INCREASING PLANT AVAILABILITY **AND COST EFFICIENCY**

What to note in practice when installing spare relief valves.

Only a plant that runs uninterrupted can achieve maximum cost efficiency. To ensure that the plants are safe, however, any safety equipment that is installed has to be serviced regularly as part of preventative maintenance.

But what should be done if the safety equipment cannot be serviced while the plant is in operation? Switching off the plant is not an option, because plant downtime means major financial losses. This white paper provides solutions for safe and uninterrupted plant operation – even during maintenance of safety equipment.

CONTENTS

1. ENSURING PLANT SAFETY

Safety plays an especially important role in our high-tech world. It is equally important to protect both people and the environment. It therefore stands to reason that maximum safety is especially required for large industrial plants, such as those in factories and in the chemical and petrochemical industry and for plant engineering in the process industry as a whole.

The input materials and intermediate and finished products must be available everywhere in the production process and must also be stored safely. Aboveground and underground tanks and vessels are the most common form of storage. They are connected to production plants via inlet and outlet pipes with the corresponding fittings. The requirements for the materials used in the vessels and fittings are extremely high.

Possible effects of breakdowns are assessed in advance and factored into a detailed plan. Moreover, catching systems have to be planned for possible leaks. This ensures that the media remains stored safely even in the event of fire. A process control system controls and monitors the plant.

1.1 CONTRIBUTING TO COST EFFICIENCY

To improve the cost efficiency of plants in the short term, it often happens that the life cycle is not considered as a whole and inadequate consideration is given to scenarios such as required service and maintenance. However, safety equipment in the process industry is subject to strict rules and standards, resulting in planned downtime, usually every five years.

Industry requirements are moving towards even longer maintenance intervals to further increase efficiency. But if safety equipment has to be overhauled or exchanged due to malfunctions or leakage, unplanned downtime may occur between these intervals.

Unplanned plant downtime therefore leads eventually to major financial losses. For example, if a refinery with an annual revenue of two billion euros goes offline for five days, it causes a loss of 27 million euros. For this reason, uptime and maintenance are important issues to consider when planning or converting a plant, especially in terms of plant availability and cost efficiency.

