



Planning manual for water treatment plants

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Preface



Since the beginning of the 1990s, pneumatic actuators have been promoted by Festo to an ever greater extent as an alternative to more costly electrical actuators for the automation of process valves in multipol applications.

This manual is intended to provide engineering offices with support in planning water treatment plants. In the past, numerous questions have come up again and again with regard to technical issues during the project engineering phase.

Emphasis is placed upon automation technology with pneumatic control components and pneumatic actuator technology. The advanced system approach using a single fieldbus and additional networks has become fully established in these applications as well in recent years, as is demonstrated by the excerpt from our list of references included below. This automation concept is united with highly reliable industrial components and significantly reduced costs for all implemented projects.

Technical contexts are documented in the manual and functions are represented graphically. This is intended to make our holistic system approach fully transparent. Various notes concerning system dimensioning are based upon actual experience gained through a large number of projects, which have been implemented together with planners and system operators. It is the responsibility of the planner to double check dimensioning in each individual case. Festo specialists are at your disposal for clarification of the system's technical details.

Important note for users of this manual:

Responsibility for planning rests solely with the engineering consultant or the system operator. Festo specialists will provide assistance during planning with information on the pneumatic and electronic control elements.

International references

Wastewater treatment plants

Austria

Graz
Telfs
Waidhofen

China

Xian No. 3 wastewater
Treatment factory

Czech Republic

Karlovy Vary – Carlsbad
Jirkov – Chomutov
Přibram
Rozna
Jindřichův Hradec
Trutnov

Denmark

Korsør, Horsens

France

Paris-Grésillons

Germany

Augsburg
Bielefeld-Heepen
Bremen
Darmstadt
München
Regensburg
Stuttgart-Mühlhausen
Wiesbaden
Wiesbaden-Biebrich

Greece

Athens, Psytalia

Hungary

Budapest
Pecs
Tatabánya

Indonesia

PT. Bekaert, Karawang,
West Java

Netherlands

Nijmegen

Poland

Bilgoraj
Chelm
Klimzowiec
Nowa Dęba
Radocha

Switzerland

Val de Ruz
Zürich, Werdhölzli

Singapore

Changi wastewater
Chua Chu Kang waterworks

Waterworks

Belgium

Diksmuide

Brazil

Gurjaú

China

Neijiang
Peking
Sichuan
Xinjiang
Xining No. 7
Xishan
Yuhan

Colombia

Bogotá
San Andrés

Croatia

Butoniga

France

Champagnole (Veolia)

Germany

Berlin, Friedrichshagen
Berlin, Stolpe
Berlin, Tegel
Berlin, Tiefwerder
Dresden, Coschütz
Granetalsperre
Kleine Kinzig
Sösetalsperre

Hungary

Tatabánya

Hong Kong

Nankeng
Panyu Nasha
Shenzhen Meilin
Zhuhai Gongbei

Indonesia

Cilandak (Suez)
Pejompong (Suez)
Tanah Grogot
Tirta Daroi, Aceh

Italy

Briosco, CAP Gestione

Korea

Seosan

Malaysia

Semenyih
Putrajaya
Bukit Sebakor

Mexico

Acapulco
Mexico-City Tlahuac
Santa Catarina
Cozoleacaque

Poland

Bedzin
Bromberg
Dzieckowice
Goczalkowice
Lublin
Nieszawa
Poznan
Przemysl
Rypin
Strumien
Warta

Russia

St. Petersburg

Serbia

Belgrade
Novi Sad
Nis

Lazarevac

Slovak Republic

Dubravka

Switzerland

Schaffhausen-Warthau

Taiwan

Chen Ching Lake
Kautang Advanced water
Purification Plants (World's
biggest Bi-membrane water
plant)

Thailand

Pathumtani

Turkey

Istanbul-Muradiye, ISKI

Vietnam

Tan Hiep Water treatment plant

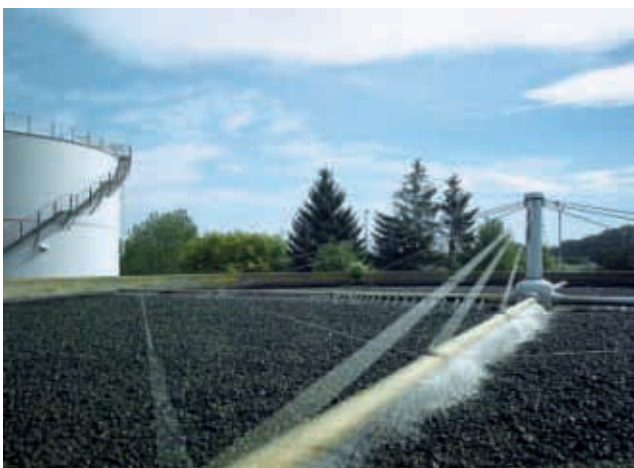
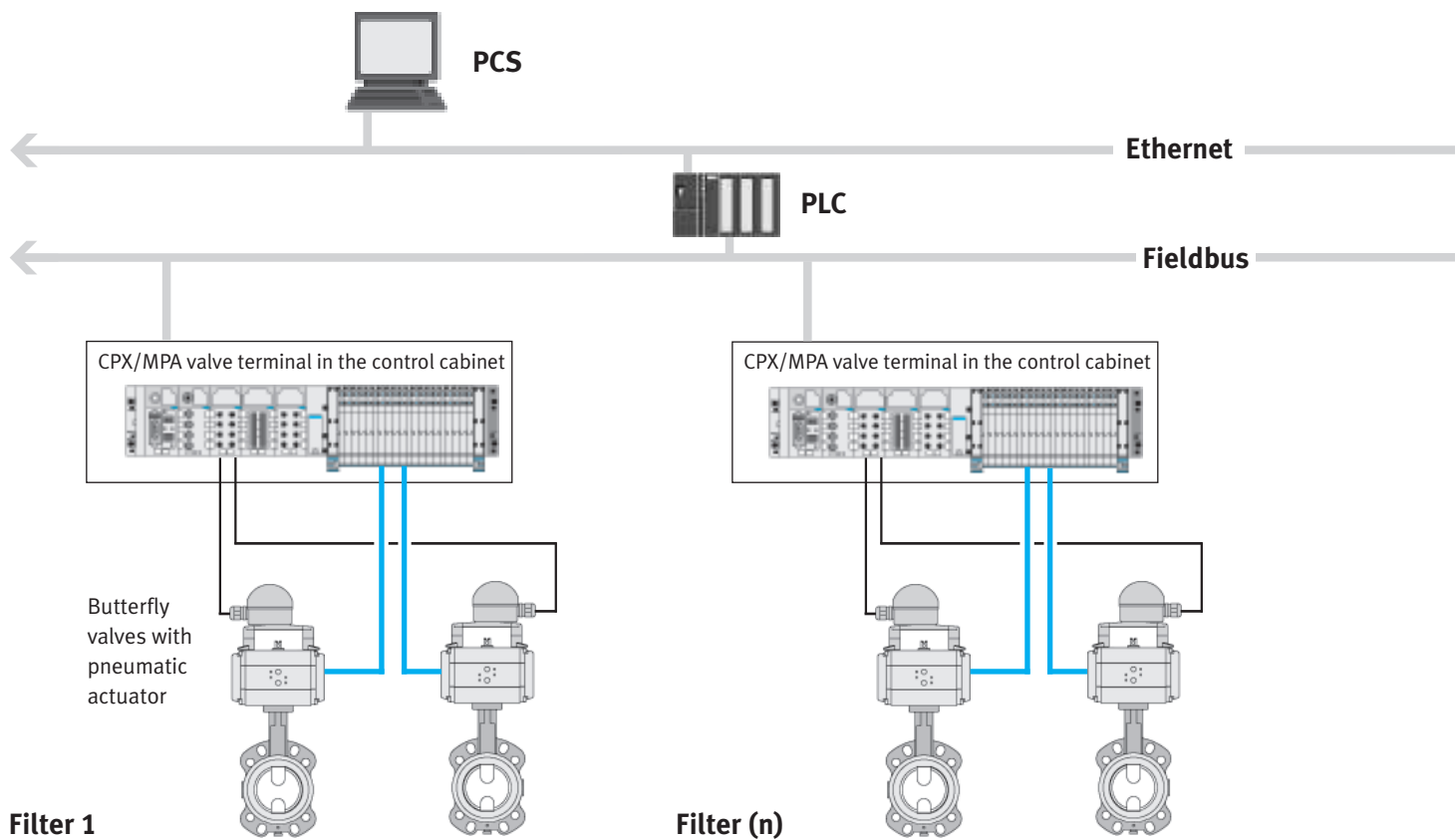


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The automation concept

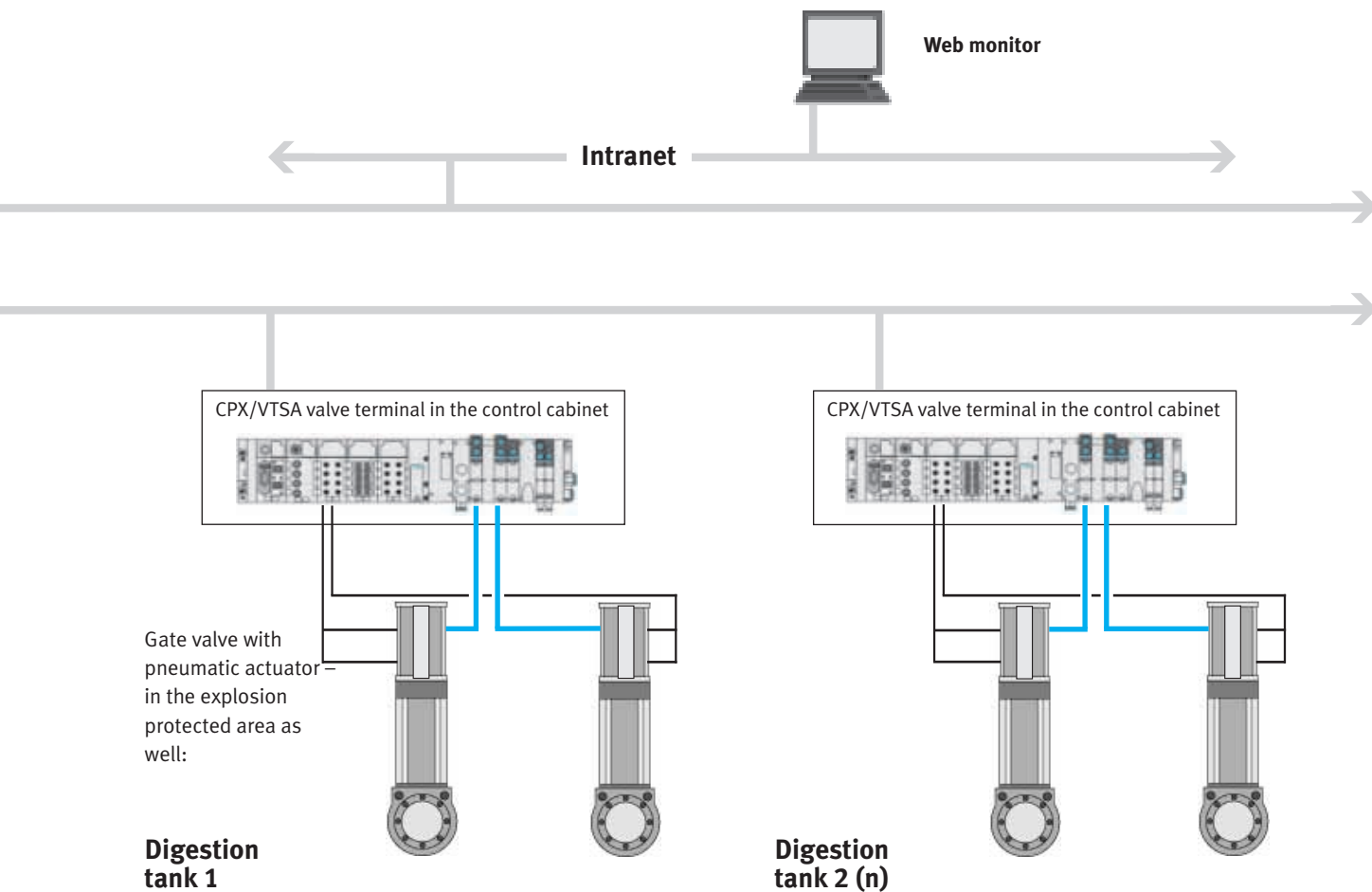


Example: water treatment plant



Nowadays, modern automation solutions are implemented by means of bus systems. Depending upon the scope of the system, automation includes a process control system (PCS), a PLC level and the so-called field level. A link to the intranet for interplant communication can also be easily implemented. Serial communication is used, i.e. via bus systems with fast data transmission. The link between the PCS and the PLC level is established via Ethernet, and connection between the PLC and the field devices via the fieldbus.

Whether process valves, pumps, blowers or measuring instruments need to be linked to the PLC, they can all be connected to a fieldbus. They're all available with appropriate fieldbus interfaces. Various communications protocols can be used for communication between a PLC and a Festo valve terminal.



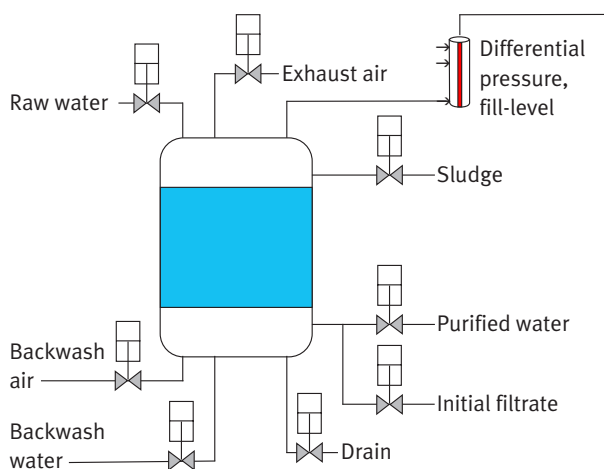
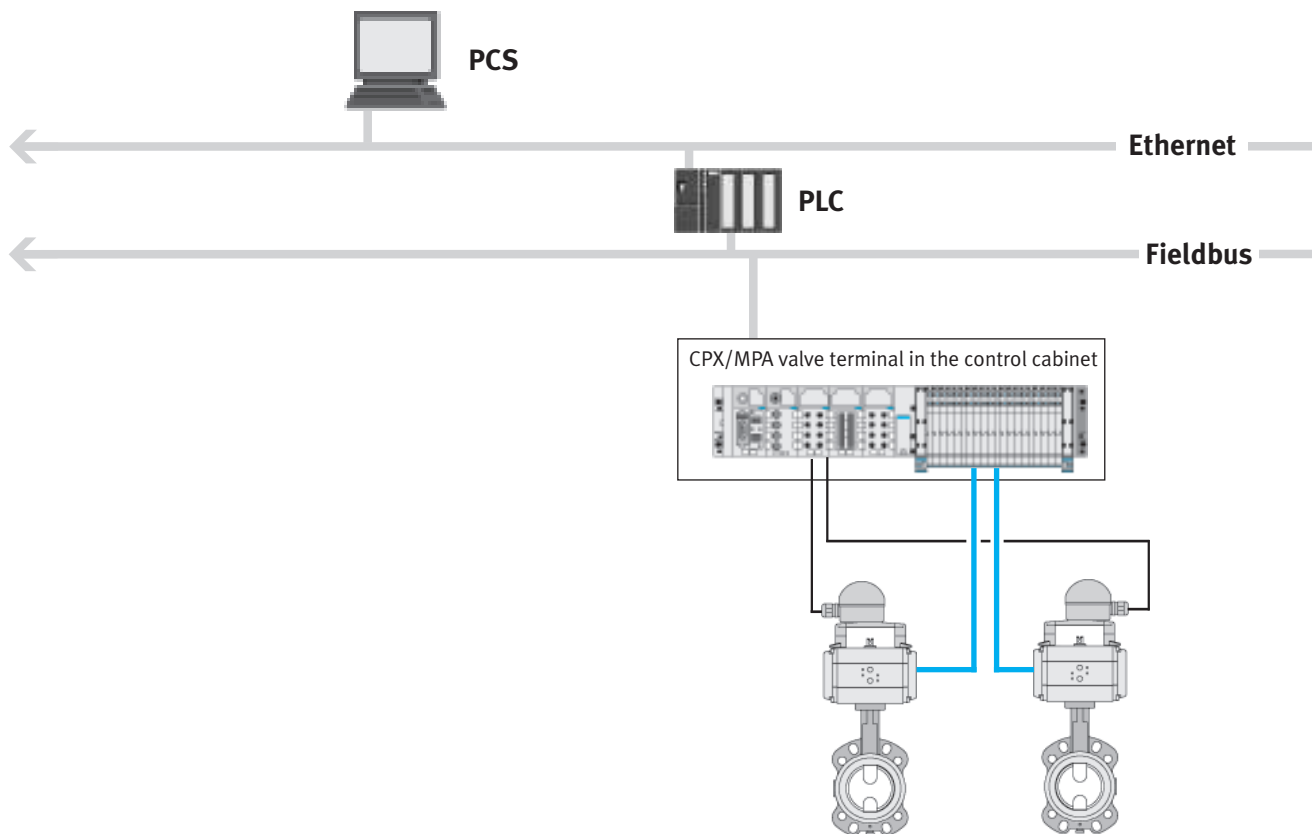
Example: wastewater treatment plant

The advantages of there automation solution

- Significant savings with regard to installation
- More transparency at the individual levels
- Consistent concept with just a few interfaces
- Faster commissioning and failure detection
- Control elements are combined on the valve terminal
- Systems can be easily expanded with the help of the bus systems



Automation for water treatment plants

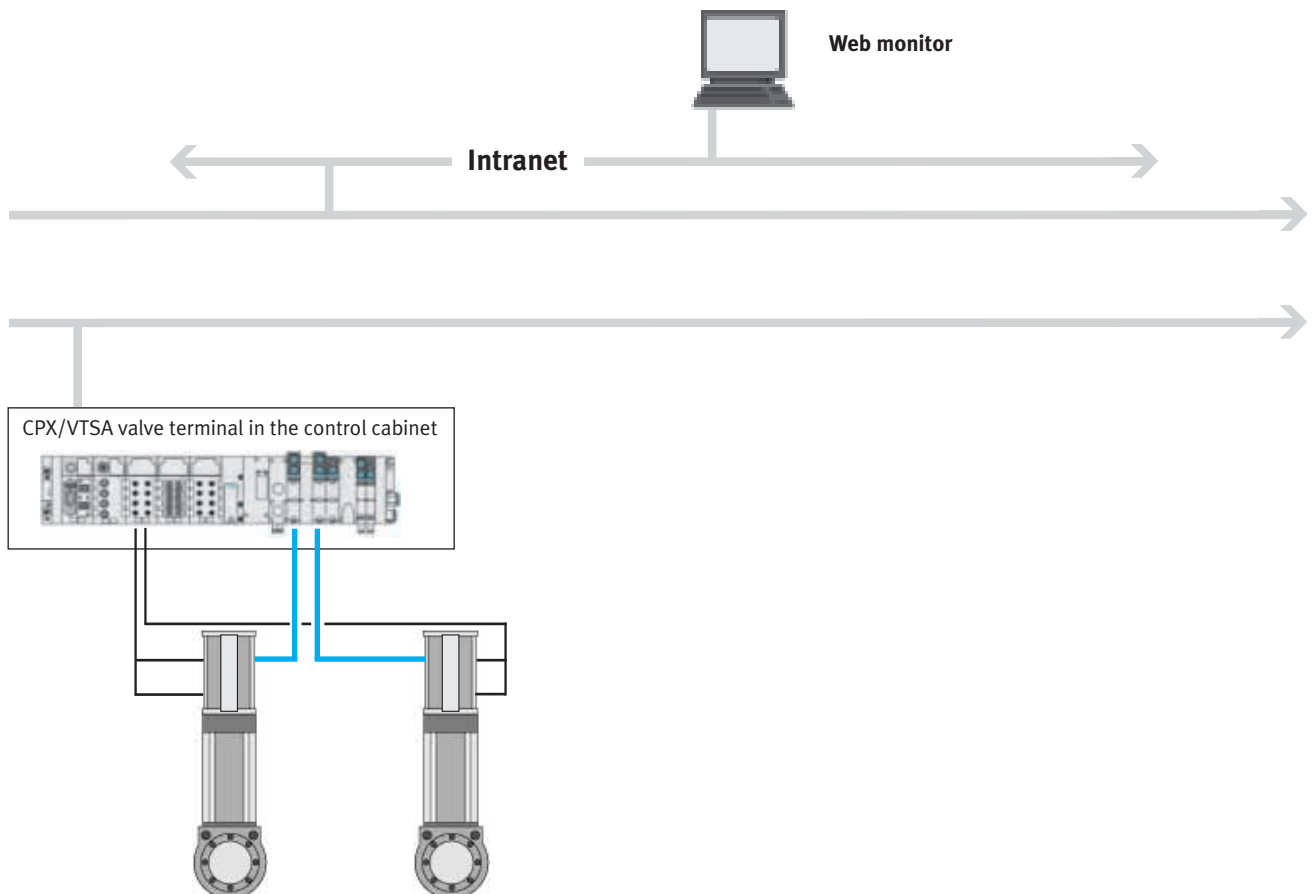


Filter

The most important components of a water treatment plant are the filters. They're used to treat and filter raw water, thus processing it into drinking water. Regardless of whether closed or open filters, or ultra-filtration systems are used, the processes are automated. The butterfly valves are equipped with pneumatic actuators to this end, and are controlled by the valve terminal. The filter's fill-level, differential pressure and flow rate are defined by its current status. These measured values are also acquired at the valve terminal. If a filter needs to be backwashed, the PLC controls the valve terminal,

and thus the order in which the butterfly valves are actuated, in accordance with the back wash programme. After the back wash programme has been completed, normal filter operation is once again initialised. The valve terminal is configured in accordance with the number of pneumatic actuators, limit switches and measuring instruments. Control cabinet installation is utilised for use in water treatment plants.

