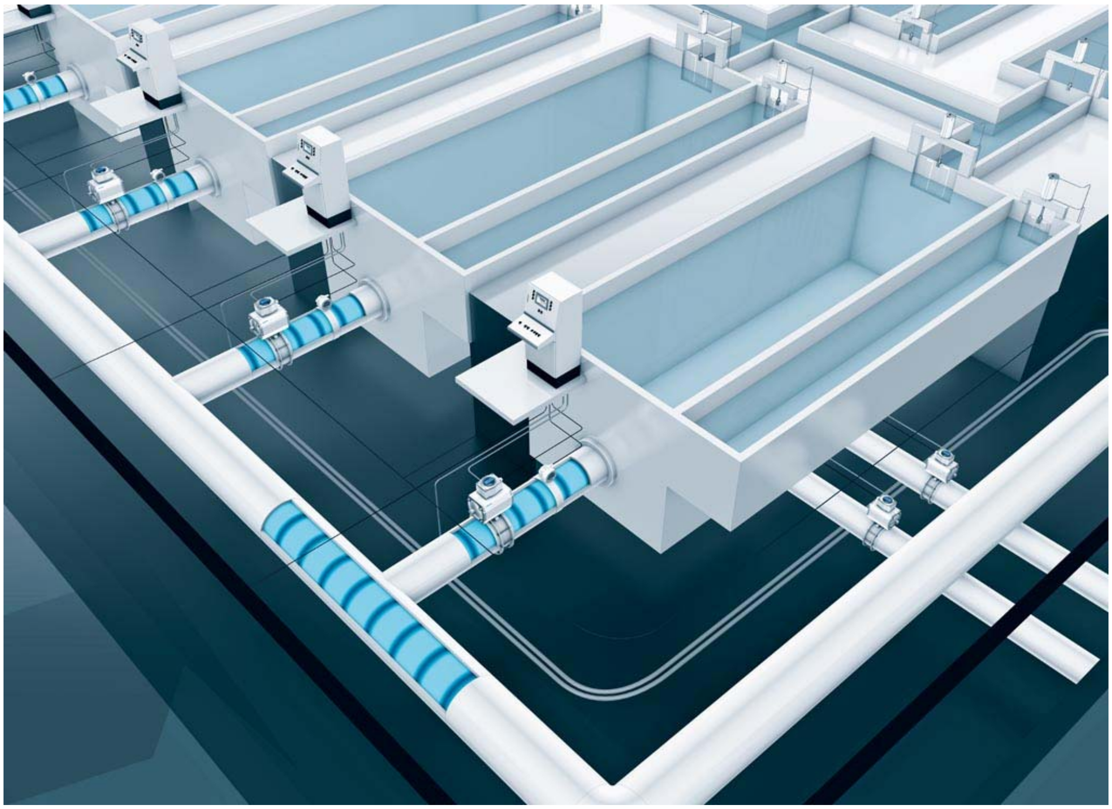
White paper
Automation solutions for fixed-bed filters



Handwheel or automated process valve? The worldwide trend is clearly moving towards automation, because it reduces energy and water consumption, especially rinsing water, and increases plant availability. Pneumatic automation of a fixed-bed filter is a good example of this.

This white paper has information on:
- Automation solutions for fixed-bed filters
- Energy and water efficiency

Open or closed fixed-bed filters (figure 1) are an important part of water treatment in water and wastewater treatment plants. They remove turbid and non-biodegradable substances and soften, de-acidify or harden the water.

Task and function

The function of a fixed-bed filter is determined by the material, particle grain size and structure of the filter bed or filling material. Depending on the task at hand, the filling material can consist of sand, gravel, hydro-anthracite or activated carbon in one or more layers.

Five to eight shut-off valves are usually required to control a fixed-bed filter (figure 2). Of these, up to three are operated in closed-loop control, while the others are operated in open/close mode. The untreated water is fed through the filling material. The filter effect is created by the large surface area of the particles onto which the turbid particles settle. More and more particles are deposited as time goes by, causing the flow rate through the filter to decrease. After contamination has reached a certain level, the filter is cleaned by means of backwashing.

Backwashing required

The degree of contamination is measured by monitoring filtrate flow, water level or pressure over the filter. Backwashing is carried out for several minutes using a combination of air and water. Depending on how contaminated the water is, backwashing is required from once a week to several times a day. This means that the process valves are actuated infrequently.