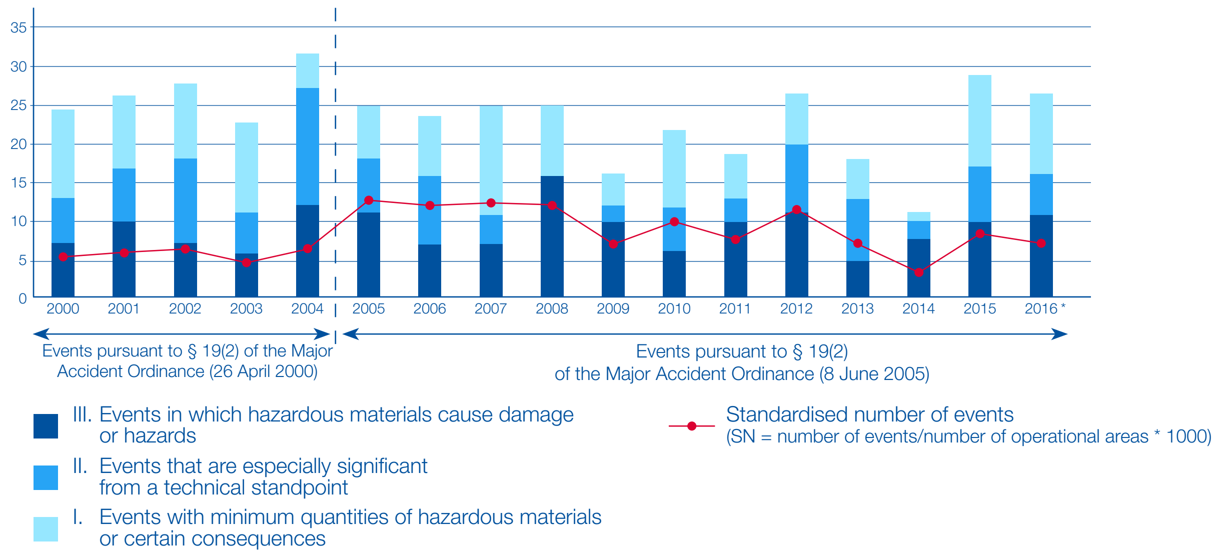
2. INCIDENTS IN CHEMICAL AND OTHER INDUSTRIAL PLANTS

Reports of incidents or multi-day production stoppages often focus the public's attention on the subject of up-to-date safety technology that exceeds widespread standards and technical regulations. Germany's Federal Environment Agency (UBA), for example, reported between 11 and 31 incidents per year from 2000 to 2016. The incidents often involved the release of hazardous substances and even explosions. An incident occurs when a malfunction takes place involving materials as per the Major Accident Ordinance and serious damage is caused to people, the environment or property. The current Major Accident Ordinance was adopted in 2017.

In 2015, a total of 29 reportable incidents occurred in 3,518 operational areas (last updated 30 June 2016).

To enable incident risks to be classified more effectively, the EU introduced what are known as 'operational areas'. An area is classified as an operational area if at least one prescribed quantity of a specific hazardous material is available in a company or could be created in the event of an accident. The legislator has specified the corresponding minimum quantities in the Major Accident Ordinance.

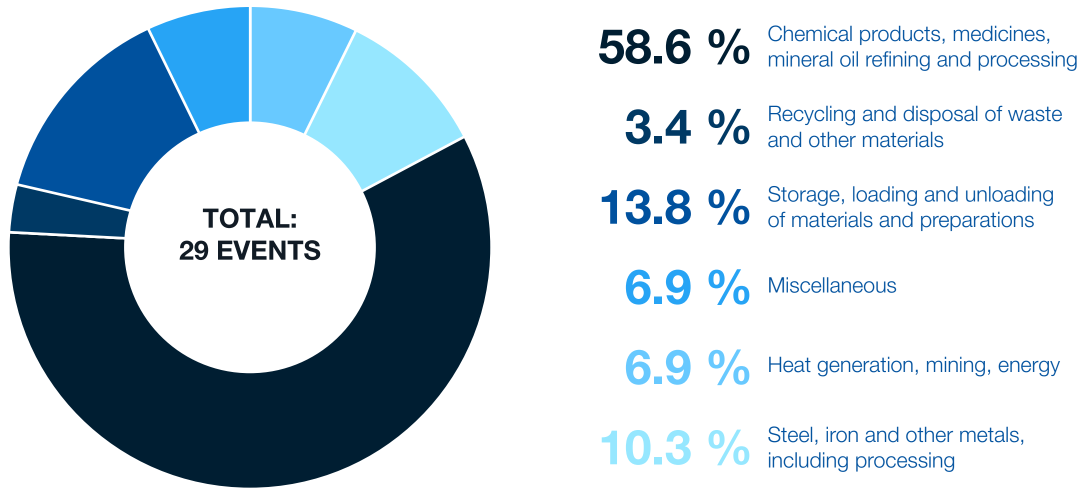
EVENTS REPORTED AFTER THE MAJOR ACCIDENT ORDINANCE



Of the 29 incidents reported in accordance with the Major Accident Ordinance, ten were classified as incidents and the remaining 19 as other serious breakdowns. 17 of these events occurred while manufacturing chemicals and refining petroleum, four during storage, three in the metal industry, two in the area of heat generation, mining and energy and one in the recycling and disposal of waste. Two events occurred in other sectors.

