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Pneumatic control loops save water and energy with fixed-bed filters

Wolfgang Rieger

Handwheel control or an automated shut-off valve? The trend world-wide is clearly towards automation. Automation saves energy and water, particularly flushing water, and increases operational reliability. This is illustrated, for example, by the pneumatic automation of fixed-bed filters in a waterworks.

Fixed-bed filters of open or enclosed design are an important element in the water-treatment processes carried out in waterworks or sewage treatment plants (**Figure 1**). They remove turbid and non-biodegradable materials and soften, deacidify or harden the water as desired.

Structure, purpose and function of fixed-bed filters

The function of a fixed-bed filter is determined by the type, particle size and structure of the filter bed or bulk material used in the filter. Depending on the purpose of the filter, the bulk material may, for example, be sand, gravel, hydroanthracite or activated carbon in one or more layers.

Generally five to eight shut-off valves will be required in order to control a fixed-bed filter. Of these, up to three shut-off valves will operate under closed-loop control, the others in simple open/close mode.

Untreated water is fed through the bulk material. The large surface area of the particles onto which the turbid material settles creates the filter effect. The longer the filter is in operation, the more dirt will accumulate, causing the flow rate through the filter to decrease. If a

filter is heavily contaminated, the only remedy is to clean it by filter washing.

Filter washing required

The degree of contamination can be measured by the flow rate of the filtrate, the water level in the filter or the differential pressure across the filter layer. Filter washing is carried out with a special flushing program with air and water for several minutes. Depending on the degree of contamination of the untreated water, it will be necessary to carry out filter washing anything from once a

week to several times a day. This means that the shut-off valves will tend to be operated rarely. A reliable operation of the shut-off valves is of important relevance.

The main types of shut-off valves used are central-bearing wafer-type butterfly valves or double-eccentric-bearing 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.

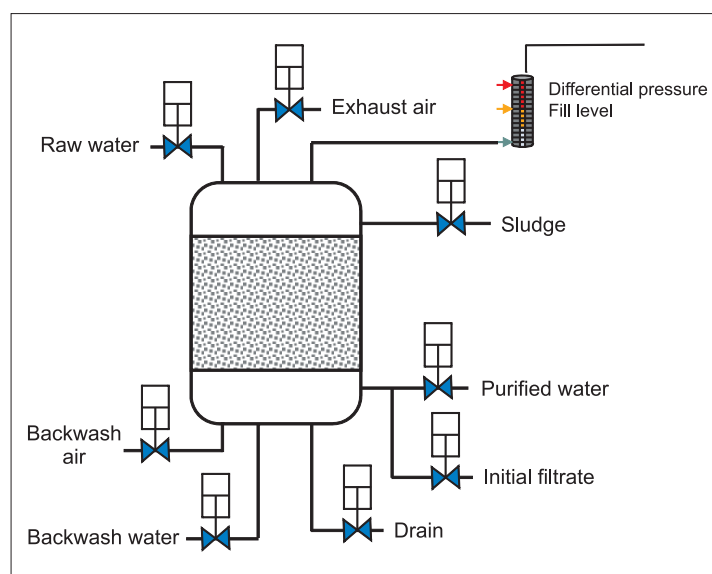


Fig. 1: Schematic diagram of a fixed-bed filter in a waterworks

Pneumatics as an alternative

No matter whether shut-off valves are actuated by a linear or rotary motion, pneumatic actuator and automation solutions are an interesting alternative in terms of economy and technology [1]. This applies particularly with regard to total costs of ownership.

Pneumatics offers greater functionality for the control of shut-off valves and can be used to achieve automatic activation of safety functions as appropriate to the operating situation. This is especially useful with regard to the behaviour of shut-off valves in the case of an electrical power failure where no emergency generator is available. The particular functions involved are the normal position of shut-off valves when a system is out of operation or starting up and the safety position of shut-off valves during an energy supply failure: Automatic closure, automatic opening or automatic maintenance of current position (Figure 2).