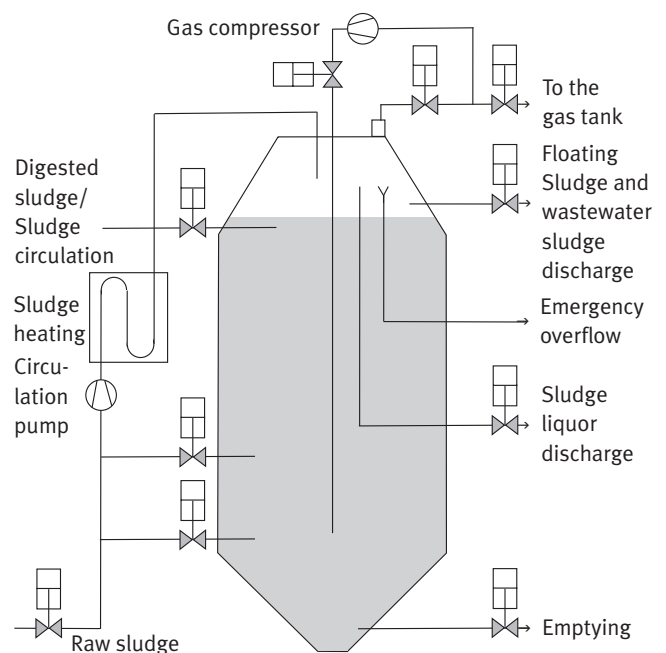
Automation for wastewater treatment plants



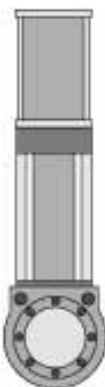
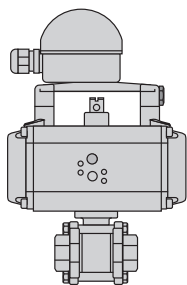
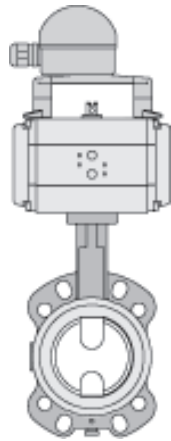
Digestion tank

Whether pump stations, digestion tanks or sludge treatment is involved – process sequences at large wastewater treatment plants are so complex that they are always automated nowadays. The use of pneumatic actuators is more than sensible, both technically and economically, wherever large numerous process valves have to be actuated. The solenoid valves on the valve terminal control the actuators such that the gate valves are opened or closed. The limit switches included in the actuators indicate the position of the valve. The valve can thus be actuated reactionless within the piping system.

Certain groups of gate valve functions are combined onto a single valve terminal in a logical fashion. The operator is thus provided with clarity and transparency regarding the individual function groups, for example for a digestion tank or a pump station. Due to ambient influences, installation of valve terminals in control cabinets is highly practical, and provides protection against tampering by unauthorised persons in outdoor areas.



Checklist for the planning process



When designing a modern automation solution involving pneumatic actuator technology and bus systems, various points relating to the different levels must be clarified and agreed on in advance. Pneumatics offer greater functionality in terms of valve control by using the “second energy source” – compressed air. When using compressed air, different safety-related functions can be forcibly controlled in line with the respective operating situation. This has consequences for the selection of control elements consisting of process valve actuators and valve terminals in a waterworks or wastewater treatment plant. This relates in particular to the behaviour of the process valves during a power failure if there is no emergency power generator available.

The checklist addresses individual aspects of the various function units that must be clarified during the planning process. It is intended solely as a guideline. You will find further information in the relevant sections of the manual.

Automated process valves

The design of process valves and the nominal sizes are defined on the basis of the R+I flow diagram. In concrete terms, this involves defining the functionality of the actuators and the specific requirements.

Normal position of the process valve when system is out of operation or when advancing

- “Closed” or “open”

Safety position of the process valve in the event of power failure, when forcibly closed, opened or paused

- Single-acting actuator for butterfly valve or ball valve
- Emergency reservoir for hand lever valve actuator

Sensing of the actuator position via two limit switches in each case

- “Open/closed sensing”
- Switching voltage, 24 V DC as standard

Adjustable opening and closing times of the process valve

- Actuator with two exhaust air flow control valves

Process valve for intermediate positions for metering material flows

- Attachment of a positioner to the actuator

Process valve for use in ATEX zones

- Definition of the ATEX zone

Special requirements with respect to the environment

- Exposure to dust
- Aggressive external stress
- Temperature range, below 0° C or above 40° C

Valve terminal and network

A valve terminal consists of a pneumatic part and an electrical part, the CPX terminal. The configuration of the valve terminal is defined by the number of actuators to be controlled and the number of electrical signals for the CPX terminal.

Definition from the R+I flow diagram of how many solenoid valves are to be provided on the valve terminal

- Number of solenoid valves
- Number of vacant positions

Function of the solenoid valves

- Single solenoid
- Double solenoid
- Mid-position closed

Flow rate of the solenoid valves, dependent on

- Size of the actuators
- Switching time of the process valves
- Length of the tubing to the actuators

Limit switches of the actuators

- Number of digital inputs

Electrical manual control unit

- Number of digital inputs and outputs

Actuators with positioner

- Number of analogue inputs and outputs

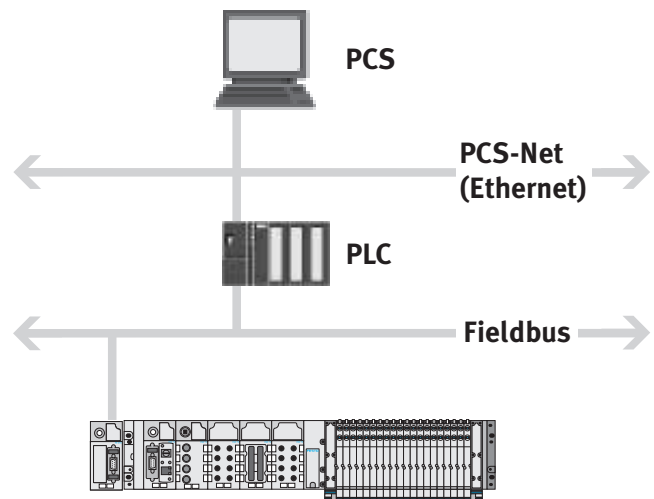
Connection of measuring devices and analogue actuators

- Number of further analogue inputs and outputs

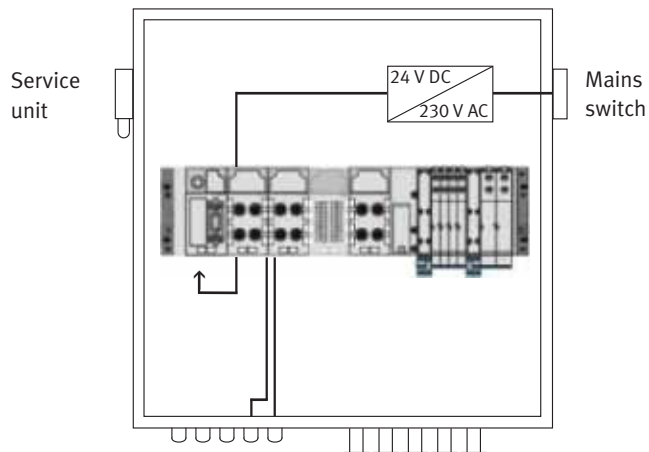
CPX terminal of valve terminal with own PLC

- Embedded Controller (CPX-CEC) for stand-alone operation

Networks with fieldbus, Ethernet and appropriate transmission protocols, depending on the higher-order PLC and the PCS.



Checklist for the planning process



Control cabinet for valve terminal

There is a wide range of control cabinet designs and cabinet layouts. Important specifications must therefore be made in advance.

Installation site, with or without heating

- Inside
- Outside

Connection surface for cables and tubing

- Underneath
- Top
- Side
- Rear

Central power supply

- 230 V AC or 24 V DC, emergency supply by means of UPS
- Cable cross section for supply

Isolation amplifier for electrical signals from ATEX zone

Master switch with fuse elements

Changeover switch for automatic/manual mode

Tubing connections

- Nominal size 16 for main supply
- Nominal size 6, 8 or 10 for actuator

Compressed air supply via service unit

- Non-return valve
- Manual on/off valve
- Pressure regulator with filter
- Pressure switch

Compressed air system and pipelines

The following points, among others, must be clarified for the precise and exact dimensioning of the compressed air generation and distribution systems.

Calculate the compressed air requirement

- Standard consumption per actuator
- Total consumption of all actuators
- Consumption per unit of time: per hour, per day, per week
- Plan the intake volume of the compressors

Select the compressors

- Single-stage or two-stage Piston compressor
- Oil-free or lubricated version

Determine the size of the reservoir required to move the process valves to the safety position

- Number of actuators that have to be actuated to reach the safety position
- Define the pressure level in the compressed air network to determine the available differential pressure

Establish the installation site of the compressors, compressed air preparation system and main reservoir

- Sufficient ventilation of the room
- Dust-free supply of intake air for the compressors
- Uniform room temperature between +10° C and 30° C

Dimension the compressed air network

- Ring circuit version
- Branch line version with secondary reservoir
- Install pressure switches and stop cocks for protecting the compressed air network
- Define the diameter of the duct

Define the compressed air quality as per the equipment specifications: Classification for

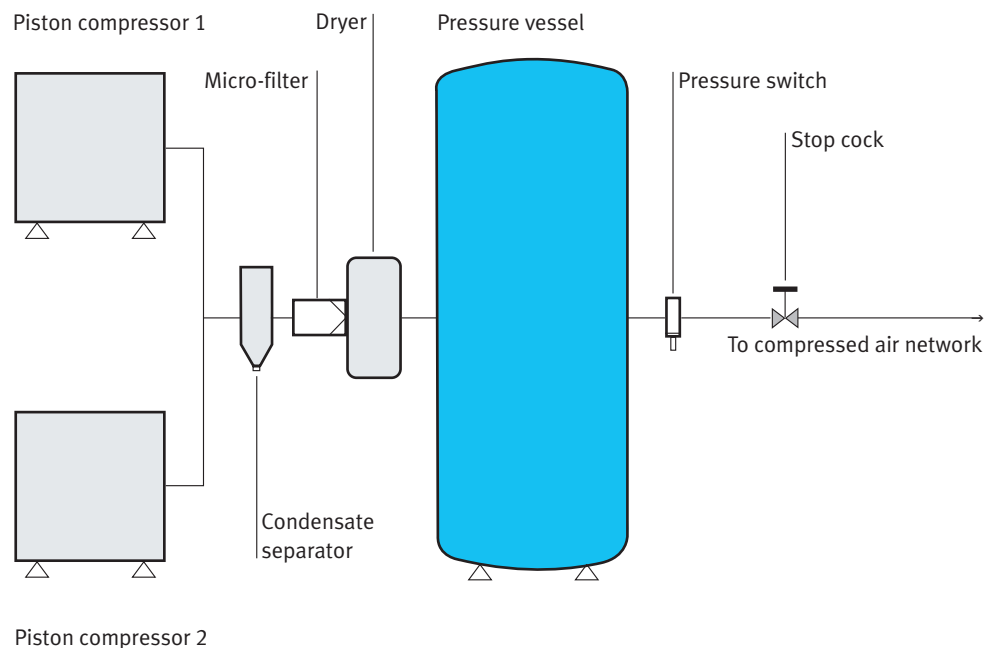
- Solids
- Water content
- Oil content

Prepare the compressed air by means of

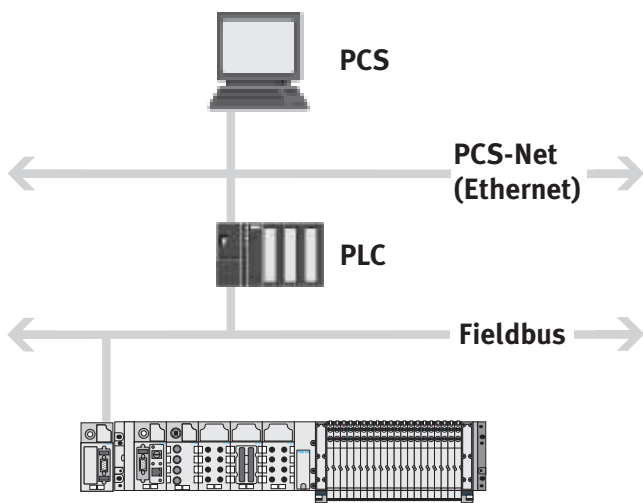
- Condensate separator
- Oil separator
- Micro filter
- Air dryer

Dimension the air dryer

- Note the pressure point and temperature range of the compressed air when using pneumatic actuators outside
- Consumption measurement/maintenance
- Operating time counter
- Monitor the compressed air consumption



Networks



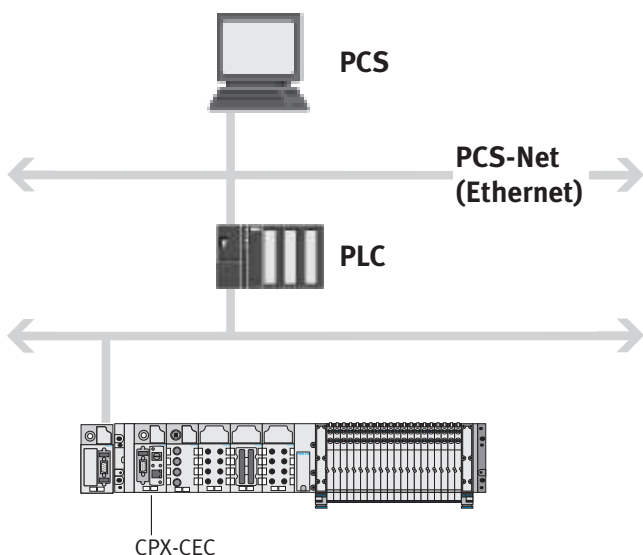
When designing automation solutions, there are different networks available in which valve terminals with the CPX terminal can be integrated. The networks ensure communication between the valve terminal, the control system and the process control system. “Industrial Ethernet” has established itself as the protocol for networking controllers and the process control system.

Integration of the valve terminal

Fieldbus systems are used at the field level. This enables the CPX terminal of the valve terminal to be operated on the following widely used bus systems:

- Profibus
- Interbus
- DeviceNet
- CANopen
- CC-Link

The respective fieldbus node is integrated in the **CPX terminal** and the valve terminal acts as a **slave** for the PLC.



Intelligent valve terminal at the fieldbus

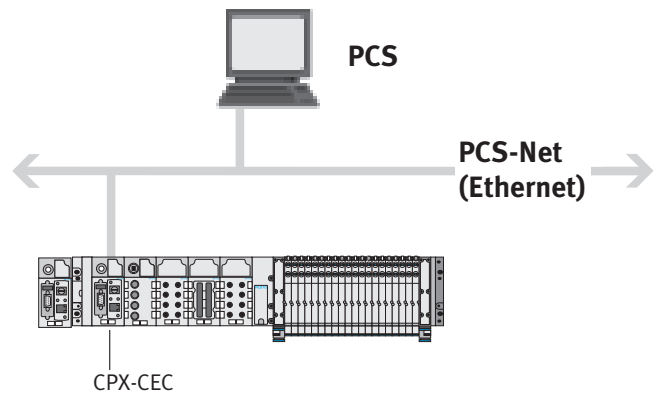
A further variant of the CPX terminal features its own PLC, the so-called **Embedded Controller CPX-CEC**, in addition to the fieldbus node. The valve terminal works like an **intelligent slave**. This enables the valve terminal to work independently of the rest of the network and/or the higher-order PLC and PCS. The CPX-CEC looks after the valve terminal’s logical links. This variant offers high system availability and enables individual system components to continue running in the event of network faults. This can be very useful for filter controllers or even for pumping stations, for example.

Intelligent valve terminals and Ethernet

The CPX terminal is directly connected to Industrial Ethernet via the Embedded Controller CPX-CEC. The valve terminal also works as a stand-alone subsystem in this variant. Communication thus takes place directly with the PCS or peer control systems.

The CPX-CEC supports the following transmission protocols:

- Ethernet/IP
- Modbus/TCP
- PROFINET
- EtherCAT

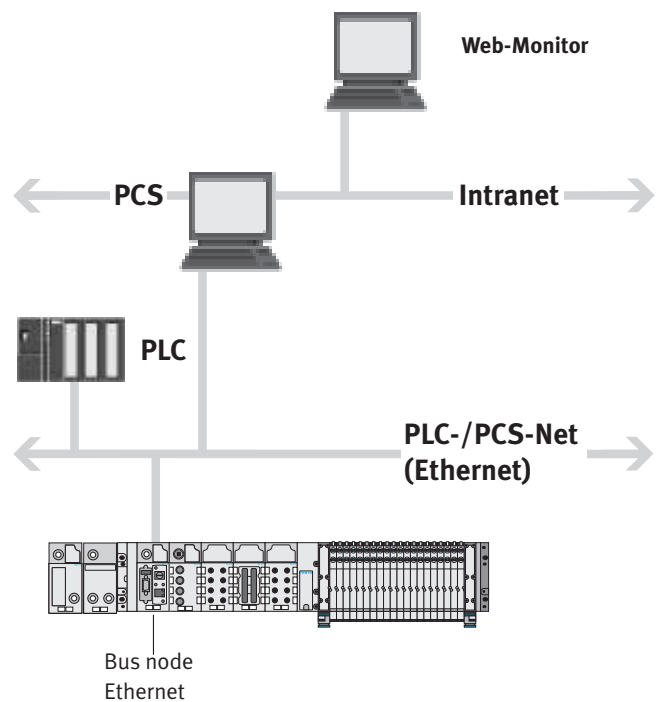


CPX terminal with integrated web monitor

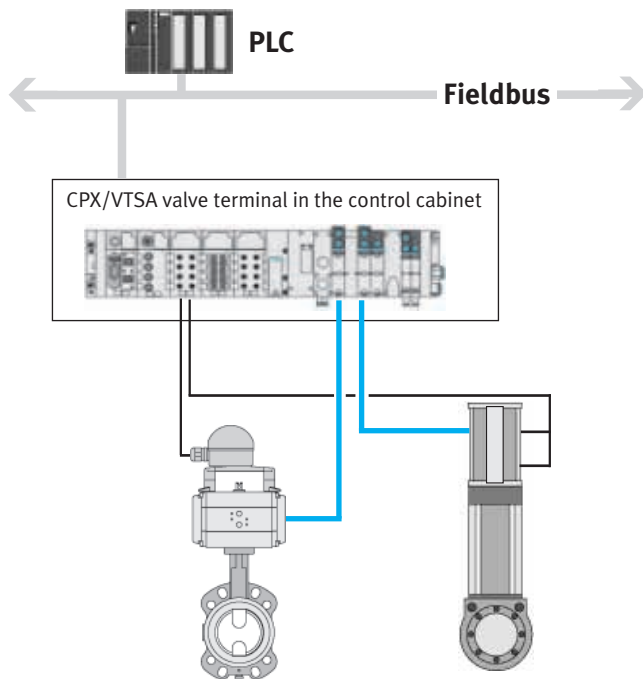
This network configuration enables the user to display the service information from the CPX terminal in real time on an external web monitor. This is a simple way of carrying out remote diagnostics. The web monitor is a software application for the CPX modules.

The CPX terminal works as a slave directly at Ethernet and the sequencing program for the valve terminal is stored in the PLC. The following transmission protocols are available:

- Ethernet/IP
- PROFINET



The valve terminal system



The valve terminal establishes a connection between pneumatic and electrical components in an ideal fashion. The valve terminal is subdivided into a pneumatic and an electrical section. An internal system bus handles communication within the valve terminal. 24 V DC supply power is provided from a central connection.

Layout and function of the valve terminal

Communication with a PLC via fieldbus: The sequencing programme for the system is stored at the PLC. The individual programme steps are transmitted via the fieldbus. The programme steps are executed by the valve terminal.

Fieldbus or multi-pin plug connection

There are two connection variants available. Serial data transmission is carried out by the PLC via the fieldbus connection. With the multi-pin plug connection, data transmission is carried out in parallel, i.e. via individual wiring. This requires I/O modules in the PLC. The connection is established via a multi-core cable.

Modular design and flexible configuration

Both the pneumatic and the electrical sections of the valve terminal can be flexibly configured through the use of a multitude of modules. Digital as well as analogue input and output modules are available for the electrical section.