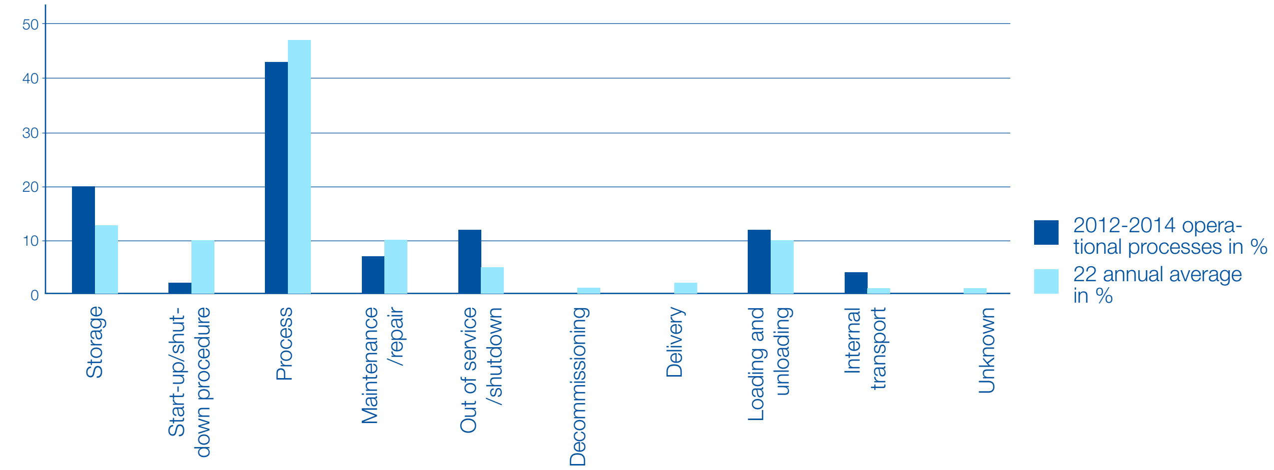
These 15 events caused approximately 125 million euros worth of damage in the operational areas. Environmental damage inside the area was reported for six events, while four events led to reports of environmental damage outside the area. The costs for cleaning the ground, extracting water impurities, disposal and other clean-up after these environmentally damaging events amounted to around three million euros.

EVENTS REPORTED AFTER THE MAJOR ACCIDENT ORDINANCE



The next infographic shows the operational processes during which the events occurred. The most frequent trigger for an incident was the process itself, accounting for 43 percent (24 events). But eleven events occurred in the area of storage (20 percent). Product handling and processes connected with plant decommissioning each accounted for seven events. Maintenance and repair only resulted in four events. Significantly fewer incidents occurred as a result of internal transport and start-up and shut-down procedures.

EVENTS REPORTED AFTER THE MAJOR ACCIDENT ORDINANCE



3. THE LIFE CYCLE HAS TO BE CONSIDERED AS A WHOLE

The ZEMA data highlights the relevance and necessity of at least adequate safety technology, or better yet, technology that exceeds widespread norms and technical regulations. Consideration should also be given to the predictive maintenance intervals for plants in the process industry. Reports on incidents affecting plant safety or on multi-day production stoppages are bad for business and undesirable. Furthermore, in order to achieve the required level of cost efficiency, the entire life cycle must be taken into consideration early on when the plant is in the planning stages or being converted or expanded. After all, the most efficient process plant is one that runs 24/7, if possible, without interruptions, manual intervention or incidents.

The safety valve is an important part of the safety equipment and must be integrated into the life-cycle evaluation. That's because safety valves are components that serve a safety function and constitute the last line of mechanical defence to protect pressurised equipment from undue overpressure when all measurement, control and regulatory devices fail. Inspections and maintenance must be performed regularly to ensure their proper functioning.

SAFETY VALVE ACCORDING TO DIN EN ISO 4126-1

A safety valve is a valve that automatically, without the support of any other energy than that of the medium, allows a quantity of the medium to flow out so as to prevent a predefined pressure from being exceeded.

It is designed to close and prevent more of the medium from flowing out once normal working pressure has been restored.

EXAMPLE: SAFETY VALVES

The main consideration when choosing safety valves is to protect people and the environment by safeguarding against impermissible pressures. The design is regulated in detail by the Pressure Equipment Directive (2014/68/EU).

More information is available at: http://bit.ly/2AhkrPX, DIN EN ISO 4126, the AD 2000 code or the ASME code. More information is available at: http://bit.ly/2BgoeRp.

3.1 DIFFERENT SOLUTIONS ARE AVAILABLE

But what should be done if the safety valve must be removed due to preventative maintenance or unplanned service? In this case, the safety of the container is no longer guaranteed and the plant must be shut down. That's because it is mandatory to permanently ensure overpressure relief in conformity with regulations. The same applies when a safety valve must be removed for maintenance or service.