Flexible automation

The number of fixed-bed filters can vary between two in the case of small local waterworks and up to 48 or more in the case of waterworks for large cities.

Any automation concept must therefore be decentral and flexible and combine pneumatic and electrical components. Pneumatic valve terminals are particularly suitable for this purpose. These provide a link between the pneumatically-actuated shut-off valves and the end-position sensors, measuring equipment and system or process control level.

The valve terminal system

A valve terminal (Figure 3) has a pneumatic section (MPA) and an electrical section (CPX terminal). Both sections can be configured flexibly with a large number of modules. Digital and analogue input and output modules are available for the electrical section, while the pneumatic section consists of various solenoid-valve functions and flow rates. The modular design ensures that the terminal can be adapted ideally to the system concept in question.

Depending on the size of an installation, an automation system may include a process control system, a PLC level and a so-called field level. The process control system and PLC level are connected via Ethernet, while the PLC and field devices are connected via parallel data transmission lines or a field bus

(serially). Modern automation solutions are produced today using field bus systems for communication on the field level. This applies to all the shut-off valves, pumps, fans or measuring equipment which are connected to a PLC. A link to an intranet for communications between factories can also be produced easily.

The advantages of this automation solution are:

- Considerable saving of installation costs
- More transparency on the individual levels
- Seamless concept with only a small number of interfaces
- Faster commissioning and fault elimination
- Concentration of final control elements on the valve terminal
- Easy expansion of installations, thanks to field bus systems

See [2] for a comparison of costs describing the concrete potential for savings relative to an individual valve solution and further information on the subject of system solutions based on valve terminals.

