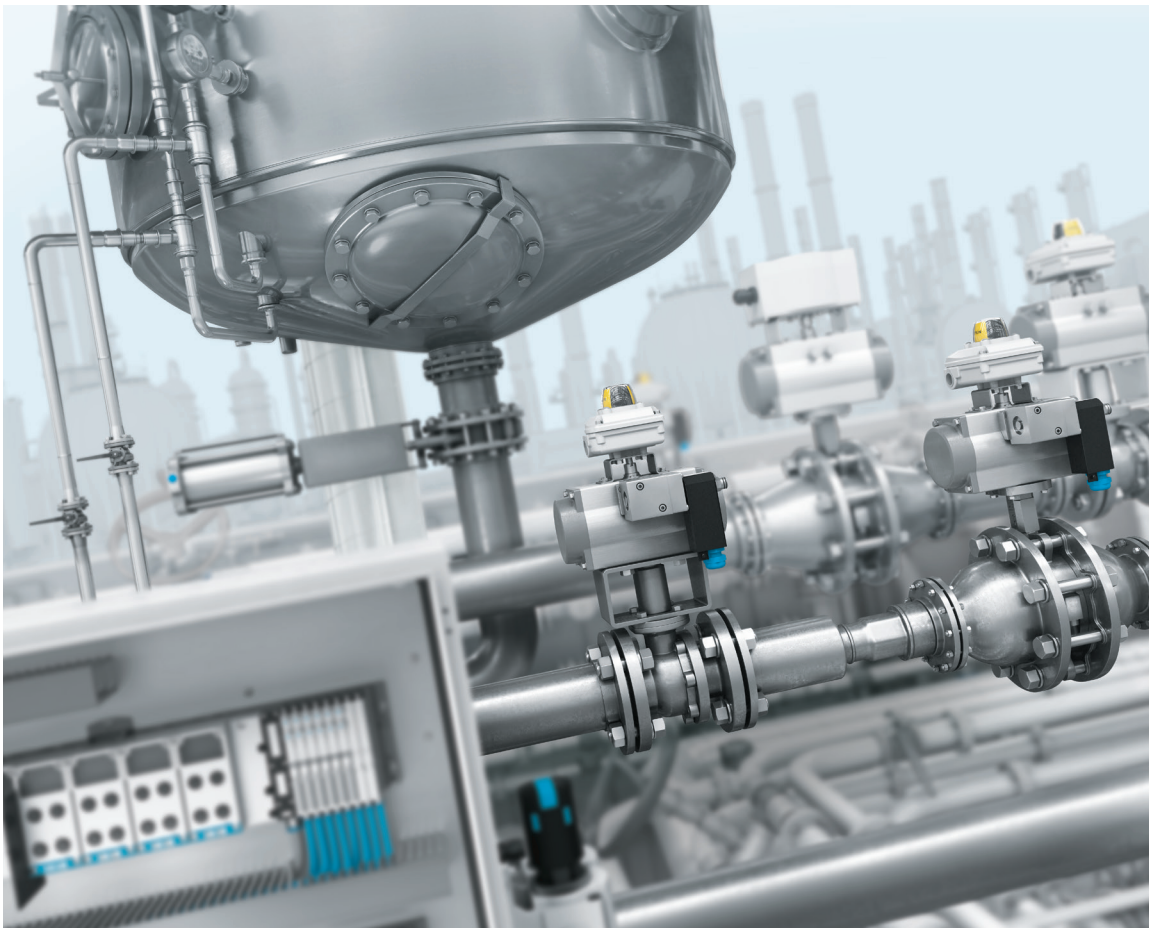


Tried and tested solenoid valve technology from Festo for SIL applications

15 years without any failures

For many years now, the products of Bayer Division Crop Science have been contributing to good yields and bigger harvests in more than 120 countries around the world; they are thus helping to ensure that world populations receive adequate supplies of high quality foods. The R&D process for a new crop protection product takes 10 to 15 years. To enable fast and individual production, Bayer created a new multi-purpose system in 2002 which places huge demands on safety and reliability.





In 2002, Bayer invested around €110 million in the construction of a multi-purpose system at its site in Dormagen, Germany. This houses everything under a single roof, from the development and manufacture of new active ingredients for crop protection, as well as laboratory processing, sampling and piloting, right up to the production processes.

The system is designed so that subsystems and equipment such as dryers, centrifuges, distillers, stirrer tanks and other reactors can be flexibly connected and operated. An in-house pipeline with adaptable piping takes care of the material flows, while the decentralised process control system is distributed over 67 automation systems, thus enabling the process controls to be flexibly adjusted.

As the process development requires the use of flammable operating fluids, frequent process changeovers and numerous interfaces and intervention points, the entire system has been classified as potentially explosive zones 1 and zone 2 according to the explosion prevention and protection measures.