But to shut down all or part of the process plant would be economically untenable. For this purpose, there are various solutions on the market to create the required redundancy. One such solution includes so-called change-over valves.

INSPECTIONS AND MAINTENANCE OF SAFETY VALVES

- Periodic inspections of safety valves should always be performed as functional tests during external and periodic internal inspections of pressure equipment.
- Inspection periods for safety valves should be looked up in TRBS 1201 Part 2.
- Simply venting the valve is not sufficient as a functional test.
- In the event of damage, neglected tests have civil and criminal consequences.

4. THE CASE OF THE FIRM COLORADOS

Colorados (name changed), a relatively small company compared to corporations like Shell or BASF, faced this very problem.

On the premises of this speciality chemical company there are multiple solvent tank farms for production, as well as a storage facility for vinyl chloride, a basic substance required for PVC manufacturing. The production and storage capacities now have to be expanded. The safety equipment is one of the aspects that have to be redesigned during planning. In addition, one of the existing storage facilities must be replaced, because the single-walled vessels and the equipment used in the fittings and safety devices no longer conform with the current state of the art. Because a safety test has been announced by an authorised inspection body (inspection periods for safety valves are regulated in TRBS 1201 Part 2), there is also a time-sensitive need for a new safety valve, which, as a pilot solution, must also be implemented in the other existing and new solvent tanks.

The Technical Regulations for Safety in the Workplace (TRBS) in Germany are on display at the Federal Institute for Occupational Safety and Health (BAuA) in Dortmund and can be downloaded at http://bit.ly/2wPJ2IY.

5. INCREASING PLANT EFFICIENCY THROUGH REDUNDANCY

Like most plant managers, Kai Müller, certified engineer and production manager at Colorados, has very specific ideas about what the new valves, especially safety valves, must be capable of. From his point of view, plant availability has the highest priority in production. The plants must run 24/7 without interruption. As production manager, he keeps an eye on maintenance and repair. Dr Friedhelm Schmitt, an engineer responsible for planning this project, also has specific ideas about the design, if not the same ones. He wants to keep the planning and design as simple as possible so that the project can be completed on time and on budget. However, he is also interested in future-proof solutions that are viable in the long term and promise to provide a rapid return on investment (short ROI, plant profitability).

In one of many project planning meetings, Müller defends his requirements: “We have to guarantee constant pressure protection, because the plants in question are relevant for safety and subject to monitoring. We have overpressure in the vessels and pipes, and the materials are hazardous. Because of this, the safety valves must always be ready for use.” Müller therefore places particular emphasis on ensuring that the safety valves are designed redundantly.

Dr Schmitt attempts to demonstrate his professional experience by pointing out a pressure tank during a tour of the plant. “There are two separate pipes attached to this tank. Both are protected by one safety valve and an upstream isolation valve, and we connect the two isolation valves together or lock them against each other. That should be enough, don't you think? The planning is more complex, but this solution has worked so far.

The solution proposed by Dr Schmitt requires two nozzles, which have to be carefully welded onto the tank. The welds have to meet the mandatory quality criteria. Furthermore, care must be taken to ensure that the isolation valves free up the entire cross section, so as not to impair the functionality and capacity of the safety valves. It should also be kept in mind that safe operation is only ensured when the two isolation valves are connected together. Otherwise, there is a danger that both sides could be closed off at the same time, so that overpressure protection is no longer provided. Furthermore, during planning and construction, it is complex and time-consuming to coordinate the various suppliers of pipes, isolation valves and interlock systems.

“We’ve yet to have an incident,” repeats Müller. “But I’m sure you know that the financial requirements for our area have got stricter. We can’t afford to shut anything down, even to perform the required preventative maintenance. Don’t the interlocks have to comply with regulations and function reliably?” Dr Schmitt pauses. “Mr Müller, surely you know that interlocking and changeover can also be accomplished with the redundant isolation valves.”

“Maybe so,” replies Müller, “But it can’t be done without problems. The procedure is error-prone and far behind the current state of the art. Not even compliance with regulations can be 100% guaranteed because of the indeterminate pressure drop values of the isolation valves.”