Intelligent valve terminal

A variant of the CPX terminal includes

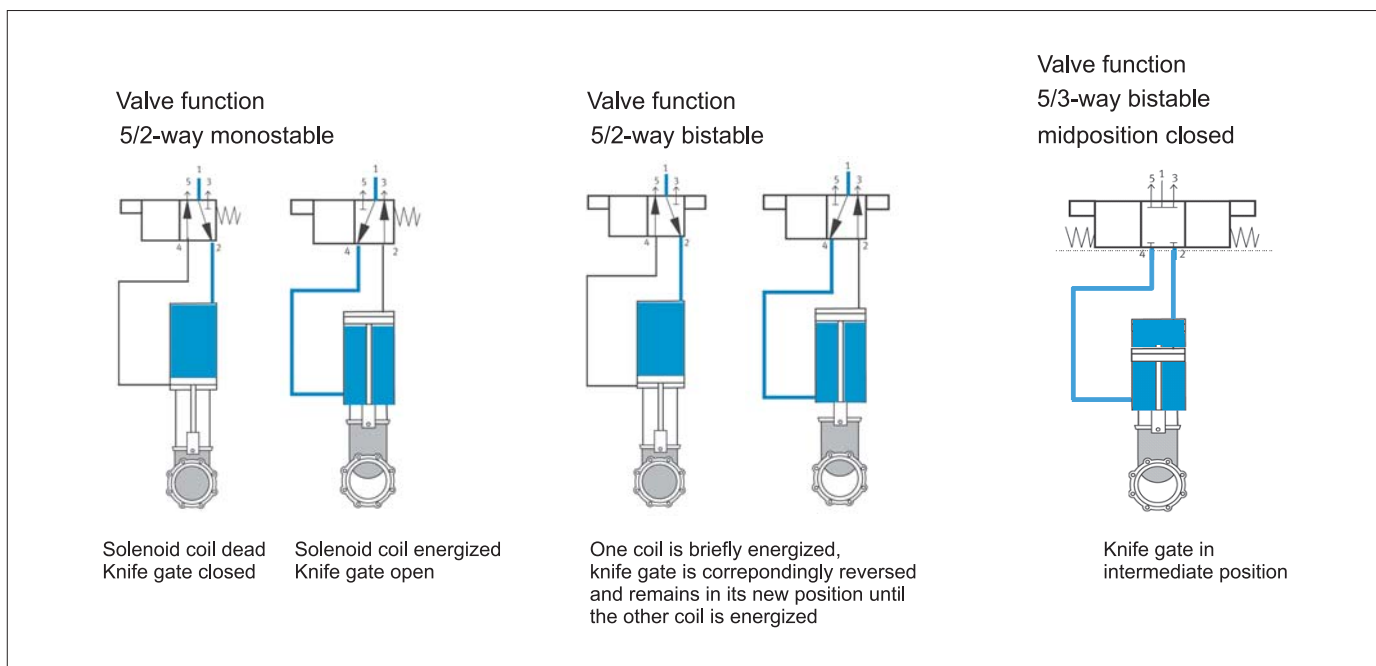


Fig. 2: Ways of achieving automatic control of shut-off valves with pneumatic actuator in the case of an electrical power supply failure: Automatic closure, automatic opening or automatic maintenance of current position

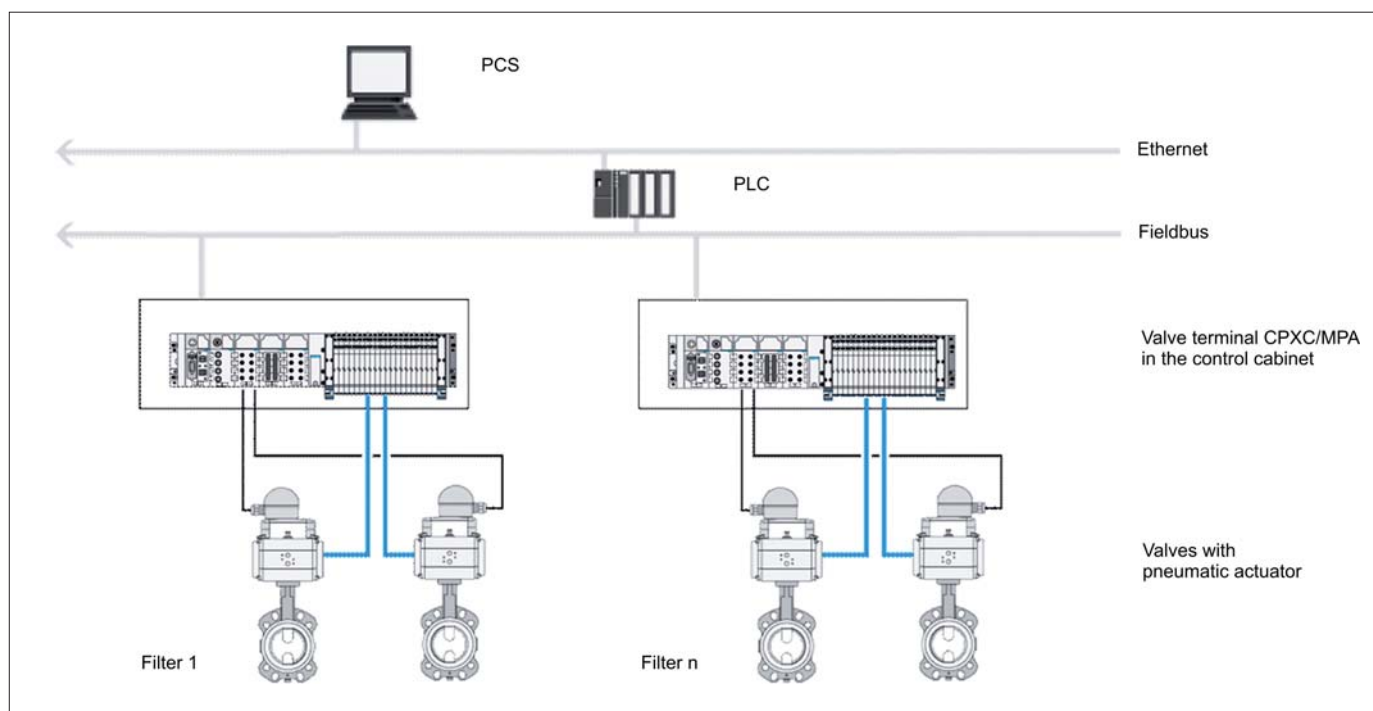


Fig. 3: Automation structure for fixed-bed filter with valve terminal as central component