Minimising safety risks for people and the environment

The probability of an incident occurring at a chemical plant depends largely on the reliability of the system components and the individual processes. This includes, for example, the availability of coolant

water, electricity, emergency stop devices, stress-relief devices, pumps, mixers and process valves.

Processes can be reliably controlled when all the important elements operate correctly, from system operation to the safety functions for instrumentation and control technology. Safeguarding process facilities in the chemical and petrochemical industry using instrumentation and control technology is thus very important. Not only does this prevent dangerous plant conditions (e.g. overpressure), but it also detects future trends at an early stage and initiates – in part automatically – suitable measures (e.g. detecting runaway reaction by calculating the temperature gradient).

Optimising the economic efficiency of processes

The economic efficiency of a process also depends largely on the reliability of the individual system components, and thus also on instrumentation and control technology. As modern process engineering systems are highly optimised, increased levels of output can only be achieved with a reliably functioning, highly productive system without downtimes. This means reducing inspection cycles and inspection times, as well as avoiding idle times or downtimes caused by repairs carried out outside of the maintenance schedule. One way of achieving this is by using reliable instrumentation and control technology components that are certified in accordance with IEC 61508.



The multi-purpose operation of Bayer Division Crop Science at Dormagen, which was built in 2002

Solenoid valves – instrumentation and control technology components with high levels of responsibility

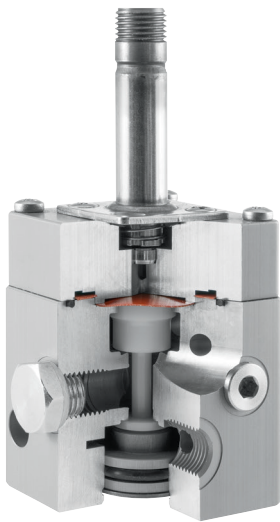
The Bayer Crop Science's multi-purpose system uses numerous instrumentation and control technology devices in order to switch dosing valves, exhaust valves, steam valves etc. to failsafe positions. The solenoid valves that activate the actuators must, at a very minimum, have the same SIL classification as the entire safety loop (with single-channel architecture). A solenoid valve in a safety loop is generally placed between the positioner and the actuator and is used to quickly exhaust the actuator and close the process valve in case of an emergency.

Solenoid valves VOFC and VOFD, which Festo added to its own product range at the end of 2012 as part of a takeover of the process automation division of Eugen Seitz AG, can be supplied with TÜV certification up to SIL 3. These valves, in accordance with the latest SIL classification from TÜV Rheinland, will guarantee a failure probability rate of 2.41×10^{-4} and a safe failure fraction of 75%. In other words, if used properly, a maximum of one faulty operation will occur in 2,410 switching cycles.

Assuming that such safety loops undergo a failsafe inspection once a year, this means that a faulty operation will occur once in 2,410 years; so it is virtually impossible for a valve not to switch when it should. These solenoid valves are available with ignition protection types "Ex em" and "Ex ia", and are thus especially well suited for use in safety

loops. However, IEC 61511, "Safety instrumented systems for the process industry sector" specifies that the operating company must implement the necessary precautions for avoiding and controlling faults throughout the entire lifecycle of the SIS.

In the case of a solenoid valve which is used in a safety loop and is only switched in case of an emergency, this is called a "low demand mode" application. This low demand mode represents a special challenge for the design and the materials of a solenoid valve, which is usually built for several million switching cycles. On the one hand the solenoid coil is always energised – for periods spanning decades – and on the other hand the solenoid valve has extremely long periods of idle time, and must nevertheless be able to shut down reliably in the event of an emergency.



Cutaway model of a 3/2-way piston valve without dynamic seals

For supply of compressed air Bayer relies on polyurethane tubes and push-in fitting from Festo



One for all applications

The ability to use Festo solenoid valves universally and their adherence to strict safety requirements were all convincing arguments for the decision makers at Bayer. More than 1,500 solenoid valves VOFC were installed in safety-related as well as non-safety-related circuits in the multi-purpose system. A large number of these valves is used to actuate ball valve units at tank systems, reactors, media supply systems and other applications. The customer also wanted a solenoid valve that could be used across the board and would be suitable for many different applications. Everything needed to be covered by a single solenoid valve, regardless of whether they would be used in indoor or outdoor applications and whether large or small actuators needed to be controlled. Last but not least, they also had to be compatible with the requirements for actuation in intrinsically safe circuits (Exi) in zone 1.

The VOFC range was developed specifically to meet these process industry criteria and requirements. A solenoid valve with piston poppet valve technology and no dynamic seals which can be switched by a diaphragm without any friction. By avoiding dynamic sealing elements, the switching operations were free of friction force, which might otherwise have had a negative impact on switching performance. Using this technology also had other advantages. With a comparably low solenoid coil power rating of just 1.8 W (or less than 200 mW with the intrinsically safe variant), the solenoid valve has outstanding flow characteristics, which in turn has a positive effect on the safety valve's closing time.