CRITERIA FOR CONTINUOUS PRESSURE PROTECTION AT COLORADOS

- To keep plant availability as high as possible, the safety valves should be installed redundantly and an easy and problem-free changeover should be made possible.
- To guarantee the required safety level, both safety valves cannot be blocked.
- Because a long-term solution has to be found and the organic solvents are definitely not compatible with every material, the safety valves and the changeover device must feature a robust design.
- Because the investment was necessary due to outdated technology, the new solution had to conform with international standards such as DIN ISO 4126, API 520 or ASME VIII. Furthermore, the maximum pressure drop in the feed cannot exceed 3% of the set pressure.
- To ensure that the right choice of redundant protection is made, reliable pressure drop coefficients and precise dimensions are required for all installations in the inlet line, such as isolation valves.
- Because parts have to be replaced for a forthcoming inspection, reliable and, above all, short delivery times are important.

6. PLANS AND SOLUTIONS FOR REDUNDANT PROTECTION

Müller and Dr Schmitt start by discussing what seems to be the easiest solution:
Plan to install a second isolation valve on the container with a second redundant pipe.

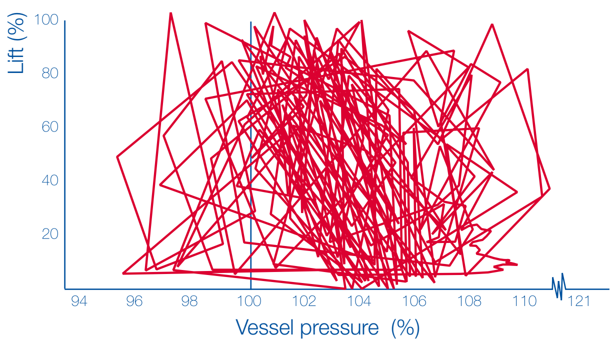
A robust solution like this is conceivable with or without mutual interlocking. However, this variant is always an individual solution that must be designed in reference to the individual case. The influence on the installation dimensions of the piping and the isolation valves in the plant itself often remains unclear. The solution with two isolation valves also fails to account sufficiently for optimising the flow to reduce pressure drops or makes this factor complex to calculate, because both the straight piping and the isolation valves have to be factored into the calculations.

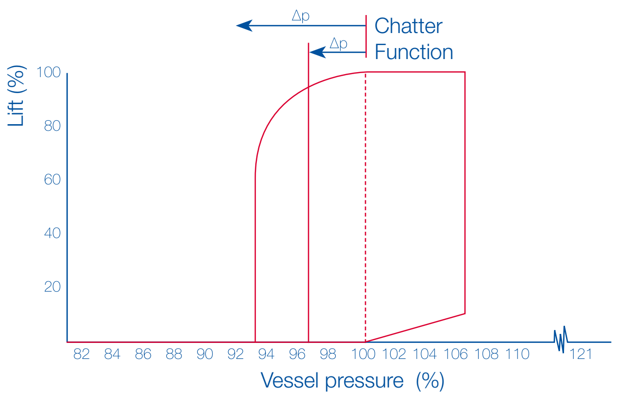
Alternative installations with only one nozzle on the container (see figure to the right) also require long pipe sections, pipe bends with various radii and tees, which result in high a pressure drop and hence may impair the functionality and capacity of the safety valve. This in turn causes the safety valve to flutter or chatter. This unstable behaviour can reduce the capacity of the safety valve and lead to an impermissible increase in pressure in the system. Furthermore, chatter damages the seating of the safety valve, which can result in constant leakage and may require the safety valve to be replaced.