not only a field-bus node but also its own PLC, a so-called CEC controller. This allows the valve terminal to operate independently of the remainder of the network or of the higher-level PLC and process control system. This variant offers higher installation availability, since even if there are malfunctions on the network, individual installation sections can continue to operate. This can be valuable in the case of filter control systems and also pumping stations.

CPX terminal with integrated web monitor

The CPX terminal can also be equipped with a web monitor. This allows users to display service data from the CPX terminal on an external web monitor in real time. This makes it easy to carry out remote diagnosis.

Practical examples

Valve terminal in control cabinet with manual control panel

To allow the use of a valve terminal with a fixed-bed filter in a waterworks, the terminal is installed in a control cabinet to protect it against external influences or to prevent unauthorized actuation of the shut-off valves. **Figure 4** shows a

valve terminal with a manual control panel in a control cabinet. The advantage of this solution is that the automated level and manual control panel are completely separate and can be protected by interlocks. A key switch is used to switch between the two.

When the key switch is activated, this sends a signal to the process control system. This convenient manual control panel is particularly useful for commissioning, allowing the connection of the electrical power supply or the programming of the PLC to be carried out at a later time, since the manual control panel operates purely pneumatically. The installation can thus continue to be operated or brought into a defined state even after a failure of the electrical power supply.

Valve terminal in control cabinet with front display panel

LEDs on the CPX terminal show the current switching status of the shut-off valves. A window in the control cabinet allows the operator to survey the status of the installation quickly and easily. An even more convenient variant is shown in **Figure 5**. In this case, the control cabinet door is equipped with a schematic diagram of the installation

and LEDs. The complete unit is of compact design. The control system for five filters is installed in one control cabinet.

Pointing the way to the future: Valve terminal in control cabinet with integrated controller (PLC), touch screen and integrated position controller functions

One future-oriented system-solutions development is a control cabinet which al-



Fig. 4: Valve terminal in control cabinet with convenient manual control panel



Fig. 5: Valve terminal in control cabinet with schematic plant diagram

allows plant operators to set at a central point all the parameters required to control the shut-off valves of a fixed-bed filter.

Figure 6 shows the previous conventional solution. For the shut-off valves with an open/close function, pneumatic actuators and individual valves with a NAMUR interface are mounted directly on the actuator. The control valve

for the filter outlet is equipped with a pneumatic actuator and a position controller. A control cabinet is assigned to each fixed-bed filter. The major components of the control cabinet are a touch screen to control the installation and a PLC. This is linked to the master control level, consisting of a higher-level PLC and a visualization system, via an Ethernet connection. The PLC in the control cabinet controls the shut-off valves,

while the master PLC controls the washing of the individual fixed-bed filters.

Festo expanded the conventional solution to include the following functionality:

- A manual control panel which allows control of the installation from the control cabinet even in the case of an electrical power supply failure.