A great variety of valve functions

Various solenoid valves can be included in the pneumatic section. Depending upon the process valve functions, any of the following valves can be used:

3/2-way valves
5/2-way, single solenoid valves
5/2-way, double solenoid valves
5/3-way valves

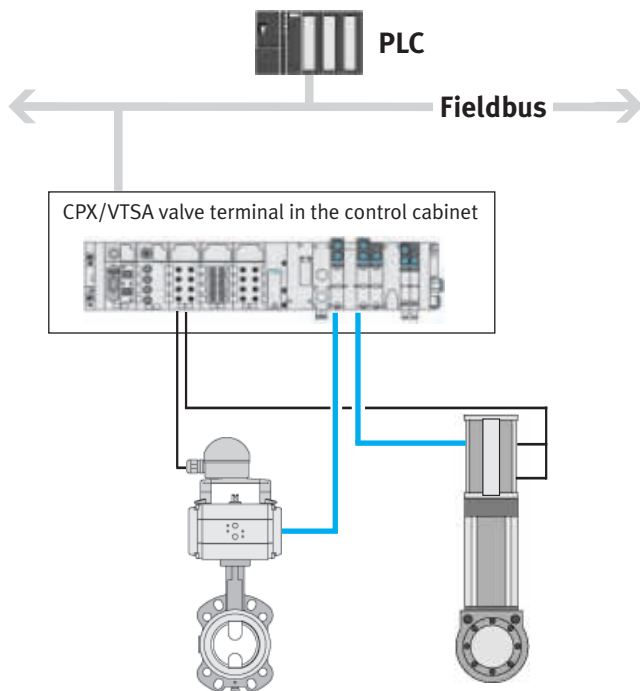
Ideal adaptation to the system concept

The modular design of the valve terminal assures ideal adaptation to the system concept. An appropriate solenoid valve is configured for each pneumatically actuated process valve. Corresponding digital inputs are included for the limit switches in the pneumatic actuators. For example, if 10 process valves need to be controlled, the valve terminal includes 10 solenoid valves and 20 digital inputs should be provided.

Valve terminal as local controller

The valve terminal functions as a central point of connection within the system. It establishes a connection to the process valves distributed throughout the system which are pneumatically controlled. The current status of the process valves is indicated at the valve terminal by means of LEDs. The manual override on the solenoid valves is especially well suited for manual operation.

Layout of the control loop system



Process valve with pneumatic actuator, open-close function

Whether knife gate valves, butterfly valves or other process valves are involved, an open-close function is usually included. The pneumatic actuator is only operated in two directions, so that the process valve can be opened or closed. A solenoid valve is required on the valve terminal in order to control the actuator. The number of process valves which have to be controlled determines how many solenoid valves are included on the valve terminal. The limit switch mounted to the actuator informs the valve terminal when the pneumatic actuator has reached its respective end-position. This means that two digital inputs are required on the valve terminal for each actuator or process valve.

Process valve with pneumatic actuator, controlled function

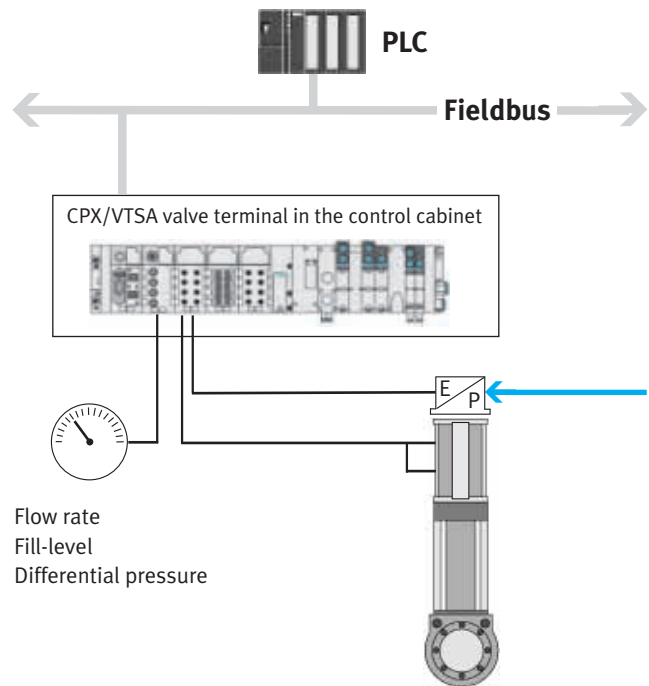
If one or more process valves are required for flow dosing, the pneumatic actuators are also capable of advancing process valves to intermediate positions. So called position-dependent actuators are used to this end. In addition to the actuator itself, actuator systems of this sort also include the following function modules:

- Electro-pneumatic positioners
- Displacement encoder for actual position (Potentiometer)
- Limit switch for sensing the actuator's end-position

A setpoint signal within a range of 4 to 20 mA is required from the valve terminal in order to control the positioner. Setpoint and actual value signals are compared with each other by the positioner. If the values are identical, the actuator is held in its current position. When a new setpoint is specified, for example 12 mA, the actuator advances to the new position.

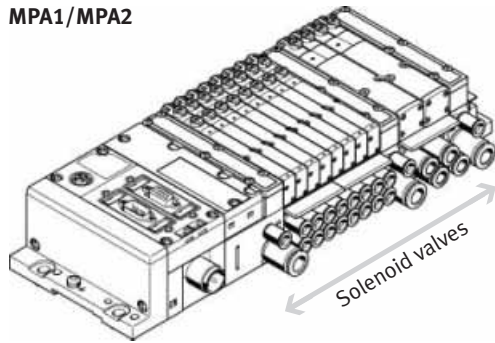
Attention: :

When used as a control valve, the cavitation characteristics of the process valve must be taken into consideration. It is especially advisable to consult with the process valve manufacturer in this respect.



Modular design of pneumatic components

MPA1/MPA2



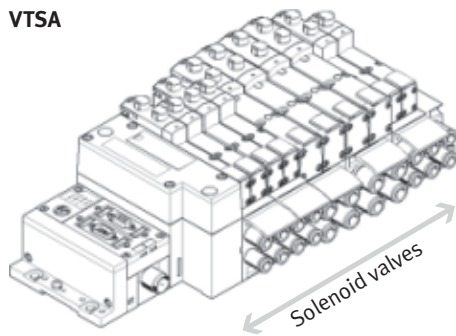
MPA1/MPA2

4 position (MPA1) and 2 position (MPA2) sub-bases are available for laying out the pneumatic components. These can be freely defined via the configurator. The pneumatic system can be expanded to include as many as 32 valve positions, or 64 coils for double solenoid valves.

MPA1 flow rate: up to 360 l/min.

MPA2 flow rate: up to 720 l/min.

VTSA



VTSA

The pneumatic system can be expanded to include as many as 32 valve positions and up to 32 solenoid coils. Two and single-position sub-bases are available for layout. These can be defined in a mixed manner via the configurator.

Flow rate for 18 mm width:
up to 550 l/min.

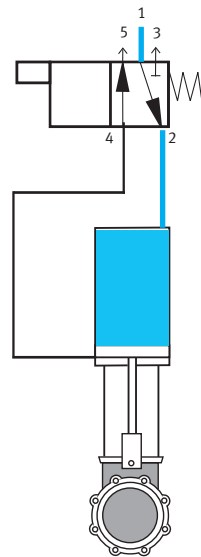
Flow rate for 26 mm width:
up to 1100 l/min.

Flow rate for 42 mm width:
up to 1500 l/min.

5/2-way single-solenoid valve function

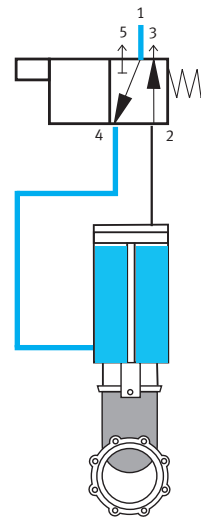
The process valve is normally closed or normally open. The solenoid coil is de-energised. The process valve is reversed by permanently energising the solenoid coil. The safety position/normal position must be defined in advance.

Deenergised solenoid coil



Gate closed

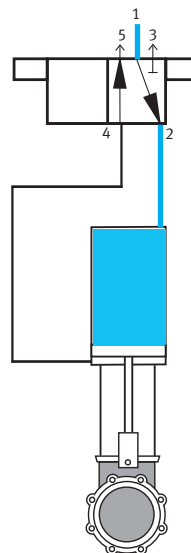
Energised solenoid coil



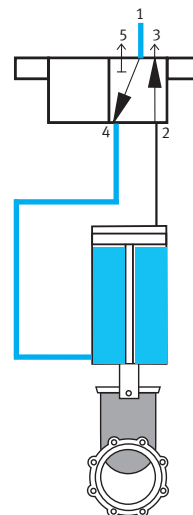
Gate open

Valve function: 5/2-way double solenoid

Once coil is briefly energised in order to reverse the valve. The process valve is correspondingly reversed and remains in its new position, whether open or closed.



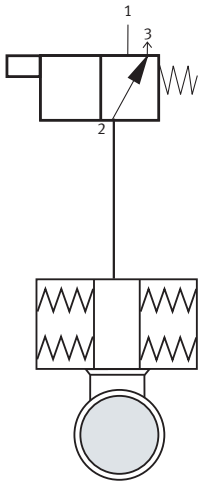
Gate closed



Gate open

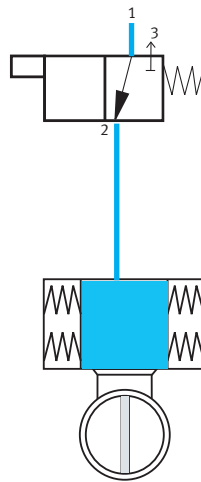
Modular design of pneumatic components

Deenergised solenoid coil



Butterfly valve closed

Energised solenoid coil

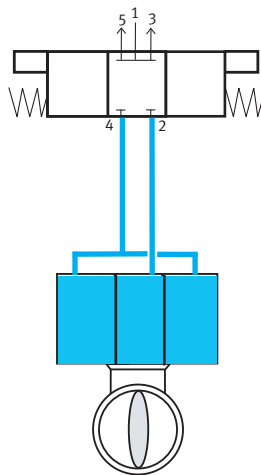


Butterfly valve open

3/2-way valve function

The process valve is normally closed. The coil must be energised to reverse the actuator. The pilot air moves the two pistons of the actuator against the springs. The process valve opens and the springs have a closing or opening effect in the event of power failure.

Deenergised solenoid coil



Butterfly valve in mid-position

Deenergised solenoid coil

Valve function: 5/3-way double solenoid, closed in the mid-position

Once coil is continuously energised in order to reverse the valve. If neither coil is energised, the valve remains in its mid-position and blocks both pistons. The actuator remains in its current position.

Modular design of CPX electrical components

Optimally adaptable to the required functions. The CPX terminal is the electrical and communications interface for the valve terminal. A maximum of 10 modules can be connected in series. The necessary 24 V DC power supply should be protected by means of a UPS (uninterruptible power supply).

Input/output modules

Digital inputs

max. 16 per module

e.g. for limit switches of actuators

Digital outputs

max. 8 per module

e.g. for electrical final control elements such as motors

Analogue inputs

max. 4 per module, 4 to 20 mA

e.g. for signals from measuring devices

Analogue outputs

max. 2 per module, 4 to 20 mA

e.g. for setpoint signal from a positioner

Network node

Integration of the PLC systems or PCS system of various manufacturers takes place via the different bus nodes. The CPX terminal supports the following protocols for fieldbus systems:

- Profibus
- DeviceNet
- InterBus
- CANopen
- CC-Link

Ethernet systems:

- Ethernet/IP
- Modbus/TCP
- PROFINET
- EtherCAT

The corresponding GSD files for the different bus protocols can

be downloaded from the Internet (www.festo.com/fieldbus).

Diagnostics via CPX terminal

Module and channel-specific diagnostics are supported, e.g.

- Undervoltage of the outputs and valves
- Short circuit at inputs, outputs and valves
- Interruptions to valves
- Parameter faults

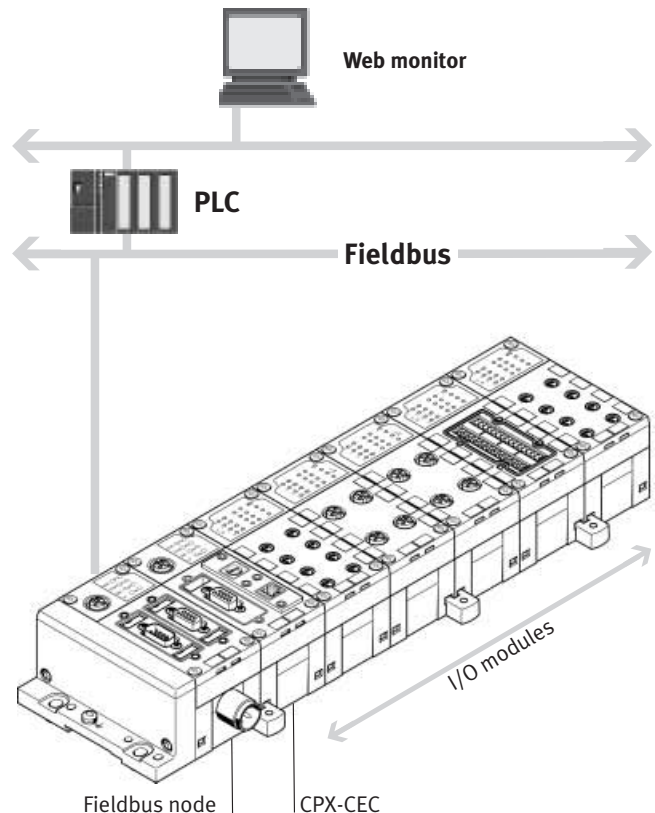
Embedded Controller CPX-CEC

Integrated PLC system for stand-alone operation of the valve terminal. The valve terminal remains operational even if communication via the fieldbus or Ethernet is interrupted. The CPX-CEC can also establish the connection with the web monitor via Ethernet. If an electrical manual control unit is desired, this can be realised through a program in the CPX-CEC via the I/O level of the CPX terminal. The valve terminal then becomes a programmable controller. A Front End Display FED offers a further means of local operation. This is connected to the CPX-CEC via the RS232 interface.

CPX macro library for ePLAN

This library is where the necessary macros for reliable planning of electrical projects are stored. This ensures planning reliability, standardisation of the documentation, access to all of the symbols as well as graphics and master data.

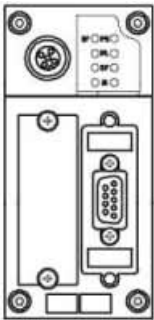
ePLAN
electric



CPX order code

Important CPX modules

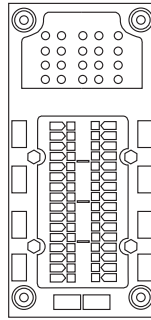
Code		Description
50E	Valve terminal, electrical section	CPX modular electrical terminal
	Electrical module, position 0 ... 9	
F06	Electrical actuator/inputs and outputs, position 0 ... 9	Fieldbus node for Interbus
F11		Fieldbus node for DeviceNet
F13		Fieldbus node for Profibus DP
F14		Fieldbus node for CANopen
F23		Fieldbus node for CC-Link
F32		Fieldbus node for Ethernet/IP
T06		CoDeSys Embedded Controller – RS232
T07		CoDeSys Embedded Controller – CANopen
F		Input module, 4 digital inputs
E		Input module, 8 digital inputs
D		Input module, 8 digital inputs (channel diagnosis)
O		Input module, 8 digital inputs (NPN)
M		Input module, 16 digital inputs
L		Output module, 8 digital outputs
A		Output module, 4 digital outputs
Y		I/O module, 16-fold, 8 digital inputs/outputs each
I		Input module, 4 analogue inputs (current)
T		Input module, 4 analogue inputs (temperature)
U		Input module, 4 analogue inputs
P		Input module, 4 analogue outputs



CPX-FB13



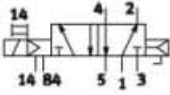
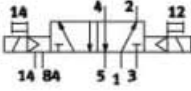
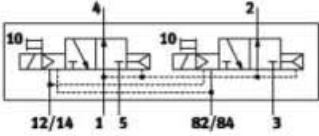
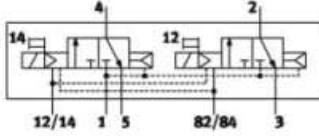
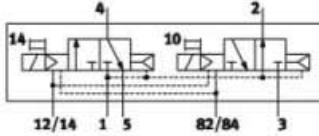
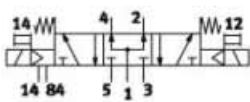
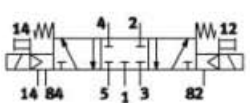
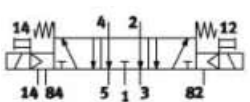
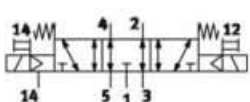
CPX-CEC



CPX-AB-8-KL-4POL

MPA1/MPA2 order code

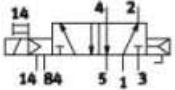
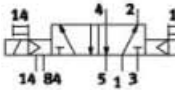
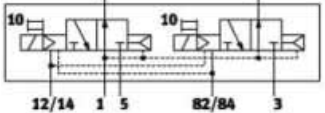
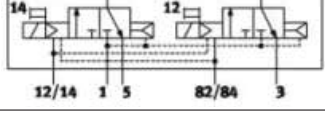
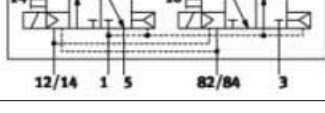
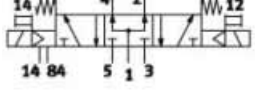
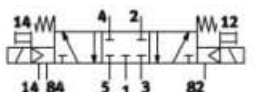
Important valve function

Code	Valve function	Description
M		5/2-way valve, single solenoid, pneumatic spring return
O		5/2-way valve, single solenoid, pneumatic spring return
J		5/2-way valve, double solenoid
N		2 ea. 3/2-way valve, single solenoid, normally open, pneumatic spring return
K		2 ea. 3/2-way valve, single solenoid, normally open, pneumatic spring return
H		2 ea. 3/2-way valve, single solenoid, neutral position 1 closed, 1 open, pneumatic spring return, operating pressure: > 3 bar
B		5/3-way valve, mid-position pressurised ¹⁾ , spring force return
G		5/3-way valve, mid-position closed ¹⁾ , spring force return
E		5/3-way valve, mid-position exhausted ¹⁾ , spring force return
L		Only for valve terminal: blanking plate for valve position

¹⁾Travel to mid-position possible without electrical signal, or using both signals

VTSA order code

Important valve function

Code	Valve function	Description
M		5/2-way valve, single solenoid, pneumatic spring return
J		5/2-way valve, double solenoid
N		2 ea. 3/2-way valve, single solenoid, normally open, pneumatic spring return
K		2 ea. 3/2-way valve, single solenoid, normally closed, pneumatic spring return
H		2 ea. 3/2-way valve, single solenoid, normal position 1x open 1x closed, pneumatic spring return
B		5/3-way valve, mid-position pressurised, spring force return
G		5/3-way valve, mid-position closed, spring force return
E		5/3-way valve, mid-position exhausted ¹⁾ , spring force return
L		Only for valve terminal: blanking plate for vacant position

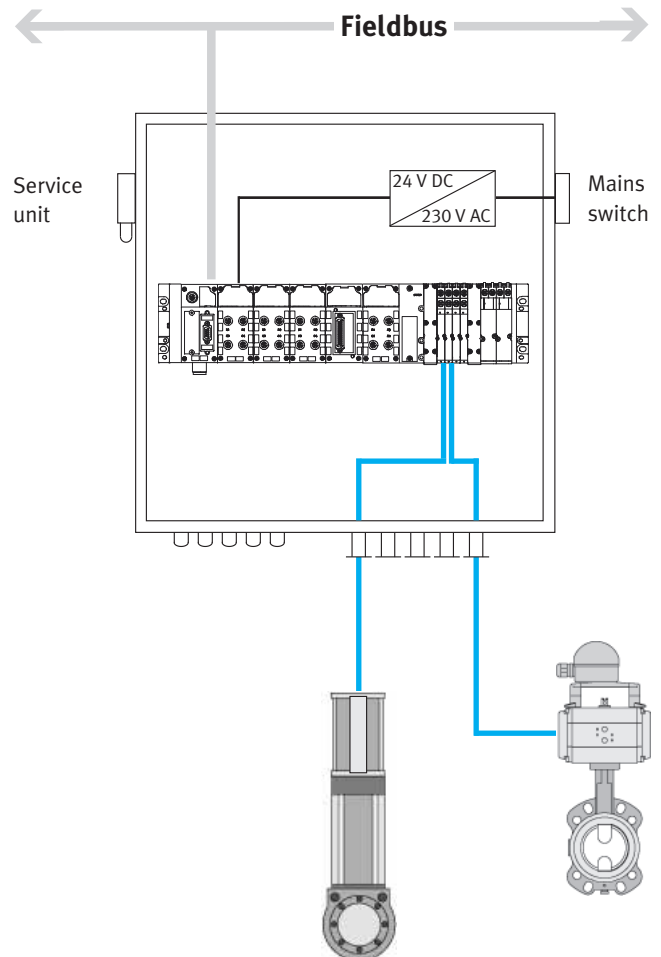
¹⁾ If neither solenoid coil is energised, the valve is advanced to its mid-position by means of spring force.
If both coils are energised simultaneously, the valve remains in the previously selected position.