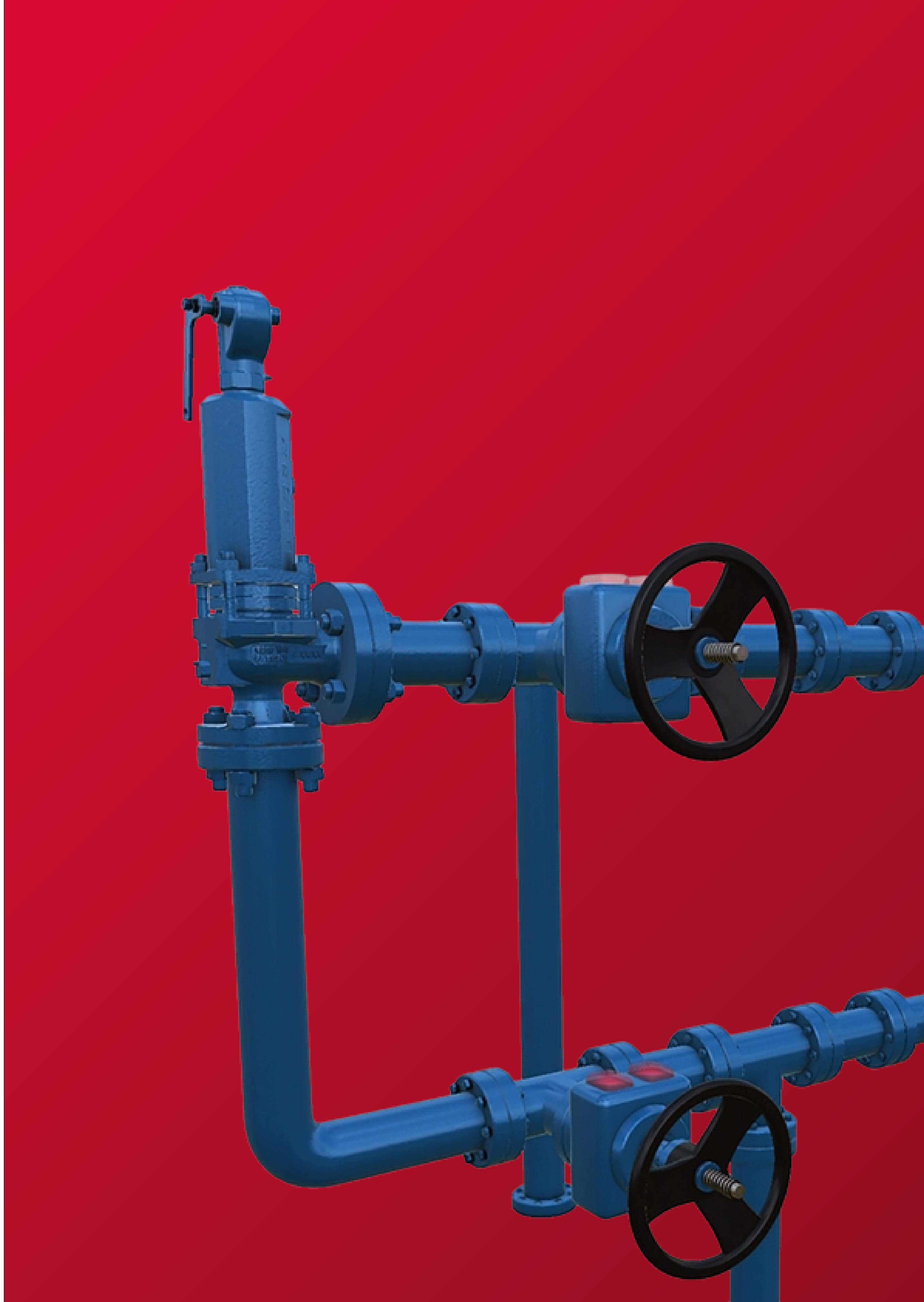
To calculate the pressure drop reliably, the entire pipework, the pipe bends and all other installations must be factored in. This leads to a complex, complicated calculation of the inlet pressure drop.

EFFECTS OF THE INLET PRESSURE DROP

An inlet pressure drop of over 3% affects the functioning of a safety valve and leads to flutter or chatter, as shown in the diagrams.







7. RAPID PROJECT IMPLEMENTATION VS. LONG DELIVERY TIMES

As production manager, Müller urges haste, so he accepts the solution originally preferred by Dr Schmitt, because he is on a tight schedule for the safety test of his production facilities. “Time is pressing. Let’s stick with the current solution. It’s tried and tested, even if it isn’t ideal. How long will it take to implement the planning and arrive at a solution?”

Dr Schmitt’s answer is disappointing: “Because redundant isolation valves with a key interlock system is an individual solution, delivery times are usually around ten weeks.”