The system's harsh ambient conditions were of course also taken into account, and the solenoid valves have top quality Ematal corrosion protection which has proven its worth for many years. As the solenoid valves are designed primarily for use outdoors, they don't have any venting holes and the exhaust ports are equipped with special non-return devices. This prevents rainwater and outdoor air from penetrating the solenoid valves and the downstream actuators.

Zero-leakage compressed air supply

The compressed air supply lines for the solenoid valves, too, have been made of polyurethane tubing together with NPQH push-in fittings for years. The benefits of this tubing can mainly be seen in its flexible, simple as well as time-saving installation. The tubing clip mechanism of the push-in fitting guarantees excellent tightness thanks to the integrated sealing ring, but still enables the connection to be quickly loosened when needed. Alongside the high resistance to UV radiation, the chemical resistance of the tubing was also crucial.

As both nitrogen and compressed air are used as a pressure medium, the availability of plastic tubes in different colours is another advantage. This meant that additional identification for tubing was not needed. The use of bulk packs meant that connection screws could also be dispensed with for large tubing lengths, thus reducing the number of possible sources of leaks to a minimum.



3/2-way piston poppet valve with extended NAMUR port and TÜV certificate in accordance with IEC 61508

Tried and tested since 2002 – new certificate with no service life limitation

Because of this innovative technology, these pilot-actuated solenoid valves were the first in the world to receive TÜV certification in 1999 for applications up to AK 7, and subsequently up to SIL 4. Since then they are used by many large, renowned chemical companies all over the world and have also been included in their standard equipment specifications.

So far none of the 1,500 or so intrinsically safe solenoid valves with TÜV certification up to SIL 3 installed in Bayer's multi-purpose system has malfunctioned during 15 years of operation. In 2015, 14 solenoid valves were removed from this reference application and subjected to extensive testing in the climatic chamber at Festo. The results of these tests were very positive. Festo was now able to match the results of the laboratory tests carried out in 1998 with 20 test objects in collaboration with the German Technical Control Board TÜV-Rheinland with results obtained from solenoid valves in actual applications.

Thanks to these follow-up tests and the FMEA conducted in parallel, the TÜV has issued a new certificate which no longer contains a reference to any limitation of the valves' service life. The operating company is therefore responsible for correct installation, operation and maintenance, and is thus able to specify the service life of the solenoid valves itself, which may vary depending on ambient conditions. Festo is the first company to receive certification with an unlimited service life for solenoid valves. This is an enormous advantage for customers planning new systems and for customers who have already been using these solenoid valves for many years.

Expert knowledge of SIL – Safety Integrity Level

Two important aspects that are taken into account for SIL are safety and reliability. However, there is a fundamental difference between the two:

In terms of safety, process technology systems have been extensively modernised in the last 20 years and now boast a very high standard of technology in Europe. On the one hand, the probability of explosions has been substantially reduced thanks to current Ex certifications and Ex zone classifications. The introduction of ATEX directives at EU level standardised the various Ex regulations of the individual European countries, thus ensuring that safety standards are on a par in all member states. Another step towards enhanced system safety was the introduction of the Pressure Equipment Directive. Air reservoirs as per this directive include containers (unfired air reservoirs), boilers, tubing, pressure-maintaining equipment parts, unfired equipment parts with safety function with an internal overpressure of more than 0.5 bar. All EU directives are continuously harmonised by the European Commission and adapted to new circumstances. For systems subject to the Hazardous Incident Ordinance, concrete PIC architectures such as the "one out of two philosophy" have been used.

Increasing the safety-oriented reliability is the requirement for extending the test intervals. This means that large amounts of money can be saved. In oil refineries, it has long been common for shutdowns to take place only every five years. The high level of reliability is primarily achieved thanks to the "two out of three philosophy" and supported by redundant systems and devices. This more expensive option pays off thanks to the high capacity of these systems. This does not always apply to chemical plants. Nowadays, plants are trying to achieve a level of reliability similar to that of redundant components by using certified, highly reliable devices (electric motors, transmitters, controllers, solenoid valves or even process valves) and suitable diagnostic methods.

**About Festo:**

Festo AG is a global player and an independent family-owned company with headquarters in Esslingen, Germany. The company supplies pneumatic and electric automation technology to 300,000 customers in the fields of factory and process automation in over 200 industry segments. Products and services are available in 176 countries around the world.

The company has around 17,800 employees in 61 national companies worldwide and generated a turnover of some €2.45 billion in 2014. More than 7% of this turnover is invested each year in research and development. 1.5% of this learning company's turnover is invested in basic and further training. However, training services are not only provided for Festo's own staff – Festo Didactic SE also supplies basic and further training programmes in the field of automation technology for customers, students and trainees.