The main types of shut-off valves used are centric butterfly valves or double-eccentric butterfly valves, with plunger valves or gate valves as control valves at the filter outlet. In the case of open-design and large-volume filters, penstocks or rotary weirs are often specified for the inlet and sludge outlet.

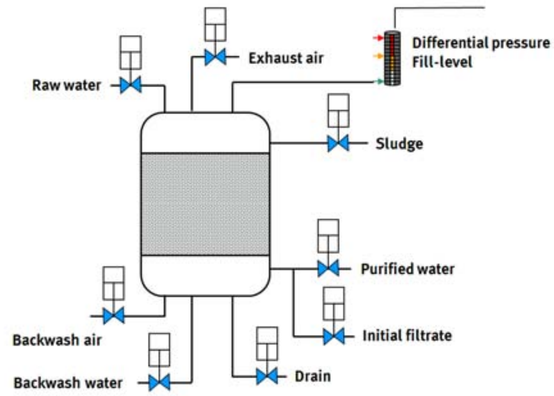


Figure 1: Schematic diagram of a fixed-bed filter

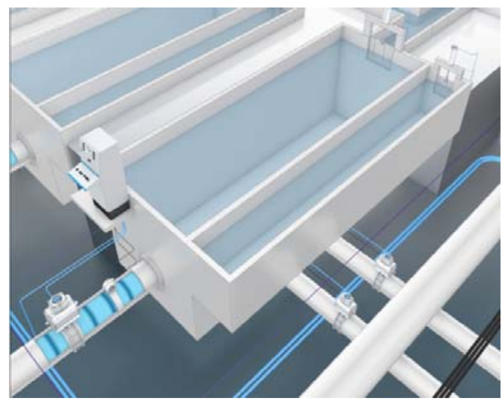


Figure 2: Five to eight process valves required

Pneumatics as an alternative

Regardless of whether the shut-off valves are actuated by linear or rotary motion, pneumatic actuator and automation solutions are an interesting alternative in terms of economy and technology [1]. This is especially true with regard to life-cycle costs.

Pneumatics offer greater functionality for controlling shut-off valves. With pneumatics, safety-relevant functions can be force controlled as appropriate for the operating situation. This applies in particular to the performance of the shut-off valves in case of a power failure when no emergency power generator is available. This specifically involves the shut-off valve's initial position when the system is not in operation and during start-up, and its safety position in case of power failure: forced closing or opening, or retained in current position (figure 3).

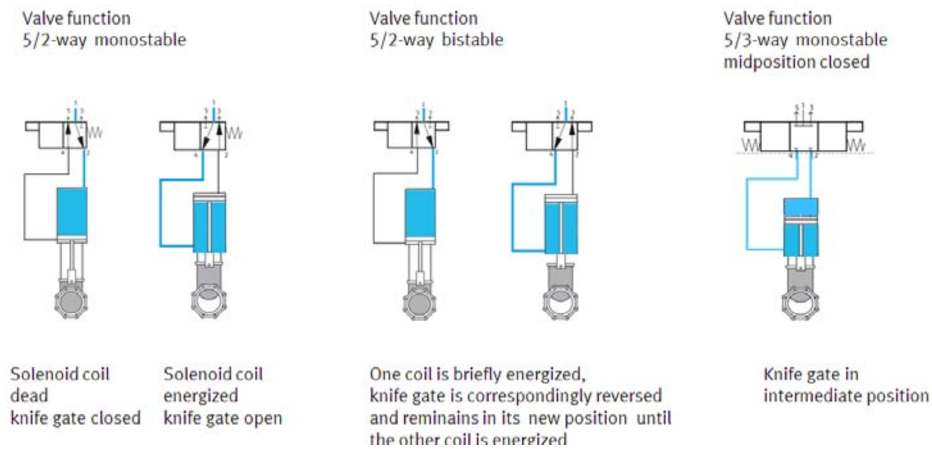


Figure 3: Options for forced control of shut-off valves with pneumatic actuator in case of power failure: closed, open or retained

Flexible automation

The number of fixed-bed filters ranges from two for small, local water treatment plants up to 48 or more in water treatment plants for large cities. Any automation concept must thus be decentralised and flexible and combine pneumatic and electrical operation. An example of a decentralised automation platform would be the CPX/MPA, from Festo. It establishes a link between the pneumatically actuated process valves and the limit switches, the measuring equipment and the control or process level.