Pneumatics in the control cabinet

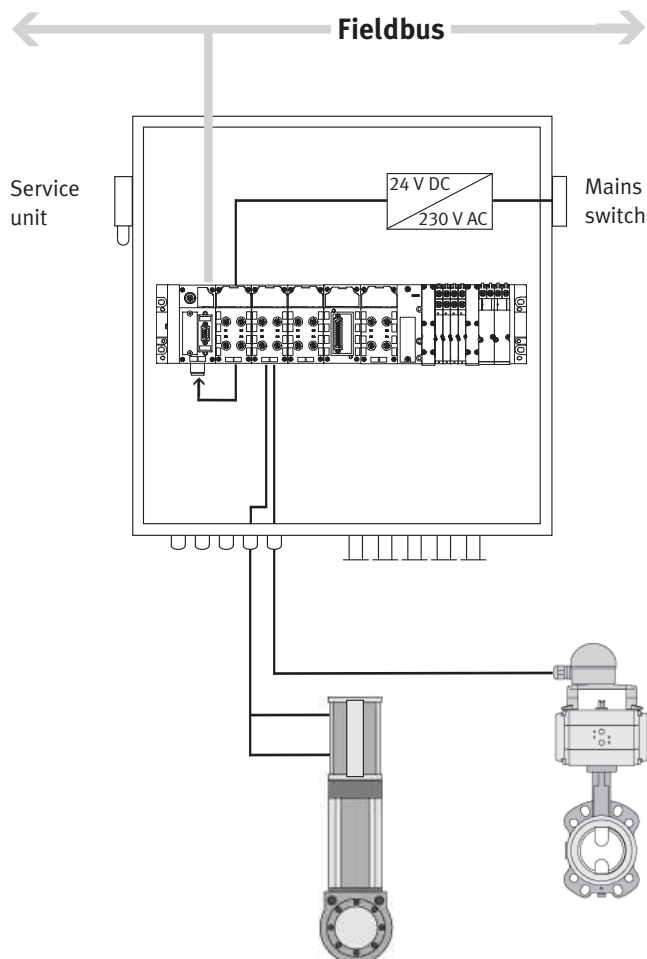
The required pilot pressure is supplied via the service unit attached externally to the side. However, the service unit can also be installed inside the cabinet if desired. The pneumatic section of the valve terminal is supplied directly from the service unit. Both of the “pilot tubes” for connecting the actuators are connected internally from the respective valve position to the QS push-in fittings. QS push-in fittings can be supplied with nominal sizes of 6, 8 and 10 mm.

The service unit consists of the following components:

- A non-return valve which prevents exhausting of the control cabinet and the actuators due to malfunctioning
- Manual on-off valve for targeted pressurisation and exhausting of the system, for example during installation, commissioning and trouble-shooting
- Pressure regulator with pressure gauge and automatic condensate drain, for adjusting the required pilot pressure of, for example, 5 or 6 bar
- A pressure switch which generates an electrical signal when pressure drops to below an adjustable value. Important preventive error-message



Electrics in the control cabinet



As a rule, supply voltage is 230 V AC and can be disconnected with the main switch. The internal fuse link is rated for 10 A.

In the event of power failure, the valve terminal and the entire control loop (e.g. PLC and PCS) must be supplied with power from an uninterruptible power supply. The UPS assures error-free restart for the system, or for system segments.

- Supply power: 230 V AC with 10 A fuse
- Power pack: 230 V AC/24 V DC, 5 or 10 A depending upon the number of solenoid valves and CPX modules
- Connections for digital inputs/outputs
- Connections for analogue inputs/outputs
- Fieldbus connection
- Solenoid valve can be switched with a key switch

Configuration of the control cabinet with valve terminal

It's advisable to install the valve terminal to a control cabinet in order to provide it with adequate protection. Especially if it's used outdoors, it's thus protected against tampering by unauthorised personnel. The control cabinet offers mechanical protection as well.

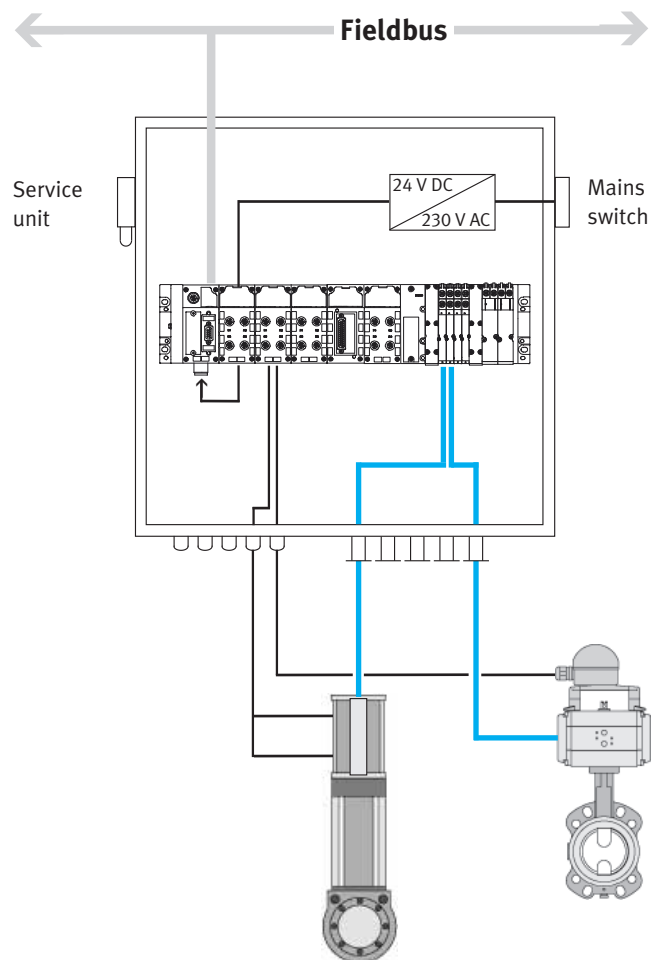
The following variants are available:

- Steel sheet metal, painted RAL 7035 amongst other colours
- 1.4301 stainless steel
- Plastic, GRP, unsaturated polyester
- Special version with observation window in the door
- Heating element for outdoor use
- Weather protection
- Rack mounting
- Wall mounting
- Connection area on top or bottom

The control cabinet includes the following components as standard equipment:

- Valve terminal
- Power pack, 230 V AC/24 V DC
- Mains switch with fuse link
- Auto/Man key switch
- Cable gland with steel conduit thread
- Service unit of pneumatic
- Tubing connections: QS-6, QS-8, QS-10

The layout of the control cabinet should be coordinated with Festo's experts in a project related fashion.



Ready-to-install control cabinets



The planning phase should include coordination between the planning office and operator about which process valves are to be controlled by the respective control cabinet. The following individual points must be defined and must then be incorporated into the technical specifications:

Configuration of the valve terminal

- Fieldbus connection/Ethernet connection/CPX-CEC
- Number of I/O connections, digital/analogue
- Number of solenoid valves, whether single solenoid or double solenoid

Project-specific realisation

Realisation of the individual control cabinets can begin following detailed coordination between the planner, operator and the Festo specialists. A project number is assigned for each control cabinet. This number is then the reference for all coordination activities between all those involved in the respective project.

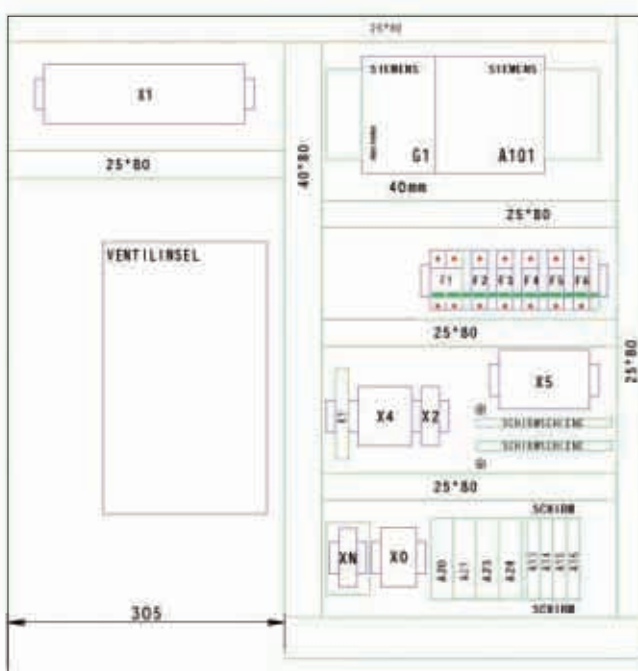
Design

The detailed design is drawn up in accordance with the specifications defined within the framework of the abovementioned points. The size of the cabinet is primarily determined by the valve terminal. The individual documents to be drawn up are as follows:

- Electrical and pneumatic circuit diagrams
- Parts lists for all necessary components
- Terminal diagrams
- Allocation of the article identifiers in accordance with the R+I flow diagram
- Equipment installation plan
- 2D control cabinet drawing

Definition of the control cabinet

- Stainless steel, sheet steel, plastic
- Size of the cabinet (WxHxD), depends on the fixtures
- Cabinet with one or two doors
- Door stop for single-door cabinet, on left or right
- Wall mounting, rack mounting
- Connections for tubing and cables top and bottom, side or rear
- Service unit inside or outside
- Master switch mounted on right or left
- Installation inside or outside



Control cabinet assembly

Mechanical preparation according to the design documents is necessary before starting on the fixtures for the various modules. Assembly of the modules as well as the laying of wiring and tubing in the cabinet can then start.

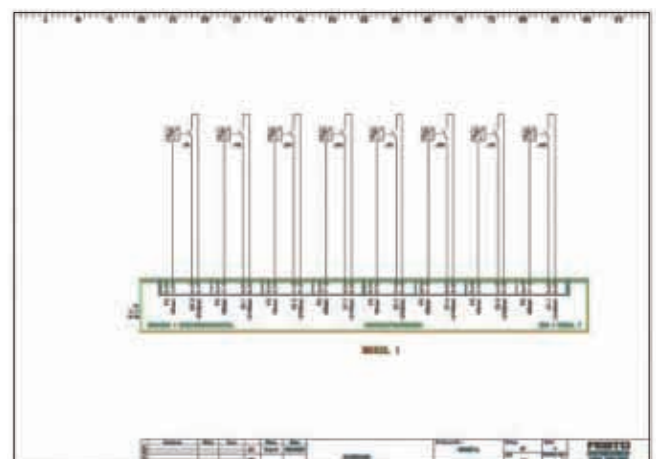
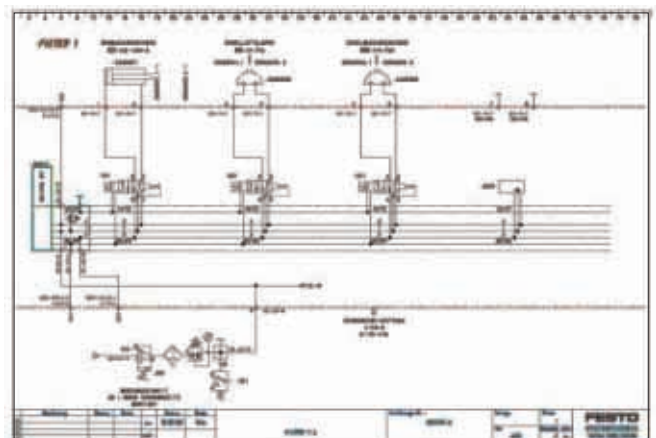
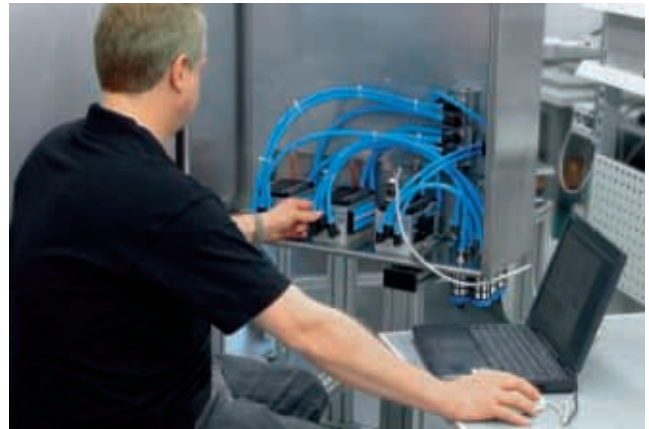
Functional test with test report

All ready-to-install control cabinets are subject to the following tests, which are documented in a test report:

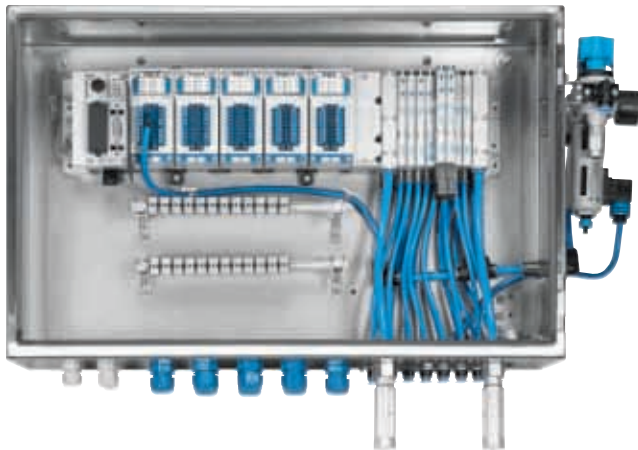
- Leak test of the pneumatics in the cabinet
- Operation at maximum and minimum pilot pressure
- Equipment identification, wiring and tubing
- Electrical and manual actuation of all valves
- EMC measures

Project documentation (EN 60 204)

Hardcopy documentation for each individual project number is enclosed with the control cabinet. This documentation is also available in softcopy format and can be requested in different file formats. The documentation is archived for a period of 10 years. This service is particularly important if upgrades or conversions are to be made to a control cabinet.



Ready-to-install control cabinets



Control cabinets for the ATEX zone

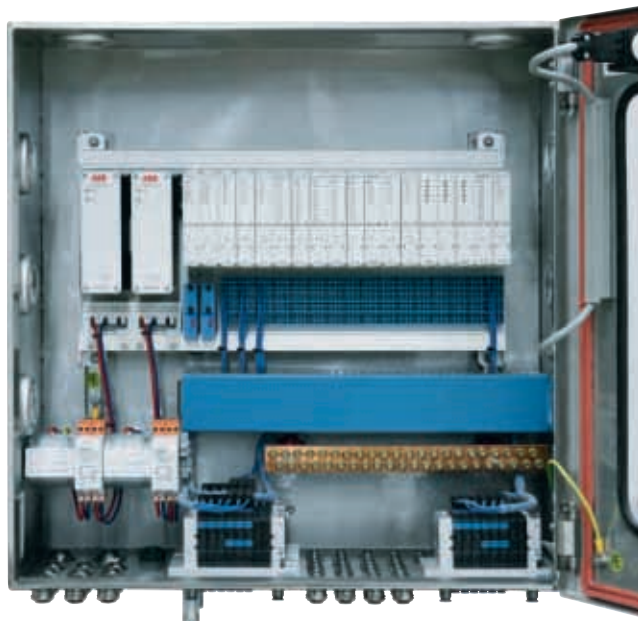
Some projects require a control cabinet to be installed in a potentially explosive area. Whether in zone 2 or zone 1, Festo has the appropriate control cabinet variant. The cabinet for zone 2 is also suitable for the connection of intrinsically safe sensors and actuators.

See also the section
“Pneumatics and explosion
protection”

Control cabinet construction from a single source

Realising projects generally requires a considerable amount of agreement, planning and coordination. Working with one professional partner has many advantages:

- One point of contact in the planning phase
- Less coordination required and professional advice
- Reliable calculations thanks to detailed definition
- One supplier, one delivery date, one process for placing the contract
- Time savings for realising the project
- Professional implementation in pneumatics and electrics
- Components and systems are optimally adapted to each other
- Design and circuit diagram drafting is carried out at the same time
- Quality and function-tested control cabinets with test record, factory acceptance test and release as well as project documentation





Use of pneumatic actuators



Harsh ambient conditions often prevail within municipal drinking water purification and wastewater treatment plants, for example moisture, high or low temperatures, rain in outdoor areas, microbiological contamination, vapours and other extremely aggressive atmospheres. The materials from which the actuators are made have been designed to fully comply with these requirements. Nearly all applications can thus be covered. Consultation with Festo's experts is necessary for use in aggressive atmospheres, for example in the chemical industry or where cleaning agents are used. No guarantee can otherwise be offered for applications of this sort.

Corrosion resistance classification

Pneumatic actuators are classified in accordance with CRC3 per FN 940070. This standard includes DIN 50017, 50021 and DIN EN ISO 6988. The materials and the surface finish are suitable for outdoor use.

Temperature range

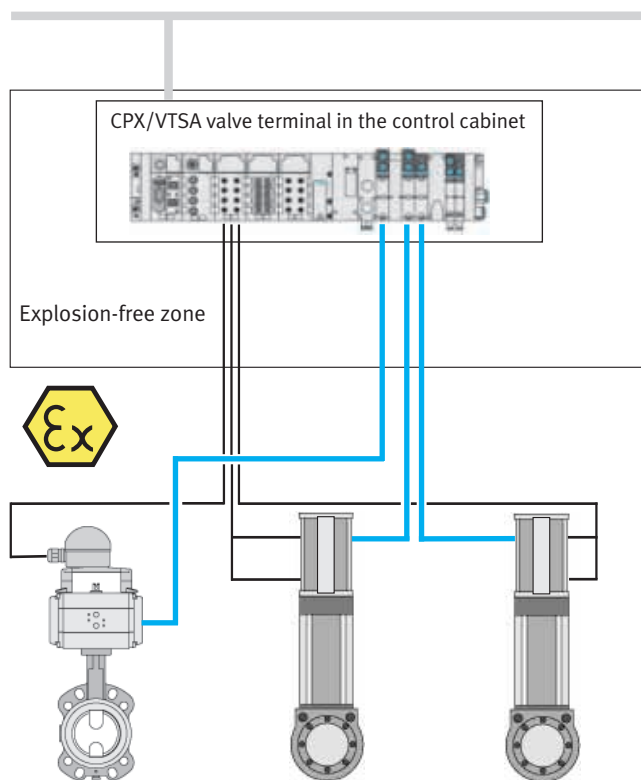
As a standard feature, the actuators are suitable for use at temperatures ranging from -20 to +80° C.

Low or high temperature

As special variants for actuators used at low temperatures of down to -50° C and high temperature of up to +150° C. Consultation with Festo's experts is required for these applications.



Use of pneumatic actuators



Explosion protected zone

This is a highly “explosive” issue, especially where wastewater treatment plants are concerned. Specialists or experts should be consulted in advance in order to determine the various zones. They can appropriately classify the individual areas of the wastewater treatment plant. The pneumatic actuators have been subjected to an ignition spark analysis, and are suitable for use in zone 1. Required device identification is affixed at the factory. Suitable variants are available for electrical components such as limit switches, solenoid valves and positioners.

See also the section “Pneumatics and explosion protection”

Application notes

Fundamentally, only the pneumatic actuators should be installed in potentially explosive atmospheres. In most cases, the control cabinet can be arranged outside of the potentially explosive atmosphere. This is the simplest and most cost effective solution, because the actuators are suitable up through zone 1 as a standard feature.

Important: The temperature range must also be taken into consideration in this respect.

Installation position for pneumatic actuators

The actuators can be installed in any desired position. However, it must first be determined whether or not the utilised process valve is suitable for the selected installation position. The weight of the actuator must be taken into consideration when installing the process valve, and the actuator must be supported if necessary.



Actuators for butterfly valves



Appropriate butterfly valves are used in order to assure either free flow or interruption of media flow in piping systems. These are available as standard products in nominal sizes ranging from DN 50 to DN 1200.

The driving forces required for opening and closing butterfly valves depend upon nominal size, operating pressure and the viscosity of the medium.

The manufacturer of the butterfly valve specifies which actuator is combined with which butterfly valve. In coordination with the various manufacturers, agreement has been reached as to which actuator size fit onto which butterfly valve.

As a rule, the actuators are mounted at the factory by the manufacturer of the butterfly valve, who also executes the required function test. A ready-to-install assembly is then shipped to the customer. The layout of the actuator must be specified in detail before assembly. The manufacturer of the butterfly valve or Festo's experts provide assistance in this area.