CHANGE-OVER VALVES

Change-over valves are switching valves used for the redundant installation of safety valves. Change-over valves switch the flow of media between two different safety valves. The forced control incorporated into the design ensures that one inflow and/or outflow is always open.

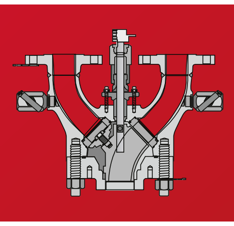
Müller is not pleased: “Your solution may be simple and already tried and proven here, but that’s out of the question. Are there no other options? With shorter delivery times?”

Dr Schmitt thinks for a moment and makes a suggestion: “We could run tests to determine how suitable the different types of change-over valves are. They come in a range of designs: rotor, shuttle and the pendulum design, which is relatively new.”

7.1 CHANGE-OVER VALVES WITH A ROTOR DESIGN

In change-over valves with a rotor design, a rotating actuator ensures that one flow path is blocked and the other unblocked. A change-over valve such as this is selected based on the same nominal size as the inlet and/or outlet of the safety valve. But the switching process itself is rather complicated.

ROTOR TYPE
CHANGE-OVER VALVE



With this type of valve and an optimised flow path and low pressure drop, it is possible to do without additional reducers. Only one pressure-drop coefficient is known for each nominal size, however. Effects caused by options or other nominal pressures are not specified. For that reason, there are some uncertainties involved in calculating the pressure drop for these change-over valves.

Müller and Dr Schmitt do research on the Internet to determine the delivery times for the different variants. Unfortunately, the rotor design entails delivery times of up to twenty weeks. “That doesn’t help us,” comments Müller.
Dr Schmitt recalls his visit to the ACHEMA trade fair and his conversations with manufacturers: “We can’t plan on using change-over valves with a shuttle design either, because they’re produced individually only after an order is placed. Delivery times of up to five months are simply too long.”

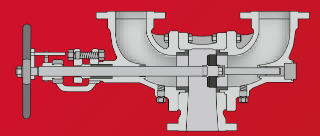
7.2 CHANGE-OVER VALVES WITH A SHUTTLE DESIGN

Change-over valves with shuttle design have 2 x 90° deflections. This results in a comparatively high pressure drop. Because of this, they can only be designed in the same nominal sizes as the inlets of the safety valve when the safety valve only has to have a low capacity or the inlet lines in question are relatively short.

For high-capacity safety valves or long piping in the inlet, the shuttle change-over valve must be at least one nominal size larger than the nominal inlet size of the safety valve. This is the only way to achieve the maximum inlet pressure drop of 3%, thereby ensuring the stable functioning of the safety valve.

As with the rotor design, a pressure-drop coefficient is often specified for each nominal size. The effects of reducers or other nominal pressures are not factored in here either. As a result, these valves are subject more uncertainties as rotor change-over valves when calculating the pressure drop.

SHUTTLE TYPE
CHANGE-OVER VALVE

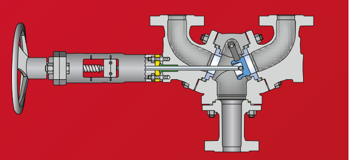


Müller sets his hopes on a change-over valve with a new design principle recently presented by LESER. “I doubt this new valve has shorter delivery times. But we should try it,” agrees Dr Schmitt, the project manager.

7.3 CHANGE-OVER VALVES WITH A PENDULUM DESIGN

The aspects that Müller addresses in his requirements are taken into consideration in the new change-over valve with a pendulum design. The special design makes it possible for the active safety valve to be switched reliably during maintenance. The shut-off disc travels along a circular path back and forth between the two outlets. The optimised flow path ensures a minimal pressure drop. Clearly defined flow resistance coefficients in each configuration make it easier to calculate the inlet pressure drop precisely.

PENDULUM DESIGN
CHANGE-OVER VALVE



The 3% criterion is therefore easy to implement. Designed for maintenance-free longevity and reliable, 24/7 uptime, the new change-over valves have undergone lifecycle tests with 1,000 change-overs with hot, cold and particulate media and at high operating pressure.