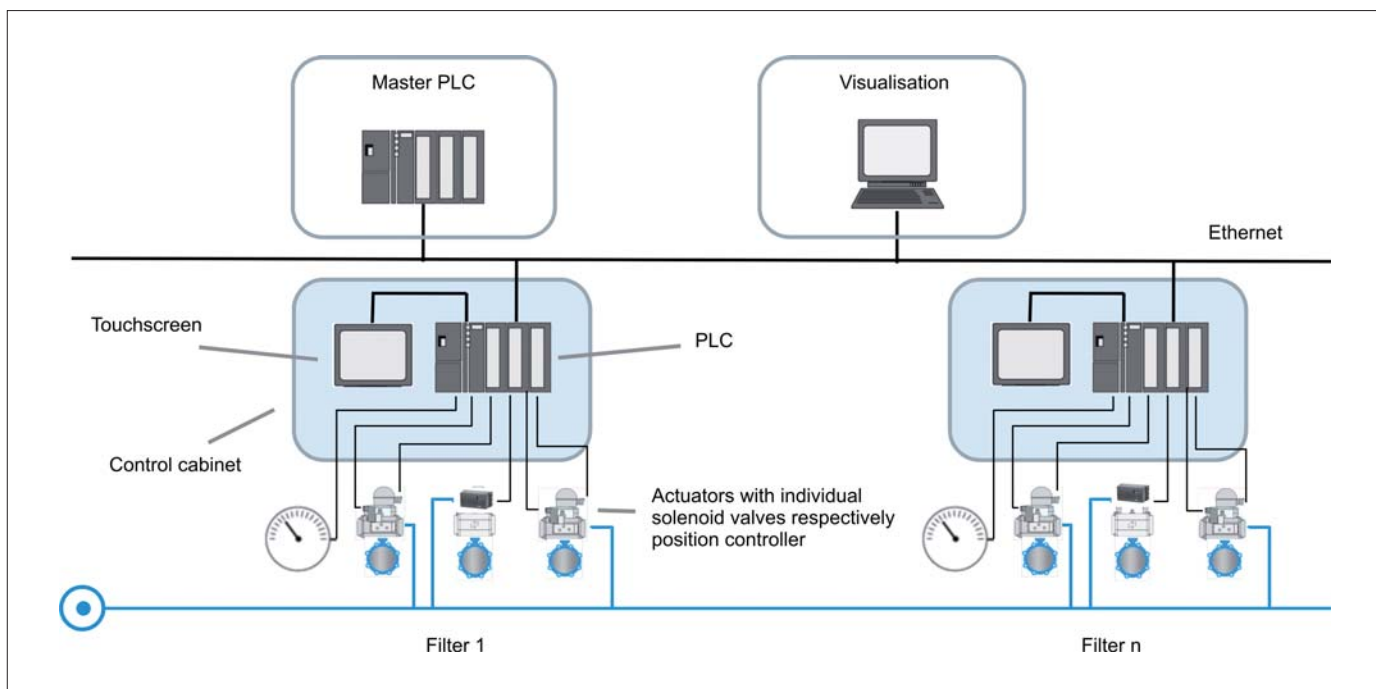


Fig. 6: Conventional automation solution with individual solenoid valves and actuator with position controller

