in reliability data.

Instead of this, selecting the valve design correctly with adequate actuator safety factors for the application is the starting point for a successful solution in emergency service. Hence, know-how of valve challenges together with systems, safety standards and applications is an important factor in the emergency valve solution. The target should be a technically as well as commercially ‘fit-for-purpose’ solution without over- or under-engineering.

Ball valves would provide additional benefit by offering a possibility to do partial stroking within the dead angle without flow passage through the valve in fail open cases such as emergency depressurising. Intelligent partial-stroke testing could be automatically initiated through the DCS or SIS system. With the inbuilt diagnostic capabilities of the intelligent safety valve controller, the performance of the ball valve in depressurising or blow-down applications would be tested with high diagnostic coverage during process uptime without additional isolation valves. Improved average probability of failure on demand brings additional flexibility for proof test intervals and may in...
crease plant uptime due to targeted safety integrity being maintained for longer test intervals. The best diagnostic tools in safety valve controllers could even see trends, such as load factors, predicting future performance and warning users automatically without manual work of failures, for example, valve stiction. While making life easier with emergency valves, an intelligent partial-stroking device saves labour and, regardless of fail open or close system, it improves the safety of the plant by revealing failures in the complete valve assembly that would otherwise remain hidden. Intelligent partial stroke devices with modern asset management systems also give the end-user an opportunity to plan his maintenance activities better and base them on tested results in addition to general guidelines.

In the case where redundant main safety elements (i.e. a solenoid or partial-stroke device) are used, the intelligent valve controller would provide additional reduction of common cause failures since the intelligent partial-stroke device is of a different type than normal solenoids valves. Therefore, this triggers lower common cause failures than with two solenoids. In some cases, one intelligent partial-stroke device may replace two redundant solenoids and still meet the safety requirement in single valve solutions. The best of safety valve controllers can test their safety function automatically without the risk of spurious trip by using an inbuilt testing procedure with self-diagnostics. This is done in a controlled way without time delay. It is important that testing a function of a main safety element is provided with an inbuilt system, and not by utilising an external method such as a pulsing solenoid with the signal coming from the SIS system. Such a method is complex, would require additional software work, and increase the risk of spurious trips, since uncontrolled time delays in external pulsing may cause unwanted movement of the valve. In addition to increased risk of a spurious trip, excessive rapid pulsing of the solenoid externally may enhance the risk of coil burnout failures in the solenoid.

In the case of an emergency trip occurring, further studies may lead to questions about the performance of the emergency valve during the trip: for instance, what was the stroking time? Valve diagnostics in modern safety valve controllers such as Neles ValvGuard are also available during the emergency trip. Some may have features to provide full-stroke testing with inbuilt diagnostic information, which can be used as a proof test for emergency valves during shutdown periods. In addition to testing, a test report can easily be generated with the help of asset management software. Hence, intelligent valve controllers would provide added value, even without partial stroking.

Safety integrity

The high-end emergency valve applications discussed are safety instrumented systems, which should be designed, installed and maintained according to the principles of IEC61508/61511 [1,2]. The standard has two fundamental concepts: the safety life cycle and safety integrity level (SIL). Reliability (or SIL) calculations are typically performed during the design evaluation phase of the safety life cycle for each safety-instrumented function (SIF). This may contain some preliminary base analysis cases with generic reliability data and then re-evaluation by using data from selected vendors. The result of SIL calculation includes, for example, an average probability of failure on demand (PFD) for low demand mode applications. The SIL shall be calculated for the complete safety loop, but PFD and suitability for the SIL safety-related system can be evaluated individually also for subsystems, such as the final element subsystem.

High-end final elements, such as the valves discussed in previous chapters, may contain rather complex instrumentation to meet strict reliability and availability requirements. The reliability verification of the final elements can be done easily by using Metso’s SIL calculation tool in an early phase of the project. The software is able to verify the SIL capability and PFD value, even for relatively complex final element subsystems, taking care of complete valve assembly and including all necessary safety related accessories by using accurate field proven reliability data.

Conclusion

Intelligence in emergency valves is combining correctly selected and reliable valves with adequate safety factors and the added value provided by intelligent valve controllers to achieve the full benefit of valve diagnostics. In the case where redundant solenoids are used, common cause failure can be reduced by replacing one of the solenoids with an intelligent valve controller. Sometimes two solenoids could be replaced by one intelligent partial-stroke device, including an inbuilt solenoid, and still meet the safety requirements. Partial stroking improves the final element PFD value, which brings additional flexibility for proof test intervals and increases plant up-time. While making life easier with emergency valves, an intelligent partial-stroking device saves labour and, regardless of fail open or close system, it improves the safety of the plant by revealing failures in the complete valve assembly that would otherwise remain hidden.

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