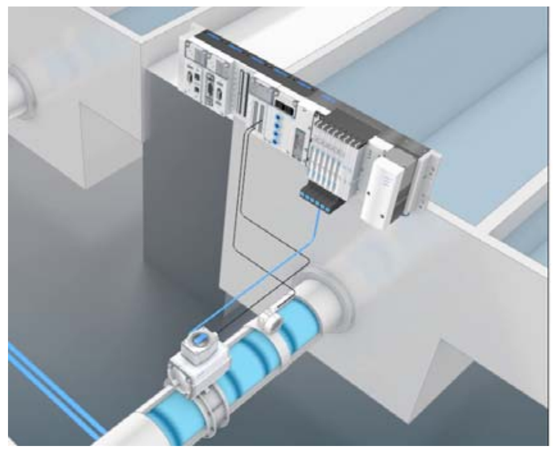


Figure 4: Automation platform CPX/MPA

The automation system

The automation platform (figure 5) has a pneumatic section on the right side (MPA) and an electrical section on the left (CPX terminal). Both sections can be flexibly configured with a variety of modules. Digital as well as analogue I/O modules are available for the electrical section. The pneumatic section encompasses various solenoid valve functions and flow rates. The modular design ensures that it can be optimally matched to the system concept.

Depending on the size of the plant, the automation system can include a process control system (PCS), a PLC level and the so-called field level. The process control system and the PLC level are connected via Ethernet, and the PLC and the devices are connected via parallel data transmission or a fieldbus (serial). Nowadays, modern automation solutions are equipped with fieldbus systems for communication at the field level. This applies to all process valves, pumps, blowers and measuring equipment which need to be connected to a PLC. A link to the intranet for inter-plant communication can be set up easily as well.

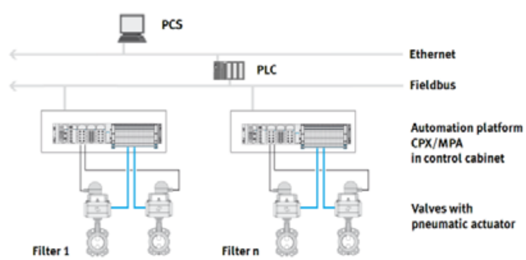


Figure 5: Automation system for fixed-bed filters

The advantages of this automation solution are:

Significant savings with regard to installation
More transparency at the individual levels

- Consistent concept with just a few interfaces
- Faster commissioning and troubleshooting
- Final control elements are combined on the automation platform

- Easy expansion with the help of fieldbus systems

A cost comparison showing concrete potential savings as opposed to a solution with individual valves, as well as further information on system solutions, can be found in [2].

Integrated controller
In addition to a fieldbus node, one variant of the automation platform CPX/MPA is when it is equipped with its own PLC. In this example,the Festo CEC controller (figure 6). This enables the automation platform to function independently of the rest of the network or the master PLC and PCS. This variant increases plant availability, because individual system components continue running in the event of network errors. This can be valuable for filter controllers, or even for pumping stations.

Integrated web monitor
The automation platform can be additionally equipped with a web monitor (figure 7).
This allows users to display service information from the CPX terminal on an external web monitor in real-time. This makes remote diagnostics easy to implement.

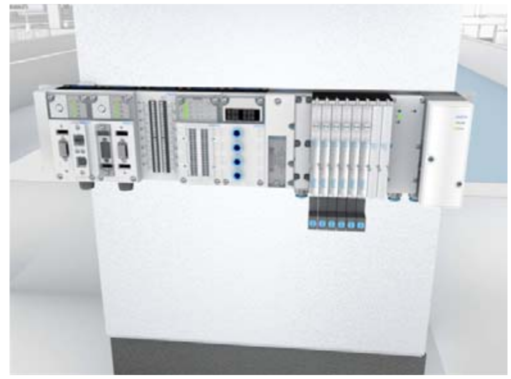


Figure 6: Automation platform with integrated controller CEC

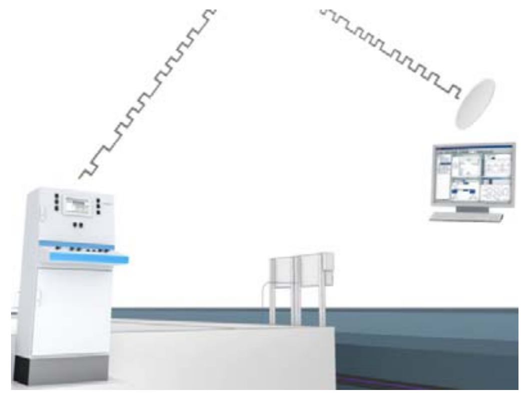


Figure 7: Automation platform with integrated web monitor

Practical example

Valve terminal in a control cabinet with integrated controller (PLC), touch-screen and integration of positioner function into the control cabinet

The control cabinet, where plant operators can centrally configure all of the parameters for controlling the process valves of a fixed-bed filter, is a pioneering system-solutions development.