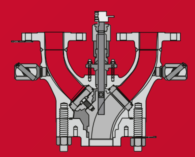
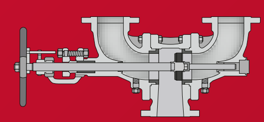
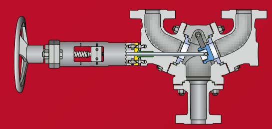
"If the planning and design of these valves were supported by the supplier and kept simple, this solution could win me over," says Dr Schmitt optimistically.

"Look at this: The manufacturer states that the change-over valves can be delivered with suitable safety valves, and they can do it in just four weeks for standard valves. So we've found a solution that saves time and money after all," says Müller in concluding the search.

LESER's portfolio includes two types of change-over valves for different requirements. Type 330 Compact fulfils the pressure drop requirements of standard applications. An example of a standard application is the installation of a lower-capacity safety valve with a short nozzle on a container. Type 320 Flow was designed especially for challenging conditions. That makes it a better choice for additional piping or in combination with higher-capacity safety valves. Both types are designed in a way that optimises the flow path and minimises the inlet pressure drop. The nominal size of the inlet body can be adjusted as required.

Thanks to this flexibility, change-over valves with a pendulum design represent a scalable solution for numerous applications. Their extremely high degree of standardisation makes for easy and efficient plant planning. The dimensions of each individual solution can therefore be predicted precisely. Because this standardisation enables the manufacturer to plan stock levels, the requested change-over valves can be made available with suitable safety valves via individual supply chains in just a few weeks after ordering.

CHANGE-OVER VALVES COMPARED

	7.1  ROTOR DESIGN	7.2  SUTTLE DESIGN	7.3  PENDULUM DESIGN
INLET PRESSURE DROP	✓ Optimised flow level	✗ Comparatively higher pressure drop due to 2 x 90° deflections (risk of chatter or larger change-over valves required)	⚠ Optimised flow path, pressure drop slightly higher than with the rotor design
RELIABLE UPTIME (prevent simultaneous closure of both sides)	✗ Complicated change-over in three steps	✓ Easy to operate using a hand wheel	✓ Easy to operate using a hand wheel
RELIABLE UPTIME (ensure seal tightness)	✗ Sealing problems	✓ Robust and long service life	✓ Robust and long service life
COUPLING ON THE INLET AND OUTLET SIDES IN LOCKABLE COMBINATIONS	✓ Lockable combination with different nominal sizes of change-over valves on the inlet and outlet of safety valves	⚠ Lockable combination only possible with change-over valves with the same nominal size on the inlet and outlet of safety valves (high weight, reducers)	✓ Lockable combination with different nominal sizes of change-over valves on the inlet and outlet of safety valves

8. CHANGEOVER TO 24/7 PLANT AVAILABILITY

The new change-over valve offers an economic solution for safe and efficient plant availability, 24/7. With the help of extensive flow tests and CFD simulations, a flow-optimised design with minimal pressure drop was developed. Every configuration of these change-over valves has a defined resistant coefficient that enables reliable and precise calculation of the inlet pressure drop. Change-over valves with a pendulum design are easy to operate and, when combined with safety valves, provide permanent protection for plants. Because of their durable design, these new change-over valves are maintenance-free and subject to extensive lifecycle tests.

Change-over valves with a pendulum design guarantee:

- Low pressure drop when the safety valve is blowing off (3% criterion).
- Opening of the full orifice area in every position during the changeover procedure.
- The economic solution, because an optimal choice can be made for every application.
- Simple changeover while the plant is in operation.

	TECHNICAL DATA
	DN 25 to DN 100
	DN 125 to DN 400
Resistance coefficient	Min. 0.15
Flow coefficient (K_V/C_V for DN 25/1" to DN 100/4")	32 ... 7018 m³/h
Pressure rattings	PN 10 to PN 250
Temperature range	-273°C to +450°C
Materials	WCB/WCC/1.0619 LCB/LCC/WCB/WCC (1.0619) CF8M/1.4408 More provided upon request

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The new change-over valve is the result of LESER's extensive experience and exclusive focus on the design, production and testing of safety valves. LESER is one of the leading companies in the industry. It's the largest safety valve manufacturer in Europe and an international market leader for safety valves.