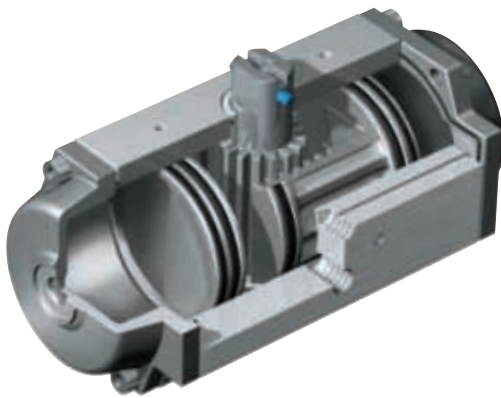
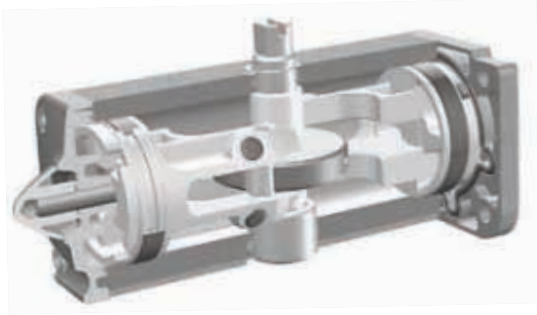
Festo collaborates with, amongst others, the following butterfly valve manufacturers:

- AVK International
- CTA Center Tech
- ERHARD
- VAG
- Wouter Witzel

Actuators with flange mounting dimensions in accordance with DIN ISO 5211 are available as standard products for butterfly valves from all common manufacturers. In addition to this, the actuators are equipped with port patterns in accordance with NAMUR VDI/VDE 3845 for the attachment of solenoid valves and sensor-boxes.



Actuators for butterfly valves



Layout and function

Scotch-Yoke actuator system

The two pistons divide the actuator into two chambers. If the outer chamber is pressurised with compressed air, the inner chamber is exhausted at the same time. The pistons move in opposite directions and cause rotary motion of the shaft by means of a lever. The drive has a swivel angle of 0° to 90°.

Rack and pinion actuator system

With this system as well, the two pistons divide the drive into two chambers. The pistons' gear racks intermesh with the pinion on the shaft. The shaft rotates when the pistons move in opposite directions. The swivel angle ranges from 0° to 90°.

Interfaces

Port pattern per NAMUR VDI/VDE 3845 for attaching solenoid valves and sensor-boxes.

Standardised port patterns simplify attachment of solenoid valves and sensorboxes, and assure compatibility.

Actuator shaft

The top end of the shaft is laid with double-flats for manual adjustment with an open-ended spanner. The bottom end of the shaft is equipped with an internal square or octagon, into which the corresponding shaft end from the butterfly valve is inserted.

Mechanical end-position adjustment

The closing element can be adjusted within the butterfly valve's sealing seat by setting the end-position. The butterfly valve's closing performance is determined by this adjustment. The deeper the flap disc extends into the sealing seat, the greater is the breakaway torque when the butterfly valve is opened.

Flange hole pattern

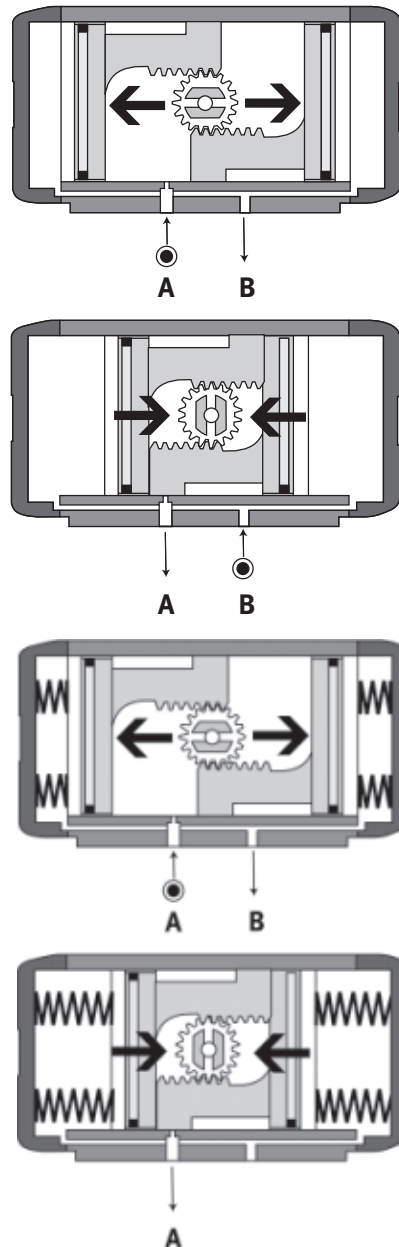
Connection dimensions per DIN ISO 5211 for mounting to the corresponding butterfly valve. The size of the pitch circle diameter and the thread for the mounting holes are specified here.

Layout and function

Double-acting and single-acting actuators

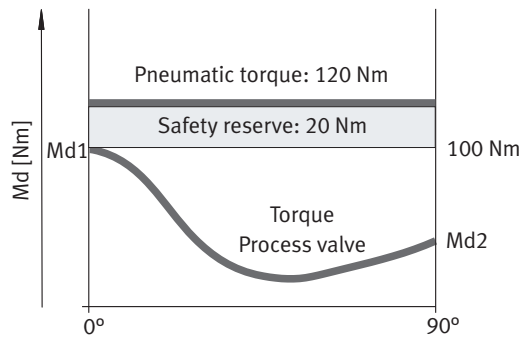
Semi-rotary actuators for butterfly valves are available in two variants, as double and single-acting actuators. Double-acting actuators are reversed by means of pilot air in combination with a solenoid valve. Single-acting actuators are equipped with return springs in the outer “chamber”, which result in forced control in the event that pilot pressure fails. Normally open and normally closed safety functions are thus made possible.

Torque generated by single-acting actuators is reduced by the opposing force of the spring. For this reason, specifications for semi-rotary actuators include “spring torque” in addition to “pneumatic torque” depending upon respective spring force. Single-acting semi-rotary actuators can be closed or opened with spring force as a safety function.



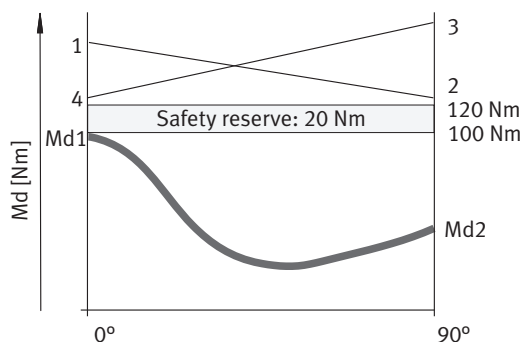
Layout for butterfly valves

Layout of a double-acting actuator



0° = process valve closed Md1 = breakaway torque
90° = process valve open Md2 = closing torque

Layout of a single-acting actuator



Required safety factor: 20% 0° = Process valve closed
90° = Process valve open

1 → 2 = Characteristic
pneumatic torque
3 → 4 = Characteristic
spring torque

Breakaway torque of the process valves

The torque characteristic of the process valve must be known in order to determine the required torque of an actuator. The greatest torque is needed when opening the process valve and closing it again, since the closing body has to be moved out of or into the sealing seat. The actuator torque should be calculated with a safety factor of 1.2, i.e. it should be 20 % greater than the breakaway torque. The safety allowance compensates for aging of the sealing seat.

Torque characteristic of a butterfly valve

The torque characteristic across the entire opening range is not linear (see graph). The greatest torque is needed to open the valve. In addition, the torque is influenced by the following factors:

- Temperature, concentration, viscosity of the medium
- Gas or liquid
- Lubricating or non-lubricating medium
- Ingredients that are deposited or caked
- Operating pressure of the medium
- Differential pressure at the process valve

Example: layout of a double-acting actuator

According to the manufacturer, the butterfly valve requires a breakaway torque of 100 Nm. A minimum safety factor of 20% is assumed. This means that a pneumatic torque of 120 Nm must be generated by the actuator.

Example: layout of a single-acting actuator

The most common application is the spring force closing function. Despite preloading of the springs in the actuator, they generate the least amount of spring torque during closing. This must be taken into consideration when laying out the actuator. The same butterfly valve with a breakaway torque of 100 Nm is to be equipped with a single-acting drive. With a safety reserve of 20 Nm, minimum spring torque must also amount to 120 Nm.

Torque generated by double-acting DAPS actuators

Actual torque [Nm] relative to operating pressure [bar] and turning angle [°]								
Size	Turning angle [°]	Operating pressure [bar]						
		3	4	5	5,6	6	7	8
DAPS-0008	0	3.8	5	6.3	7	7.5	8.8	10
	50	1.9	2.5	3.1	3.5	3.8	4.4	5
	90	3.8	5	6.3	7	7.5	8.8	10
DAPS-0015	0	8	10.7	13.4	15	16.1	18.8	21.4
	50	4	5.4	6.7	7.5	8	9.4	10.7
	90	6	8.1	10.1	11.3	12.1	14.1	16.1
DAPS-0030	0	16.1	21.4	26.8	30	32.1	37.5	42.9
	50	8	10.7	13.4	15	16.1	18.8	21.4
	90	12	16.1	20.1	22.5	24.1	28.1	32.1
DAPS-0060	0	32.1	42.9	53.6	60	64.3	75	85.7
	50	16.1	21.4	26.8	30	32.1	37.5	42.9
	90	24.1	32.1	40.2	45	48.2	56.3	64.3
DAPS-0106	0	57	76	95	106	114	133	151
	50	28	38	47	53	57	66	76
	90	43	57	71	80	86	100	114
DAPS-0180	0	96	128.4	160.8	180	193.2	225.6	264.8
	50	48	64.8	80.4	90	96	112.8	128.4
	90	72	97.2	121.2	135	145.2	169.2	193.2
DAPS-0240	0	128.6	171.4	214.3	240	257.1	300	342.9
	50	64.3	85.7	107.1	120	128.6	150	171.4
	90	96.4	128.6	160.7	180	192.9	225	257.1
DAPS-0360	0	192	256.8	321.6	360	386.4	451.2	513.6
	50	96	129.6	160.8	180	192	225.6	264.8
	90	144	194.4	242.4	270	290.4	338.4	386.4
DAPS-0480	0	257.1	342.9	428.6	480	514.3	600	685.7
	50	128.6	171.4	214.3	240	257.1	300	342.9
	90	192.9	257.1	321.4	360	358.7	450	514.3
DAPS-0720	0	384	513.6	643.2	720	772.8	902.4	1027.2
	50	192	259.2	321.6	360	384	451.2	529.6
	90	288.1	388.8	484.8	540	580.8	676.8	772.8
DAPS-0960	0	514.3	685.7	857.1	960	1028.6	1200	1371.4
	50	257.1	342.9	428.6	480	514.3	600	685.7
	90	385.7	514.3	642.9	720	771.4	900	1028.6
DAPS-1440	0	768	1027.2	1286.4	1440	1545.6	1804.8	2057.4
	50	384	518.4	643.2	720	768	902.4	1059.2
	90	576	777.6	969.9	1080	1161.6	1353.6	1545.6
DAPS-1920	0	1028.6	1371.4	1714.3	1920	2057.1	2400	2742.9
	50	514.3	685.8	857.1	960	1028.6	1200	1371.4
	90	771.4	1028.6	1285.7	1440	1542.9	1800	2057.1
DAPS-2880	0	1542	2057	2571	2880	3085	3600	4114
	50	771	1028	1285	1440	1542	1800	2057
	90	1028	1371	1741	1920	2056	2400	2742
DAPS-3840	0	2057	2743	3428	3840	4114	4800	5485
	50	1028	1371	1714	1920	2057	2400	2742
	90	1543	2057	2571	2880	3085	3600	4114
DAPS-5760	0	3085	4114	5142	5760	6171	7200	8228
	50	1542	2057	2571	2880	3085	3600	4141
	90	2313	3085	3856	4320	4628	5400	6171

Torque for various sizes at 5.6 bar with a turning angle of 0°

Layout for butterfly valves

Torque generated by single-acting DAPS actuators with spring force 4

Actual torque [Nm] relative to operating pressure [bar], spring force and turning angle [°]															
Spring force	Operating pressure [bar]														
	5			5.6			6			7			8		
	0°	50°	90°	0°	50°	90°	0°	50°	90°	0°	50°	90°	0°	50°	90°
DAPS-0480															
4	394.3	118.6	234.3	480	240	320	537.1	274.3	377.1	680	360	520	822.9	445.7	662.9
DAPS-0720															
4	591.4	282.9	351.4	720	360	480	805.7	411.4	565.7	1020	540	780	1234	668.6	994.3
DAPS-0960															
4	788.6	377.1	468.6	960	480	640	1074.3	548.6	754.3	1360	720	1040	1645.7	891.4	1325.7
DAPS-1440															
4	1182	565	702	1440	720	960	1611	822	1131	2040	1080	1560	2468	1337	1988
DAPS-1920															
4	1577	754	937	1920	960	1280	2148	1097	1508	2720	1440	2080	3291	1782	2651
DAPS-2880															
4	2365	1131	1405	2880	1440	1920	3222	1645	2262	4080	2160	3120	4937	2674	3977

Torque for various sizes at 5.6 bar with a turning angle of 0°

Torque generated by double-acting DRD actuators

Theoretical torque [Nm] at turning angles of 0° and 90° relative to operating pressure [bar]						
Size	Operating pressure [bar]					
	3	4	5	6	7	8
DRD-1	3.72	4.96	6.2	7.44	8.68	9.92
DRD-2	8.1	10.8	13.5	16.2	18.9	21.6
DRD-4	18.6	24.8	31	37.2	43.4	49.6
DRD-8	37	49.3	61.6	74	86.3	98.6
DRD-14	72	95	119	143	167	191
DRD-26	133	177	222	266	310	354
DRD-50	253	337	421	505	589	673
DRD-77	385	513	642	770	898	1026
DRD-100	506	675	843	1012	1181	1350
DRD-150	758	1011	1264	1517	1770	2023
DRD-225	1138	1517	1896	2275	2654	3033
DRD-375	1896	2528	3159	3791	4423	5055
DRD-575	2879	3839	4799	5758	6718	7677
DRD-880	4407	5876	7345	8814	10 283	11 752

Note:

The following minimum degrees of efficiency apply to all semi-rotary actuators:

DR...-1...4: ≥ 80 %

DR...-8...880: ≥ 90 %

Layout for butterfly valves

DRE semi-rotary actuators, single-acting

Theoretical torque [Nm] at turning angles of 0° and 90° relative to operating pressure [bar]								
Number of springs ¹⁾	Spring force [Nm]	Available Md	Operating pressure [bar]					
			3	4	5	6	7	8
Rotary actuators DRE-2								
6	2.7	min.	2.7	5.4	8.1	10.8	13.5	16.2
	5.4	max.	5.4	8.1	10.8	13.5	16.2	18.9
8	3.6	min.	0.9	3.6	6.3	9	11.7	14.4
	7.2	max.	4.5	7.2	9.9	12.6	15.3	18
10	4.5	min.	–	2.8	5.5	8.2	10.9	13.6
	8	max.		6.3	9	11.7	14.4	17.1
12	5.4	min.	–	–	2.7	5.4	8.1	10.8
	10.8	max.			8.1	10.8	13.5	16.2
14	8.3	min.	–	–	0.9	3.6	6.3	9
	12.6	max.			5.2	7.9	10.6	13.3
Rotary actuators DRE-4								
6	6.1	min.	6.4	12.6	18.8	25	31.2	37.4
	12.2	max.	12.5	18.7	24.9	31.1	37.3	43.5
8	8.2	min.	2.2	8.4	14.6	20.8	27	33.2
	16.4	max.	10.4	16.6	22.8	29	35.2	41.4
10	10.3	min.	–	4.2	10.4	16.6	22.8	29
	20.6	max.		14.5	20.7	26.9	33.1	39.3
12	12.3	min.	–	–	6.4	12.6	18.8	25
	24.6	max.			18.7	24.9	31.1	37.3
14	14.4	min.	–	–	2.2	8.4	14.6	20.8
	28.8	max.			16.6	22.8	29	35.2
Rotary actuators ORE-8								
6	12.3	min.	12.1	24.4	36.7	49.1	61.4	73.7
	24.9	max.	24.7	37	49.3	61.7	74	86.3
8	16.4	min.	3.8	16.1	28.4	40.8	53.1	65.4
	33.2	max.	20.6	32.9	45.2	57.6	69.9	82.2
10	20.5	min.	–	7.8	20.1	32.5	44.8	57.1
	41.5	max.		28.8	41.1	53.5	65.8	78.1
12	24.6	min.	–	–	11.8	24.2	36.5	48.8
	49.8	max.			37	49.4	61.7	74
14	28.7	min.	–	–	4.5	16.9	29.2	41.5
	57.1	max.			32.9	45.3	57.6	69.9

¹⁾ Smaller number of springs on request

Note:

The following minimum degrees of efficiency apply to all semi-rotary actuators:

DR...-1...4: ≥ 80 %

DR...-8...880: ≥ 90 %

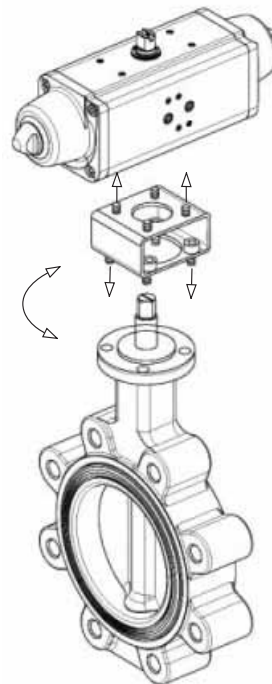
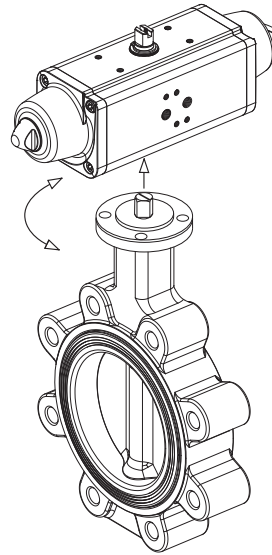
Mounting actuators to butterfly valves

Direct mounting of the actuator

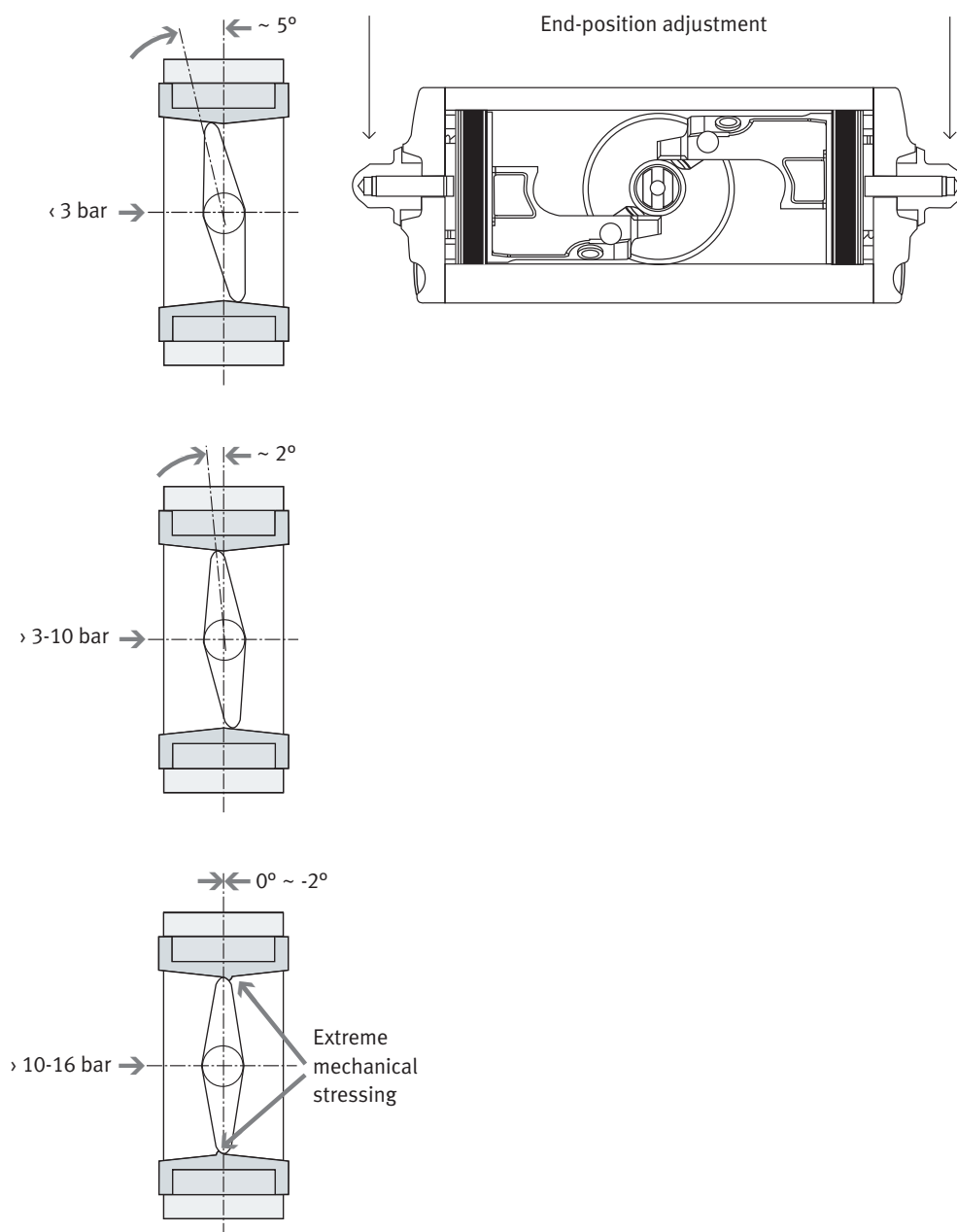
As a rule, automatable butterfly valves are equipped with a so-called open shaft end with internal square, which is suitable for direct mounting of an actuator. The width across flats and flange dimensions should first be checked, in order to assure dimensional compliance (see also section entitled “Standards”). Direct attachment is considerably simpler and less expensive.