Figures 8 and 9 show the previous, conventional solution. For the process valves, the pneumatic actuators and individual valves with NAMUR interface are mounted directly on the actuator. The control valve for the filter outlet is equipped with a pneumatic actuator and positioner. Each fixed-bed filter is assigned its own control cabinet. The main control cabinet components include a touch-screen for operating the system and a PLC. Connection to the control level, consisting of a master PLC and visualisation of the process, is via Ethernet. The PLC in the control cabinet controls the process valves, while the master PLC coordinates backwashing of the individual fixed-bed filters.

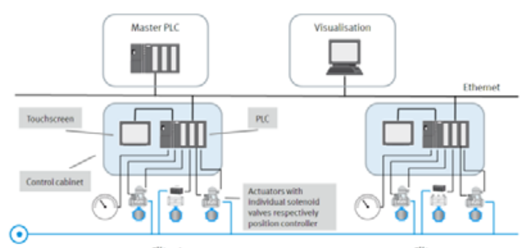


Fig. 8. Scheme of the conventional solution

Fig. 9. Conventional solution with single solenoid valves and process valve with positioner

Festo expanded the conventional solution to include the following features:

- Manual operation to enable the system to be operated from the control cabinet even in the event of failure, or in the event of a power failure
- A sturdy and more flexible solution for the control valve, which can be operated even without electrical power. The controller parameters can be configured centrally in the control cabinet.
- Excellent reliability – not just for commissioning but above all for operation

Figure 10 and 11 show the new solution. The main differences are: valve terminal instead of individual valves, integration of a pneumatic, manual operating level and elimination of the positioner by distributing its function among three elements: feedback indicating the position of the process valve via a sensor box with 4 to 20 mA analogue output, activation of the actuator with a 5/3-way solenoid valve on the valve terminal and relocation of the controller software to the PLC.

This offers several advantages in comparison with the conventional solution with positioner:

- The demands placed on compressed air quality are reduced as compared with the previously used positioner.
- The higher flow rates of the solenoid valves allow fast motion and a safety function, even with large actuators.
- All process valves, including the control valve, can be actuated via manual operation even where there is no electrical power. (The control valve cannot be adjusted without electrical power if an electro-pneumatic positioner is used.)
- The plant operator no longer has to go to the process valve to change the positioner's parameters, as changes to the control parameters can now be made directly at the control cabinet.

All in all, this solution is more economical than the conventional system.

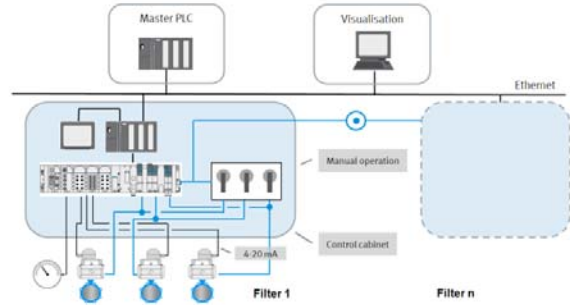


Fig. 10. Scheme of the new solution

Fig. 11. Festo solution with valve terminal and integration of the positioner functionality in the control cabinet

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- 1] Rieger, W.; Herrmann, C.; Torney, M.: Transparenz im Kostendschungel – Total Cost of Ownership entscheidet über langfristige Wirtschaftlichkeit von Antriebslösungen für Industriearmaturen ("Transparency in the Costs Jungle – Total Cost of Ownership is the Crucial Factor in Determining the Long-Term Cost-Effectiveness of Actuator Solutions for Industrial Shut-Off Valves"), P&A November 2007, pages 65-68.
- [2] Rieger, W.: Vorteile für Armaturenanwender durch Systemlösungen ("Advantages for Shut-Off Valve Users through System Solutions"), "Industriearmaturen" Issue 3, September 2007, pages 254-259.