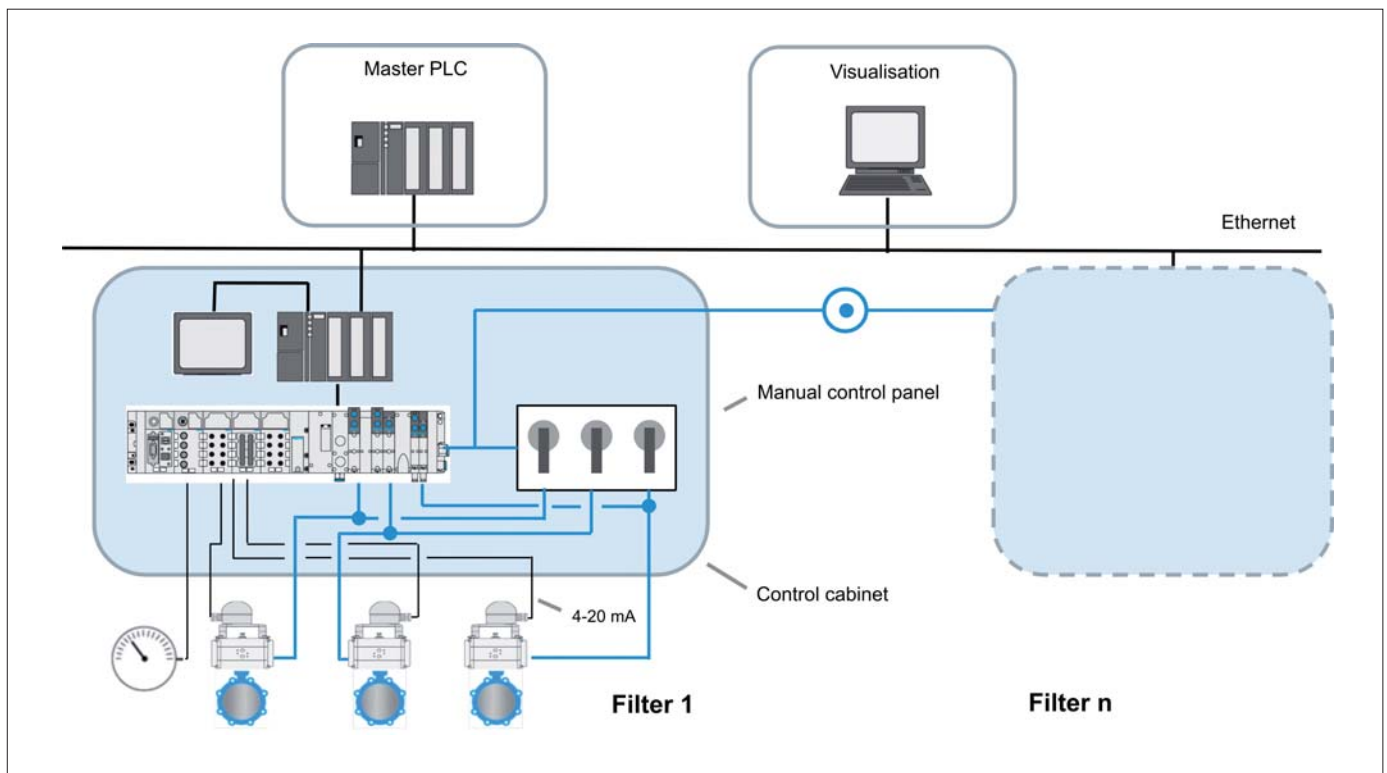


Fig. 7: Festo automation solution with valve terminal and integration of position controller function into control cabinet

- A robust and more flexible solution for the control valve. This remains controllable even without electrical power. The parameters for the controller can be set centrally on the control cabinet.
- A high level of reliability, not only during commissioning but above all during normal operation.

Figure 7 shows the new solution. The major differences are: Valve terminal instead of individual valves, integration of a pneumatic manual control panel and elimination of position controller by distributing its function among three components: Feedback signal for the shut-off valve position by means of a sensor box with an analogue output 4 ... 20 mA, activation of actuator by a 5/3-way solenoid valve on the valve terminal and relocation of the controller software to the PLC.

In comparison with a conventional solution with a position controller, this solution offers several advantages:

- It does not require such high-quality compressed air as the position controller previously used.

- The higher flow rates of the solenoid valves allow fast motions and provide a safety function, even with large actuators.
- The shut-off valve can be adjusted via the manual control panel alone even without electrical power.
- The plant operator no longer needs to go to the shut-off valve, since he can make control parameter changes directly on the control cabinet.

Overall, this solution is more economical than the conventional solution.

Literature

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The Company

Festo is a leading innovator in manufacturing and process automation. The success is based on the simplest drive principle in the world: air. Pneumatics has become a key technology in automation and is Festo's core competence. Festo has been active for many years in the area of water treatment, with complete, single-source automation solutions tailored to meet the needs of plant operators. Festo can supply everything from actuator technology to the field level and deliver it as individual components or a pre-assembled system. Reliable technology and economic efficiency are always bound to be at the forefront of decision making. Festo's automation concept takes both factors into account by reducing complexity and increasing operating reliability.
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