Attachment with mounting adapter

Attachment with mounting adapter is required whenever dimensional compliance is not fulfilled. In particular when retrofitting manual process valves, various flange connections and shaft adaptation are required. A comprehensive range of accessories is available to this end.



Mounting actuators to butterfly valves



Mechanical end-position adjustment for actuators

The sealing performance of resilient seated butterfly valves depends to a great extent upon the closing angle of the disc. The more pilot pressure is applied to the disc, the deeper it must penetrate into the sealing seat. This adjustment of the disc has a decisive influence on the service life of the butterfly valve. The sealing seat is subjected to considerable mechanical stressing each time the valve is opened and closed. The adjoined graphics demonstrate the effect of the disc's closing angle with various amounts of pilot pressure applied to the disc.

The position of the disc can be ideally adjusted by means of the actuator's mechanical end-position adjustment.

Accessories for actuators

Layout and function

Tubing connections

Push-in fittings can be attached at the factory in order to allow simple tubing connections. As a rule, a nominal diameter of 6 or 8 mm is used. Only tubing with a standard outside diameter may be used with push-in fittings.

Exhaust air restrictors

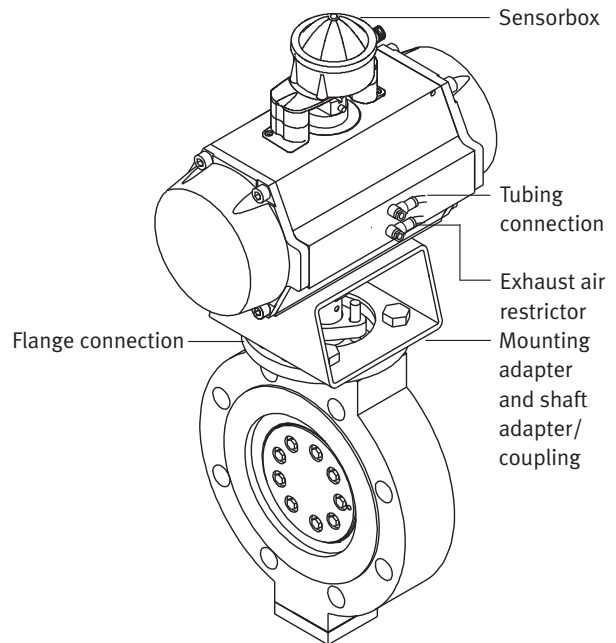
Exhaust air restrictors are integrated into the tubing connections in order to be able to ideally match the actuator's adjusting speed to the respective application. Speed can thus be separately adjusted for opening and closing the butterfly valve. As a rule, butterfly valves should be opened and closed slowly.

Sensorbox

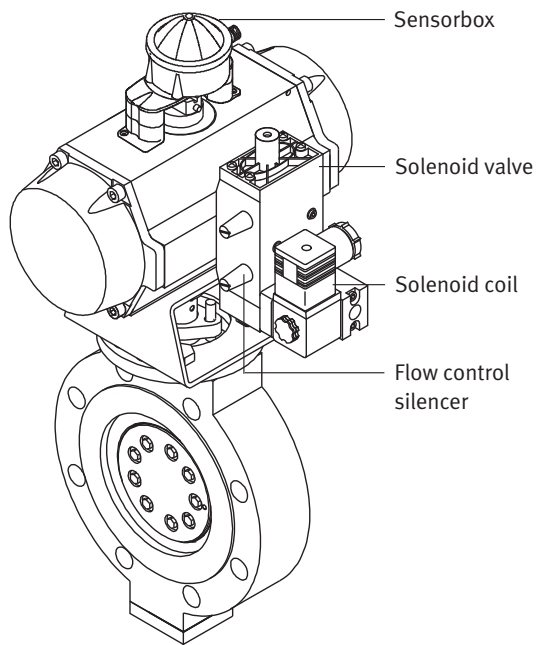
Attachment of a sensorbox which detects the butterfly valve's position is highly advisable. Two sensorbox are normally integrated into the box which activates a switch in the closed and the open position. This type of position sensing assures the necessary safety for automated operation, i.e. the next butterfly valve is not actuated until the previous valve has returned to its normal position. The current position is indicated optically as well. A sensorbox can be mounted and adjusted at the factory.

Flanged connection

Depending upon the flange connection at the butterfly valve side, corresponding connections are also provided at the actuator side, or they are implemented by means of a mounting adapter and a shaft adapter/coupling.



Accessories for actuators



Layout with solenoid valve

Solenoid valve

Corresponding NAMUR valves are available for direct attachment. The valve is actuated by means of a solenoid coil. Various coils are available, which are energised with, for example 24 V DC, 110 V AC or 230 V AC. The solenoid valves can be mounted at the factory such that the actuator closes or opens the butterfly valve when the coil is deenergised.

Sensorbox

Position sensing of the butterfly valve provides the required levels of safety for automated process sequences. Two limit switches are installed in the sensorbox which activate a switch in the closed and the open position. The butterfly valve's current position is displayed at a visual indicator. A sensorbox can be mounted and adjusted at the factory.

Flow control silencer

Exhaust air restrictors are mounted in the exhaust air connections in order to be able to ideally match the actuator's adjusting speed to the respective application. Speed can thus be separately adjusted for opening and closing the butterfly valve. As a rule, a slow disc speed should be selected in order to prevent water hammers within the piping system.

Tubing connection

A push-in fitting can be mounted at the factory for easy tubing connection. Nominal diameter of 6 and 8 mm are most commonly used. Only tubing with a standard outside diameter may be used with the push-in fitting.

Controllable actuators for butterfly valves

Layout and function

Positioner (E-P controller)

If a butterfly valve is required for dosing specified quantities of material, the actuator can be equipped with a positioner. The positioner is attached to the actuator and is rigidly connected to the shaft. An integrated displacement encoder is thus able to detect the current position. The setpoint (4 to 20 mA) for the position to which the actuator should advance is transmitted to the positioner from a PLC. The positioner corrects position internally until the setpoint and the actual value indicated by the displacement encoder are identical. After the actuator reaches the specified position, the positioner locks it into place. When a new setpoint is read out from the PLC, the actuator is advanced to the new position.

Proximity switches

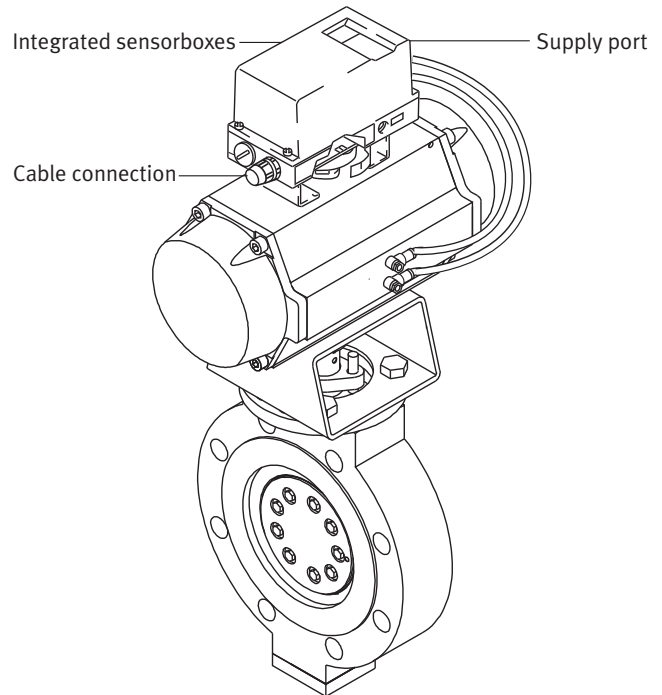
In the case of automated sequence control, unequivocal position acknowledgement indicating that the butterfly valve is closed is especially important. This is made possible by the sensorboxes integrated into the positioner.

Tubing connections

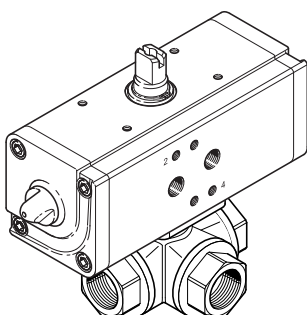
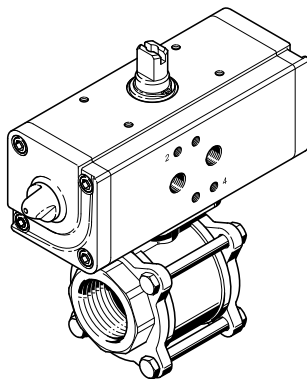
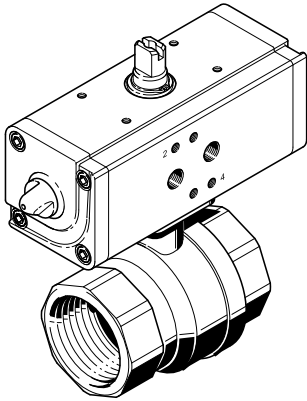
A push-in fitting with a nominal diameter of 6 or 8 mm should be attached for the supply of pilot pressure (supply port). Two lengths of tubing connect the positioner to the actuator. The two working chambers are pressurised and exhausted via these “working connections”.

Note:

The suitability of butterfly valves for use as a “regulating process valve” must be checked in advance with the manufacturer.



Actuators for ball valves



Ball valves, with their simple structure, are an important shut-off element in water technology. They can generally be easily installed with a pneumatic quarter-turn actuator by means of direct mounting. Ball valves are used in particular with smaller pipe diameters. They are cost-effective and available in nominal sizes from DN15 to DN100 or Rp 1/4 to Rp 4.

The hole in the ball means that the ball valve has a free passage and can therefore be cleaned (so-called “pigging”), i.e. it can be cleaned without opening the duct. The sealing system at the ball is typically made of PTFE and is subject to normal wear and tear. Suitable operating media are dry and lubricating fluids without abrasive and other ingredients. Water, compressed air or neutral gases are the most frequently used operating media. Ball valves can also be used to shut off vacuums. The necessary leakage rate must, however, be observed here. Appropriate ball valves are available for special requirements.

The wide range of designs enables flexible adaptation to different applications. The following criteria, among others, must be reviewed before the appropriate ball valve is selected:

- Operating pressure and temperature of the medium
- Suitability of the materials for the operating medium
- Switching frequency of the ball valve
- Closing and opening times
- Required function for the material flows:
- 2-way or 3-way ball valve

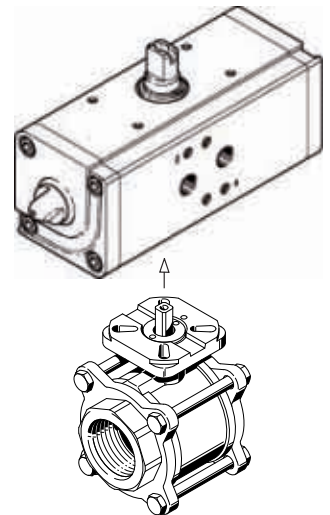
Actuation

Pneumatic actuator
Hand lever

There are two versions of quarter-turn actuators: single-acting and double-acting. When used in combination with a solenoid valve, the double-acting version is reversed by means of the pilot air. The single-acting actuators are moved to their initial position by means of spring force during venting. Forced control is required with some applications involving special safety functions. The ball valve is then closed or opened when pressureless.

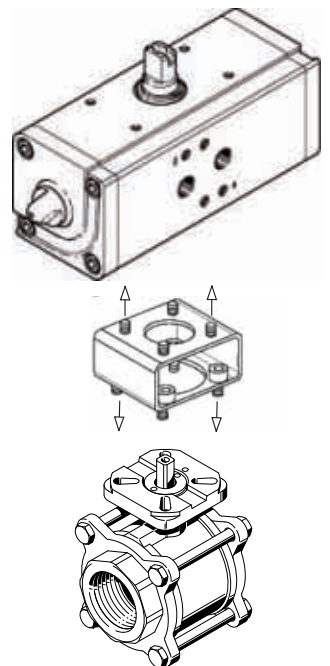
Assembly of the actuators

Direct mounting of the actuator on the ball valve is possible if the width across flats of the square and the bolt circle of the mounting holes are the same. The ball valves generally have a mounting flange to ISO 5211.

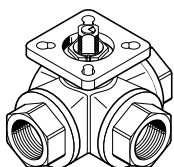
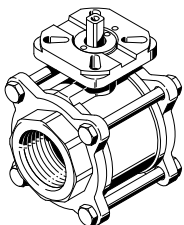
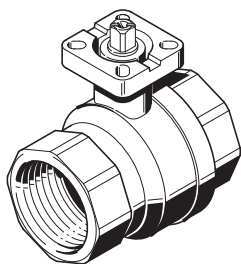
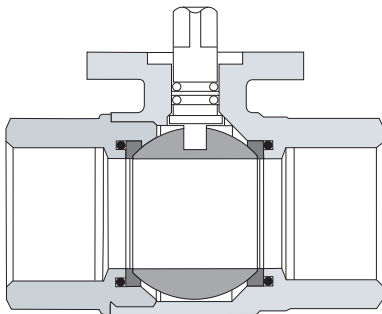


Dimensioning of the actuators

A certain torque is needed to open and close a ball valve. This torque depends on the nominal size, the operating pressure and the operating medium. The actuator torque should be at least 20 % greater than the required breakaway torque of the ball valve. This minimum safety allowance must also be taken into consideration with single-acting actuators. Whether the spring force has a closing or opening effect, the spring torque in each case should be 20 % greater than the breakaway or closing torque of the ball valve. (See also the section “Dimensioning butterfly valves”.)



Structure and function of ball valves



Designs

- Two-piece or three-piece housing
- 2-way design
- 3-way design with L or T-hole in the ball
- Sealing by means of O-rings with clearance volume
- Sealing by means of half shells without clearance volume
- Mounting flange to ISO 5211

Materials for housing and ball

- Nickel-plated brass, hard-chromium plated ball
- Steel or stainless steel
- Plastics such as PA, PVC, PP, PVDF

Connection variants

- Female thread to different standards
- Male thread to different standards
- Welding stub
- Flange

Standard nominal sizes

Brass ball valve, 2/2-way, Rp 1/4 to Rp 2 1/2
 Stainless steel ball valve, 2/2-way, Rp 1/4 to Rp 4
 Stainless steel ball valve, 3/2-way, Rp 1/4 to Rp 2

Operating pressure and temperature range

Brass ball valve:
 Nominal pressure for Rp 1/4 up to Rp 1 1/4 40 bar
 Nominal pressure for Rp 1 1/2 up to Rp 2 1/2 25 bar
 Temperature range -20 to +150° C
 Operating pressure drops when above 25° C (see technical data)

Stainless steel ball valve:
 Nominal pressure 63 bar
 Temperature range -10 to +180° C
 Operating pressure drops when above 40° C (see technical data)

Sealing systems

Spherical seal: PTFE, glass-fibre reinforced
 Shaft seal: Fluoro elastomer

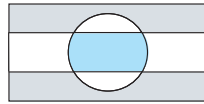
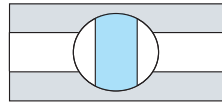
Normal position of ball valves

With ball valves, the closure component, the ball, can rotate through 360°. This means there is a free choice of normal position for ball valves when combined with actuators. In the case of a 2/2-way ball valve, this will then mean that the ball valve is open or closed when the actuator is at 0°.

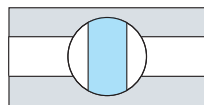
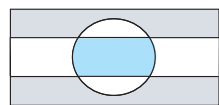
The same options are available for 3/2-way ball valves. No matter whether the valve used has an L or T bore, the normal position can be selected as appropriate to a given application.

Important note regarding 3/2-way ball valves: These are not overlap-free during switchover. This means that undesired mixing may occur during a switchover from one flow of material to another. In order to prevent this, it is possible, for example, to fit 2/2-way ball valves in the main material supply lines to interrupt flow during switchover.

2/2-way, normal position

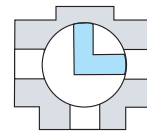
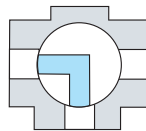
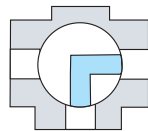


Position 0°

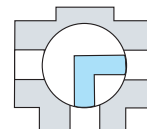
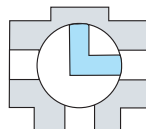
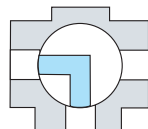


Position 90°

3/2-way, normal positions with L bore

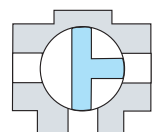
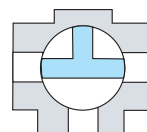
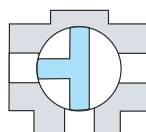
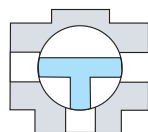


Position 0°

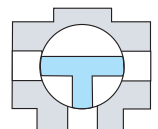
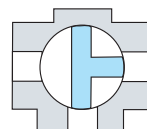
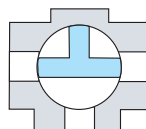
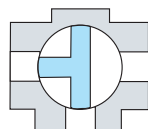


Position 90°

Normal positions with T bore



Position 0°



Position 90°

Actuators for gate valves



Appropriate gate valves are used in order to assure either free flow or interruption of media flow in piping systems. These are available as standard products in nominal sizes ranging from DN 50 to DN 600.

Actuators force required for opening and closing the gate valve depends upon nominal size, operating pressure and the solid/liquid ratio of the medium. A pilot pressure of 6 bar is always assumed when selecting a suitable actuator.

The manufacturer of the gate valve specifies which actuator is combined with which gate valve. In coordination with the various manufacturers, agreement has been reached as to which actuator sizes fit onto which gate valve. Festo has defined part numbers for various actuator types according to manufacturer, in order to assure unequivocal allocation.

As a rule, gate valves are assembled at the factory by the manufacturer who also executes all of the necessary function tests. A functional assembly is then shipped to the customer. Layout of the actuators must be specified in detail. The manufacturer of the gate valve or Festo's experts provide assistance in this area.

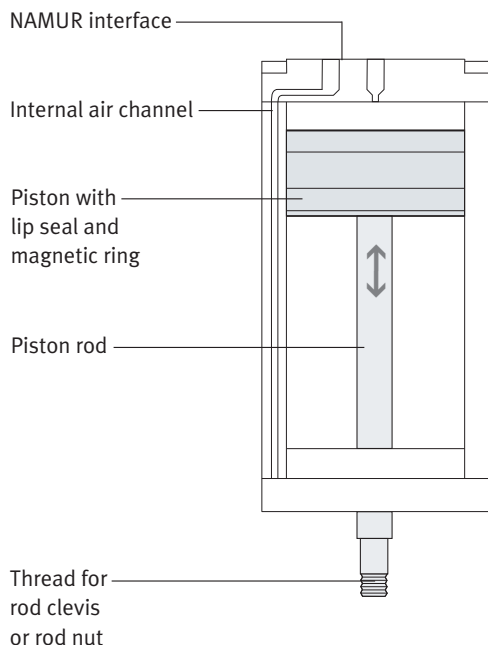
Actuators with connection dimensions in accordance with DIN ISO 5211 are available as standard products for gate valves supplied by:

Erhard
VAG
Stafsjö
Weco
Sistag
Lohse
Orbinox

However, suitable actuators are also available for other gate valves as special variants. This applies in particular for the retrofitting of gate valves which, for example, are being switched over from handwheel operation or operation with an electrical drive.



Actuators for gate valves



Layout and function

NAMUR interface

Port pattern per NAMUR VDI/VDE 3845 for attaching solenoid valves with corresponding port pattern.

This port pattern simplifies attachment of solenoid valves, and assures compatibility.

Internal air supply

In combination with the NAMUR interface, the bottom drive chamber is pressurised and exhausted via an internal air duct. This eliminates the need for an external air connection. In actual practice, the tubing is often turn off as a result of "protrusions" of this sort.

Actuator piston

The piston divides the actuator into two chambers. If the top chamber is pressurised with compressed air and the bottom chamber is simultaneously exhausted, the piston and the piston rod moves down. If these conditions are reversed, the piston moves up. The two-sided lip seal is self-compensating and thus has a long service life. A magnetic ring around the inside circumference of the piston actuates any attached limit switches.

Piston rod

The knife of the gate valve is actuated directly by the piston rod. The thread is designed to accept a rod nut or a rod clevis, which in turn is connected to the knife.

Flange hole pattern

Connection dimensions per DIN ISO 5211 for mounting to corresponding gate valves. The size of the pitch circle diameter and the thread for the mounting holes are specified here.

Layout and function

Tubing connections

Push-in fittings can be mounted at the factory in order to allow simple tubing connections. As a rule, a nominal diameter of 8 or 10 mm is used. Only tubing with a standard outside diameter may be used with the push-in fittings.

Exhaust air restrictors

Exhaust air restrictors are integrated into the tubing connections in order to be able to ideally match the actuator's adjusting speed to the respective application. Speed can thus be separately adjusted for opening and closing the gate valve, for example in order to cause a flush during sludge discharge by means of rapid opening.

Proximity switches

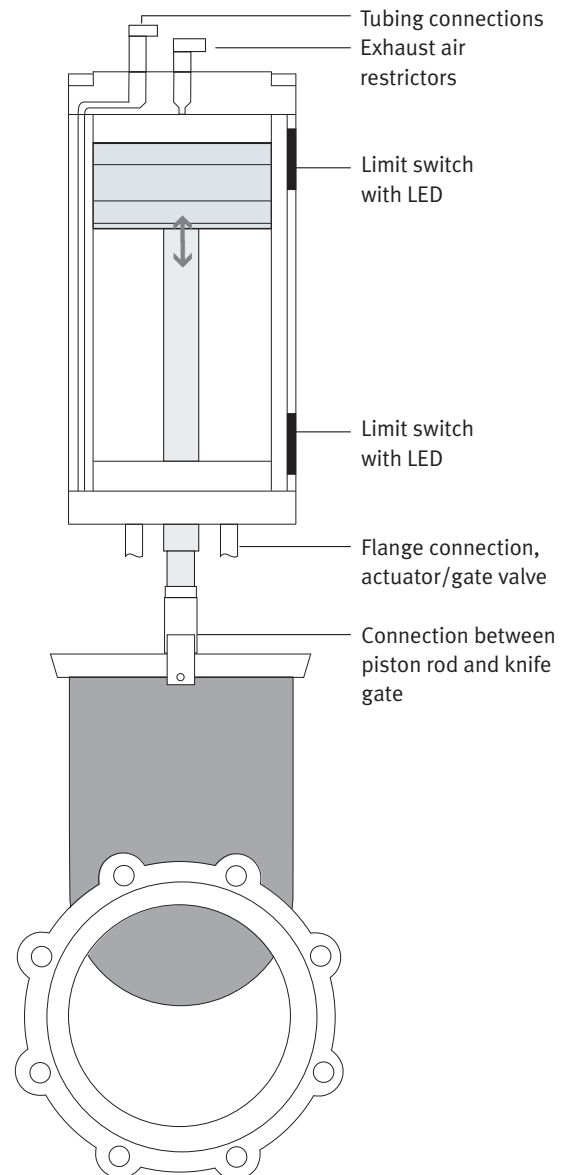
Contactless actuation of the limit switches by means of a magnetic strip in the piston is used to detect the respective position, regardless of whether the piston is advanced or retracted. This type of position sensing assures the required safety for automated sequences, because actuation of the next gate valve is only enabled when the previous gate valve is in the correct position. LEDs are integrated which optically indicate the current valve function. The limit switches can be mounted at the factory.

Flange connection

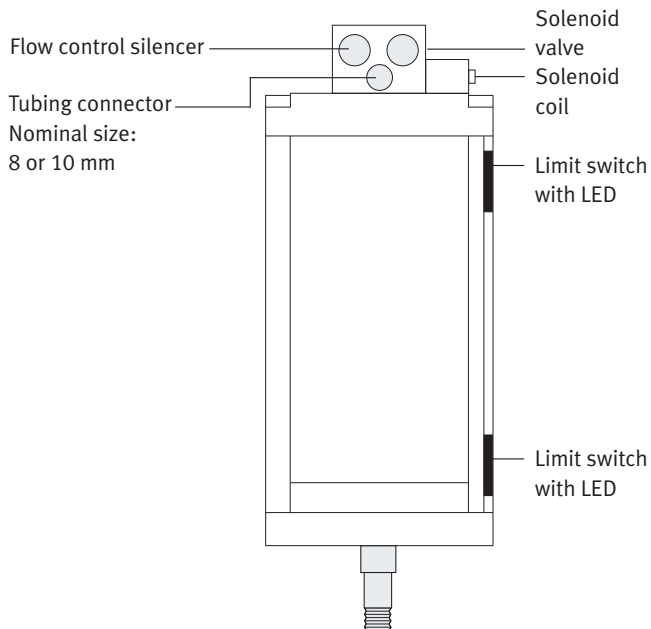
Depending upon the flange connection at the gate valve side, corresponding connections are also provided at the actuator side.

Connection to the knife gate

Suitable rod clevises and rod nuts are available for the respective gate valves. Exactly how adaptation is executed has been set forth in cooperation with selected gate valve manufacturers. Travel of the knife gate into the sealing seat can be easily adjusted using the thread on the piston rod.



Actuators for gate valves



Layout with solenoid valve

Solenoid valve

Corresponding NAMUR valves are available for direct attachment. The valve is actuated by means of a solenoid coil. Various coils are available, which are energised with, for example 24 V DC, 110 V AC or 230 V AC. The solenoid valves can be mounted at the factory such that the actuator closes or opens the gate valve when the coil is deenergised.

Port flow control with silencer

Exhaust air restrictors are mounted in the exhaust air connections in order to be able to ideally match the actuator's adjusting speed to the respective application. Speed can thus be separately adjusted for opening and closing the gate valve, for example in order to cause a flush during sludge discharge by means of rapid opening.

Limit switch

Contactless actuation of the sensorboxes by means of a magnetic strip in the piston is used to detect the respective position, regardless of whether the piston is advanced or retracted. This type of position sensing assures the required safety for automated sequences, because actuation of the next gate valve is only enabled when the previous gate valve is in the correct position. LEDs are integrated which optically indicate the current valve function. The limit switches can be mounted at the factory. Switching voltages of 24 V DC, 230 V AC, as well as others, may be used.

The switching point can be varied by moving the limit switch in the slot.

Tubing connector

A push-in fitting can be mounted at the factory for easy tubing connection. As a rule, a nominal diameter of 8 or 10 mm is used. Only tubing with a standard outside diameter may be used with the push-in fitting.



Actuator to gate valve allocation

Thrust and tensile force

The size of the piston surface determines the actuator's thrust and tensile force relative to the specified pilot pressure. As a rule, a pilot pressure of 6 bar is always assumed. This pressure level has been substantiated as economically and technically ideal.

The actuator's thrust is always greater than its tensile force, because the effective surface at the bottom of the piston is reduced by the surface area of the piston rod.

Piston diameter (mm)

	Thrust (N)	Tensile force (N)
80	3016	2827
100	4712	4524
125	7363	6881
160	12 064	11 561
200	18 850	18 080
250	29 452	28 698
320	48 255	47 501

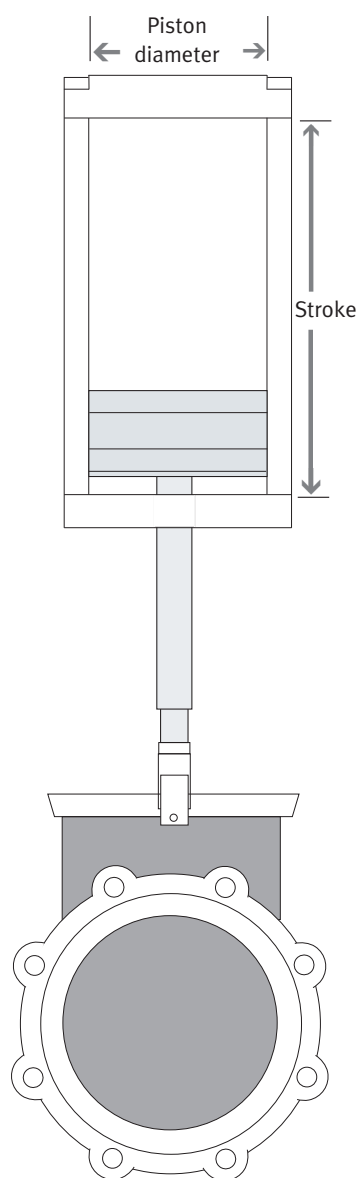
Type designation of the actuator

For example

DLP-160-150-A
 DLP actuator type
 160 piston diameter (mm)
 150 actuator stroke (mm)
 As magnetically actuated
 position sensing

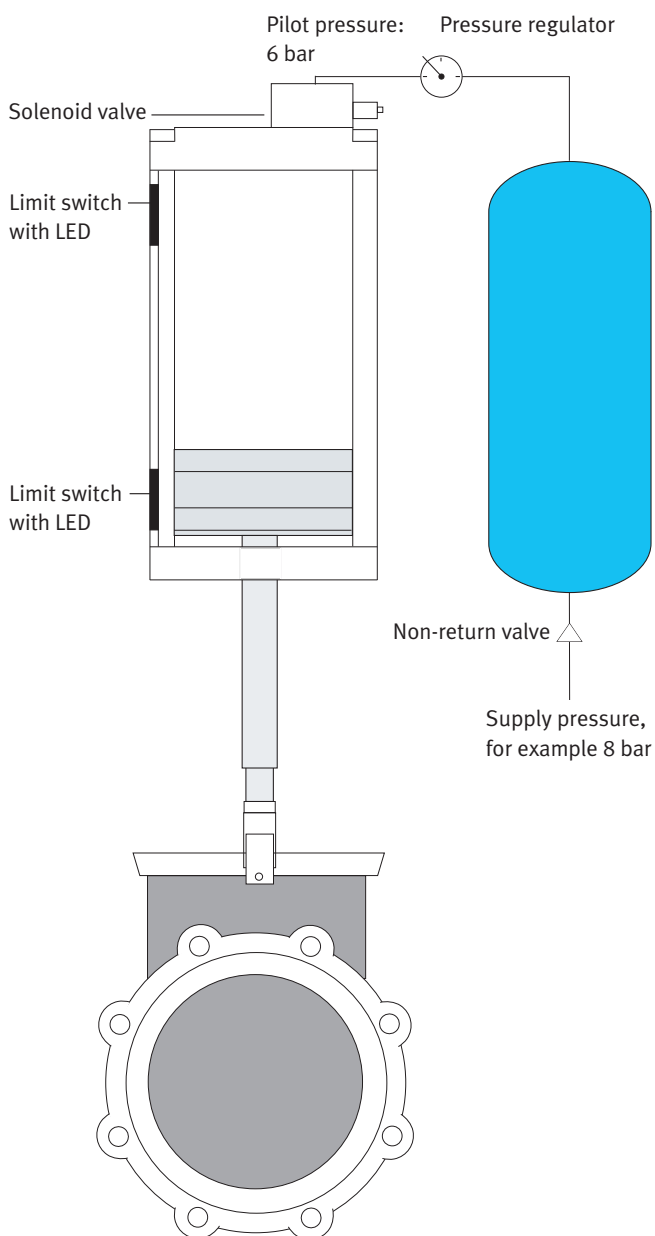
Stroke length of the actuator

As a rule, the stroke length of the actuator corresponds to the nominal size of the process valve. Depending upon the manufacturer, deviations exist which, however, are taken into consideration when specifying various actuators for the individual gate valves.



Gate valve
Nominal size (DN)

Actuators for gate valves



Layout with solenoid valve and emergency reservoir

Additional safety function

The installation of an upstream air reservoir is an ideal solution for special gate valves, in order to be able to close or open the gate valve in the event of a power failure. The solenoid valve reverses the actuator forcibly when voltage drops off.

Air reservoirs

The volume of the air reservoir must correspond to the volume of the actuator. The necessary reservoir volume can be calculated based on the supply pressure, for example 7, 8 or 9 bar.

Non-return valve

A non-return valve is installed on the inlet side to prevent reverse venting of the air reservoir in the event of a pressure drop in the compressed air network.

Pressure regulator with pressure gauge

The higher pressure level of 7, 8 or 9 bar in the air reservoir is reduced to the pilot pressure of 6 bar for the actuator.

Air reservoir calculation

If the actuator is dimensioned for a pilot pressure of 6 bar, the pressure in the reservoir must be above this pressure. If the pressure in the reservoir is 7, 8 or 9 bar, for example, this results in a pressure differential of 1, 2 or 3 bar respectively. The key variable is the volume of the actuator. This gives the size of the air reservoir as a function of the available differential pressure.

Volume of the actuator:
piston area x stroke,
e.g. DLP-100-80
100 piston diameter (mm)
80 actuator stroke (mm)

V₁ = Volume of the actuator
for one stroke

P₁ = Pilot pressure of the
actuator, 6 bar

V₂ = Volume of the air reservoir
P₂ = Pilot pressure in the air
reservoir 7, 8 or 9 bar

The air reservoir size is calculated based on the following equation:

$$V_1 \times P_1 = V_2 \times (P_2 - P_1)$$

$$\Delta P = P_2 - P_1$$

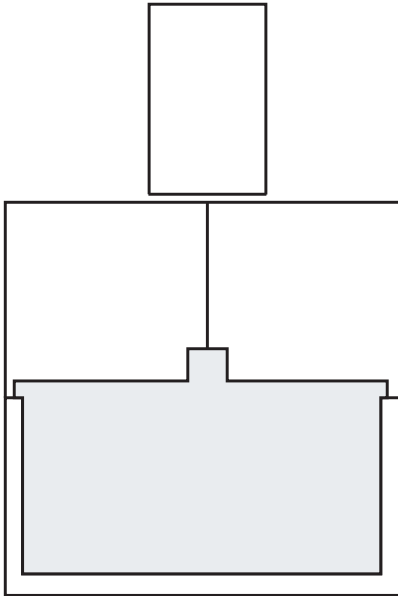
For the air reservoir V₂, this then gives

$$V_2 = \frac{V_1 \times P_1}{\Delta P}$$

Actuator type	Actuator type	Actuator volume V ₁ Litres	Reservoir volume V ₂ at		
			Δ P = 1 bar Litres	Δ P = 2 bar Litres	Δ P = 3 bar Litres
DN 80	DLP-100-80-A	0.63	3.8	1.9	1.3
DN 100	DLP-125-100-A	1.23	7.4	3.7	2.5
DN 125	DLP-125-125-A	1.53	9.2	4.6	3.1
DN 150	DLP-160-150-A	3.02	18.2	9.1	6.1
DN 200	DLP-160-200-A	4.02	24.2	12.1	8.1
DN 250	DLP-160-250-A	5.04	30.3	15.2	10.1
DN 300	DLP-200-300-A	9.42	56.6	28.3	18.9
DN 350	DLP-200-350-A	11	66	33	22
DN 400	DLP-250-400-A	19.63	117.8	58.9	39.3
DN 500	DLP-250-500-A	24.53	147.2	73.6	49.1
DN 600	DLP-320-600-A	48.23	289.4	144.7	96.5

Which actuator fits onto which gate valve depends upon the respective manufacturer. A selection of common combinations is listed in the table. This may vary in individual cases.

Actuators for penstocks and sluice gates



The same basic principles apply with regard to the actuation of these types of shutoff valve as for gate valves. The following ancillary conditions must also be taken into consideration when laying out process valves of this type:

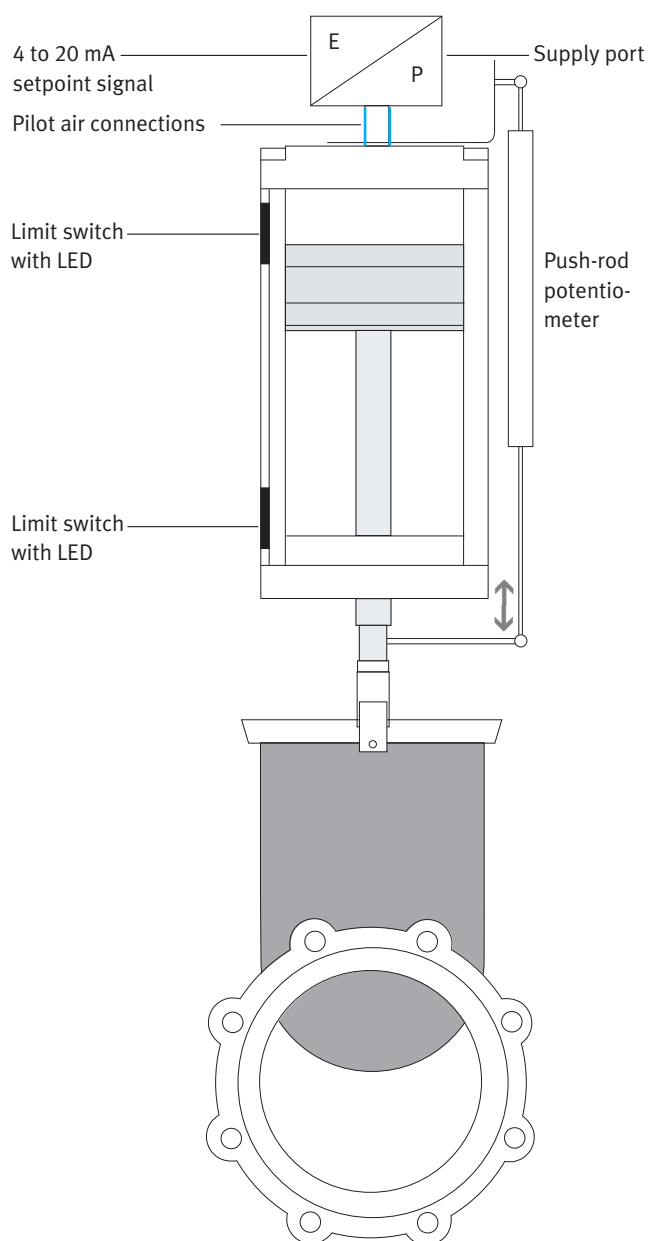
- Thrust and tensile force
- Stroke length
- Mounting to the process valve
- Connection between the piston rod and the “knife”
- Closing and opening times
- Function: open-close or controlled



Controllable actuators for gate valves



Controllable actuators for gate valves



Layout and function

Positioner (E-P controller)

If a gate valve is required to meter out specified quantities of material, the actuator can be equipped with a displacement encoder and a positioner. The displacement encoder is connected to the piston rod or the knife gate, and thus acquires the current position value. The so-called setpoint (4 to 20 mA) for the position to which the actuator should advance is transmitted to the positioner from a PLC. The positioner corrects position internally until the setpoint and the actual value indicated by the displacement encoder are identical. After the actuator reaches the specified position, the positioner locks it into place. When a new setpoint is read out from the PLC, the actuator system is advanced to the new position. The positioner must be suitable for the connection of a separate displacement encoder.

Displacement encoder

A linear potentiometer with push-rod in accordance with the actuator's stroke length is also attached. Due to its mechanical connection with the piston rod or the knife gate, the push-rod traces motion of the knife gate and reads out the current position valve (actual value).

Tubing connections

A push-in fitting with a nominal diameter of 8 or 10 mm should be attached for the supply of pilot pressure (supply port). Two lengths of tubing connect the positioner to the actuator. The two working chambers are pressurised and exhausted via these "working connections".

Limit switch

The contactless, magnetically actuated limit switches indicate that the actuator has reached the respective end-position. In the case of automated sequence control for gate valves, unequivocal acknowledgement to the PLC indicating that the gate valve is closed is especially important. Switching voltages of 24 V DC, 230 V AC, as well as others, may be used.

Layout and function

Positioner (E-P controller)

External attachment to the actuator as previously described. This layout variant simplifies access and replacement. Setpoint signals ranging from 4 to 20 mA for controlling the regulator. With this variant, the displacement encoder is integrated into the drive.

Integrated displacement encoder

This offers the advantage of mechanical and corrosion protection for the displacement encoder.

Tubing connections

Pilot air is supplied via the supply port. The push-in fittings should have a nominal size of 8 or 10 mm. Two lengths of tubing connect the positioner to the actuator. The two working chambers are pressurised and exhausted via these “working connections”.

Limit switches

The contactless, magnetically actuated limit switch indicate that the actuator has reached the respective end-position. In the case of automated sequence control for gate valves, unequivocal acknowledgement to the PLC indicating that the gate valve is closed is especially important.

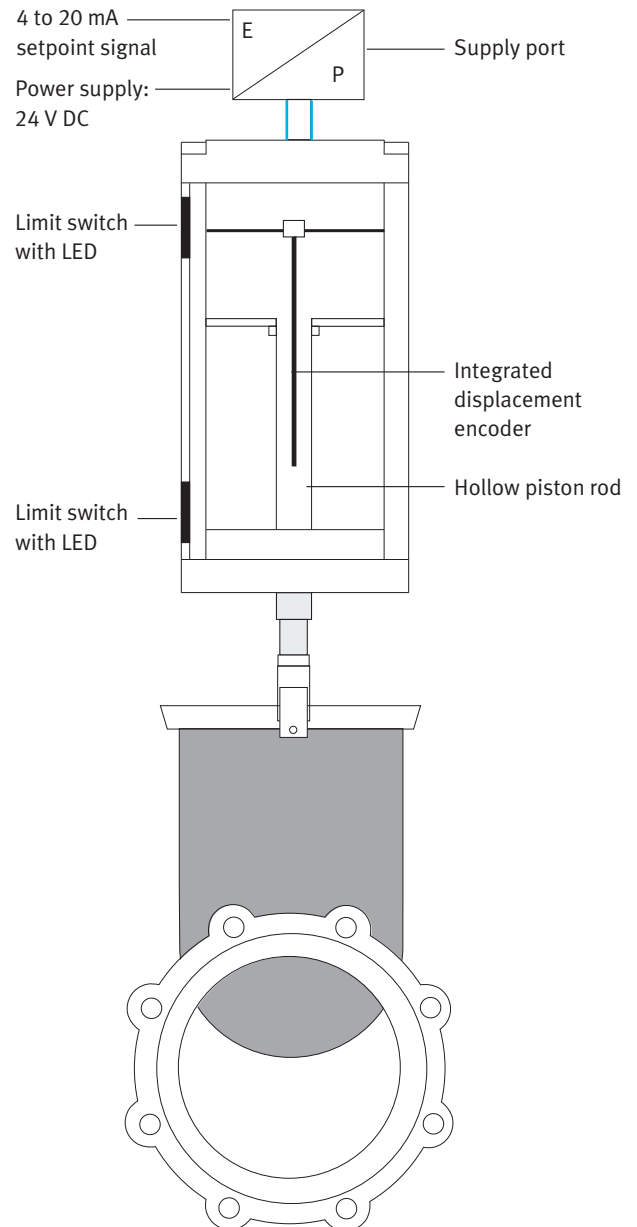
Integrated positioner, integrated displacement encoder

Both function modules are integrated into the actuator with this variant. This version is particularly interesting for applications which are exposed to harsh environmental conditions.

Power supply: 24 V DC
Setpoint: 4 to 20 mA

Note:

The suitability of hand lever valves for use as a “regulating process valve” must be checked in advance with the manufacturer.



Layout and function of the compressed air system

A properly laid out compressed air system is a prerequisite for supplying air for pneumatic automation. The components of the system include compressed air generation and distribution. The location at which the system is installed must fulfil the following conditions:

- Dust-free atmosphere
- Adequate fresh air and ventilation
- Room temperature of +10 to +30° C

Compressed air consumption in these application is normally not continuous, because the process valves might be actuated as infrequently as once a week, once a day or once an hour. This means that the compressor is only operated for a short period of time. A system concept with two piston compressors is advisable, so that they can be operated alternately. This is advantageous, because when one of the compressors is unavailable, the supply of compressed air to the system is nevertheless assured.

Compressed air generation and preparation

Compressor

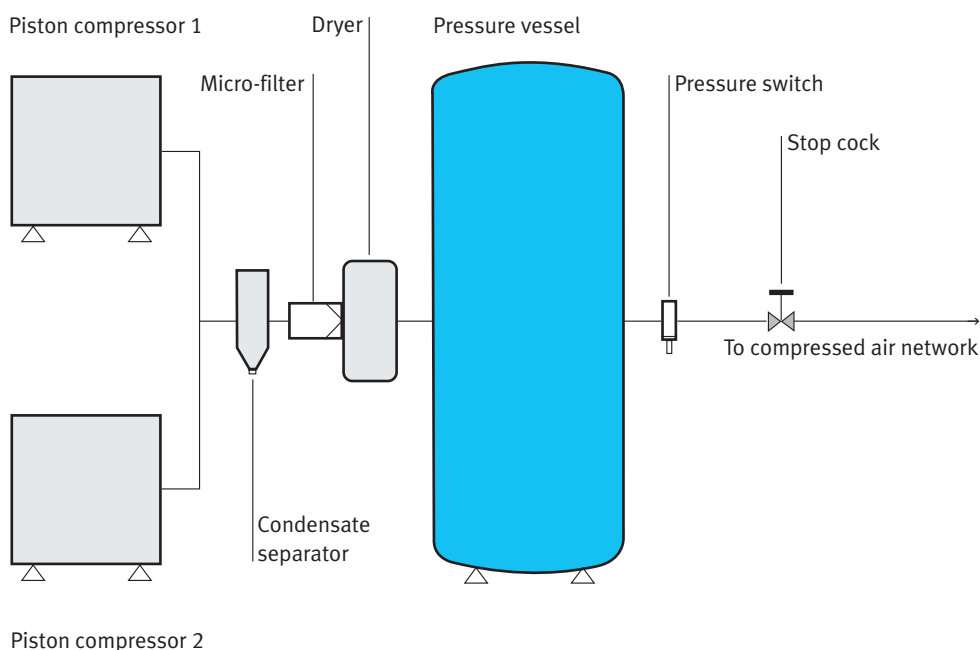
Air is drawn in from the atmosphere and compressed in the compressor, for example to a pressure of 10 bar. Without a doubt, the design of the piston compressor makes it the right selection for use in water and wastewater treatment plants.

Condensate separator

Compressed air contains contamination and atmospheric humidity which must be eliminated, because they cause damage in the long-term to downstream control components. Removed condensate must be drained off in a suitable form.

Micro-filters

Fine contamination particles can be removed with micro-filters. A micro-filter should be installed when a membrane dryer is used.



Dryers

After compression, the compressed air still contains a considerable amount of humidity. This must be removed in any case, because it will otherwise be precipitated as condensate downstream within the system. Condensate water results in malfunctioning of the pneumatic control components.

Refrigeration dryers

Pressure dew point of +3° C, suitable for indoor areas with temperatures higher than +10° C.

Membrane dryer

Pressure dew points of down to -30° C, suitable for outdoor areas with temperatures higher than -20° C.

Pressure vessel

Compressed, prepared control air is stored in a pressure vessel, which neutralises pressure fluctuations within the compressed air system. The size of the vessel is based upon requirements such as compressed air consumption and the residual volume necessary for advancing the process valves into their safety settings. The pressure vessel must comply with applicable pressure vessel regulations, and must be approved for use. Standard sizes of 90, 150 and 250 litres are currently available. A maximum gauge pressure of 10 bar is usually adequate.

Pressure switch

The compressed air system is monitored by means of two pressure switching points. The upper switching point is set to, for example, 10 bar. The compressor is switched off as soon as this pressure level has been reached. If the lower switching point has been set to, for example, 8 bar, the compressor is switched back on again when pressure drops to this level. In the event that the compressor cannot be started up due to a power failure, the lower pressure level of 8 bar is still assured.

Stop cock

The stop cock must be closed when starting up the system in order to build up the set maximum pressure. Only when this pressure is reached is the stop cock opened and the compressed air network supplied with air. This same procedure is necessary if the system was ever unpressurised. A solenoid valve can also be used as an alternative to the manual stop cock. Control then takes place via the PLC. Only when the pressure switch upstream of the solenoid valve has reached the set pressure level is the solenoid valve reversed by the PLC and the compressed air network supplied with compressed air.

Layout and function of the compressed air system

Compressed air quality

In particular for economical and technical reasons, compressed air should only be purified to the extent necessary for the respective application. Preparation must be executed such that long service life and error-free operation of the pneumatic control components are not impaired.

Compressed air quality is defined on the basis of various characteristics according to quality classifications per DIN ISO 8573-1:

- Solid content
- Water content
- Oil content

In each individual case, the manufacturer's specifications regarding compressed air quality must be adhered to for the operation of pneumatic control components. This is the only way to assure error-free operation, and to assure long service life for the utilised components.

Definitions of the classes

Class	Particle		Water		Oil
	Particle size max. in μm	Particle density max. in mg/m^3	Pressure dew point in $^{\circ}\text{C}$	Water content in mg/m^3	Residual oil content in mg/m^3
1	0.1	0.1	-70	3	0.01
2	1	1	-40	120	0.1
3	5	5	-20	880	1
4	15	8	+3	6 000	5
5	40	10	+7	7 800	25
6	–	–	+10	9 400	–

The compressed air quality for actuators, solenoid valves and process valves is defined by Festo in the specification.

Solids, particle size 40 µm
Class 5

Water content: pressure dew
point at least 10°C below
ambient temperature
Class 4 to class 2

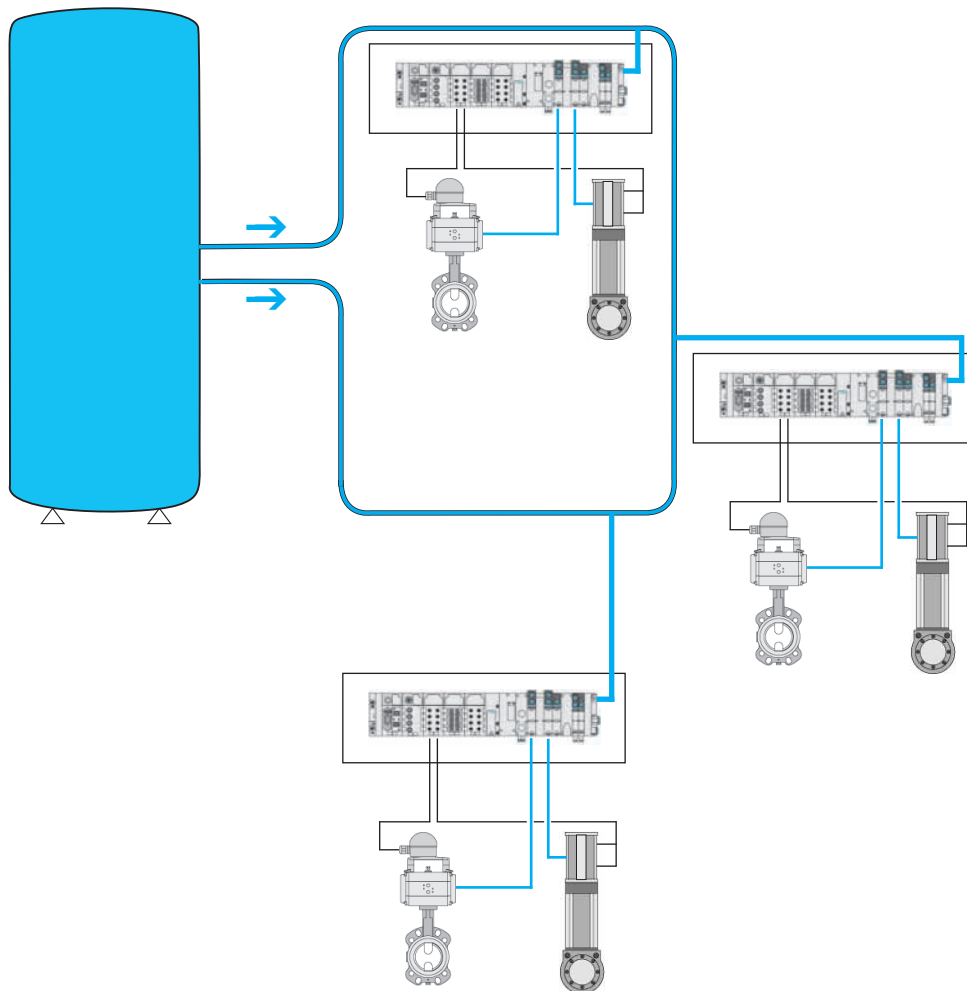
Residual oil content from the
compressor
5 mg/qm when using mineral oil
or 0.1 mg/qm when using bio-oil
Class 4 to class 2

The specified values from all
manufacturers for solids, water
content and residual oil content
must be taken into considera-
tion when dimensioning water
separators, oil separators,
micro filters and air dryers in
the compressed air preparation
system.

The filter in the service unit
combinations used is intended
solely for separating out solids
and not for separating out water
and oil.



Compressed air network



The most sensible and functionally reliable variant for the compressed air network's main line is the ring circuit. When air is consumed by the control components, compressed air can be supplied to the ring circuit from two sides in order to compensate for consumption. In the case of a branch line, pressure compensation for the consumption of pilot air takes considerably longer. The diameter of the compressed air network also plays an important role in supplying air to the control components. In actual practice, pipe diameters of 1, 2 or 3 inches have proven reliable. However, each individual case must be examined separately. Essential factors for dimensioning the compressed air network include:

- Switching frequency of the actuators used to actuate the process valves
- Simultaneous or non-simultaneous activation of the actuators
- Compressed air consumption of the actuators
- Required switching time for the actuators

Consultation with one of Festo's experts is recommended in this respect. A down-sloping gradient of 1 to 2% in the direction of flow is recommended when laying supply pipes, especially in the case of branch lines. Actual practice has shown that condensate may unexpectedly accumulate in the supply line, especially when the compressed air system is first started up or restarted. A drain valve must be installed at the lowest point in the supply line for draining condensate. Installation of additional shut valves makes it possible to shut down individual segments of the compressed air network.



A further variant in addition to the ring circuit is the branch line. To balance out the disadvantage of slower pressure compensation in the network, a smaller reservoir should be installed at the other end of the branch line. The pressure drop is then likewise compensated from this reservoir and the pressure level restored to the original value. This allows new compressed air to flow very quickly into the entire system after compressed air has been consumed in controlling the actuators.

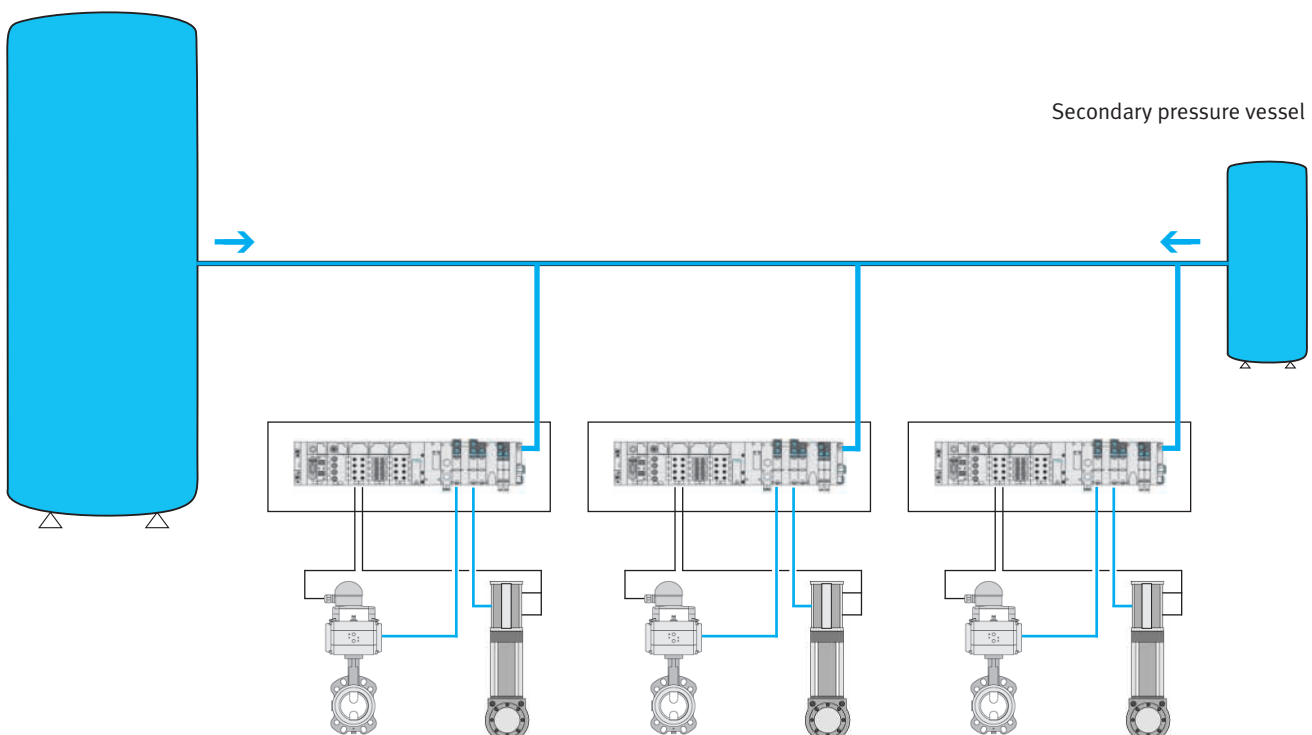
The pressure in the network, whether ring circuit or branch line, should be at least 1, 2 or 3 bar greater than the pilot pressure of the actuators. This is set by means of a pressure regulator at the reservoir for the compressor system. Since the required pilot pressure for the actuators is generally dimensioned for 6 bar, the network pressure should therefore be set to at least 7 bar. The network pressure of 7 bar and higher is then reduced to 6 bar via the pressure regulator in the control cabinet. These section-by-section pressure drops guarantee reliable control of the pneumatic actuator technology.

Safety in the network

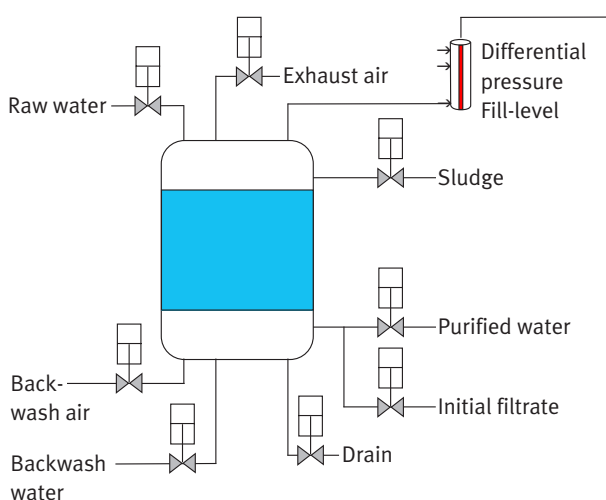
The network should be monitored using pressure switches. These are installed in the service units of the valve terminal control cabinets. If the pressure suddenly drops, for example due to a ruptured or disconnected tube, the pressure switch sends a signal to the PLC. The PLC can then initiate appropriate steps using the program.

Main pressure vessel

Secondary pressure vessel



Calculating air consumption



In order to dimension compressed air generating equipment, operating consumption per hour, day or week must be calculated. As a rule, compressed air consumption is minimal. This will be demonstrated by the following examples. Systems are frequently over-dimensioned in actual practice, which results in uneconomical compressed air generation. Two aspects must be taken into consideration when calculating consumption: consumption for controlling the process, i.e. actuating the process valves, and the size of the pressure vessel. The size of the pressure vessel is based upon the number of process valves which still have to be controlled in the event of a power failure. This situation will be impressively substantiated by the examples.

The following factors serve as a basis for calculating compressed air requirements:

- Nominal size of the process valves
- Type of utilised actuators
- Actuator volume per stroke
- Actuator volume per cycle

In order to simplify the calculation, the compressed air requirement will be calculated back to the compressor's intake volume.

Example for a filtration system in a water treatment plant

The water treatment plant is equipped with 8 filters. 7 butterfly valves and 1 plunger piston valve are installed to each filter for sequentially controlling the purified water. The water treatment plant is not equipped with an emergency power system. In the event of a power failure, the filters have to be closed at the raw and purified water sides so that they don't run dry. If a filter is being washed at the moment that power failure occurs, backwashing is interrupted and the air or back wash water butterfly valve is closed. This factor must be taken into consideration when dimensioning the pressure vessel.

Air requirement per filter

Nominal size	Process valve	Actuator type	Intake volume per stroke in litres	Intake volume per cycle in litres	Intake volume per week
DN 250	Plunger valve	DRD-50	12	24	1008
DN 250	Butterfly valve	DRD-50	12	24	24
DN 50	Butterfly valve	DRD-8	2.1	4.2	4.2
DN 400	Butterfly valve	DRD-225	49.8	99.6	99.6
DN 250	Butterfly valve	DRD-50	12	24	24
DN 250	Butterfly valve	DRD-50	12	24	24
DN 100	Butterfly valve	DRD-8	2.1	4.2	4.2
DN 400	Butterfly valve	DRD-225	49.8	99.6	99.6
Total per filter					≈1300

The filters are backwashed once a week, i.e. the actuators complete one cycle per week. The plunger valves are an exception.

Air requirement for the plunger valve

An adjustment frequency of 5 times per hour has been assumed for calculation purposes. Adjusting travel distance amounts to 10% of the stroke for each adjustment. This results in the following air requirement:

Per hour: $12 \text{ litres} \times 0.1 \times 5 = 6 \text{ litres per hour}$

Per day: $6 \text{ litres} \times 24 \text{ hours} = 144 \text{ litres per day}$

Per week: $144 \times 7 \text{ days} = 1008 \text{ litres per week}$

Air requirement per week for **one filter** based on table

1300 litres

Air requirement per week for **8 filters**, rounded of

10,400 litres

Compressor performance:

Assumed: 50 % duty cycle
50 % efficiency

A piston compressor should be operated with a 50 % duty cycle, i.e. on-time and off-time are identical. The degree of efficiency specifies the effective quantity supplied relative to the compressor's intake volume.

Intake volume per week:

$10\,400 \text{ l} : 0.5 : 0.5 = 41\,600 \text{ l/w}$

Intake volume per minute:

$41\,600 \text{ l} : 7 : 24 : 60 = 4.2 \text{ l/min}$

In addition to compressed air required for actuating the process valves, system-related leakage of the pneumatic control components must also be taken into consideration. Due to long idle times for the compressor, we can initially assume that the actual required quantity is doubled. Furthermore, air requirements are also increased by the length of each tubing section used to connect the control cabinet and the valve terminal.

Example:

Tubing type PLN-8 x 1.25, material: PE

- Outside diameter: 8 mm
- Inside diameter: 6.75 mm
- Volume per 10 metres length: 0.36 litres

The calculation example plainly demonstrates how little compressed air is required for the filtration system in a water treatment plant.

Commercially available piston compressors have intake volumes of 150 litres per minute and more.

Calculating air consumption

Pressure vessel storage capacity

As mentioned above, the required storage capacity results from the number of process valves which have to be closed. The filtration process will be assumed for our purposes. All of the plunger valves and raw water butterfly valves have to be closed.

Due to the fact that pilot air for the actuators is set to 6 bar and minimum pressure in the pressure vessel is, for example, 8 bar, differential pressure amounting to 2 bar is available for safety actuation.

The minimum size of the pressure vessel results from the requirement of approximately 200 litres divided by the differential pressure of 2 bar.

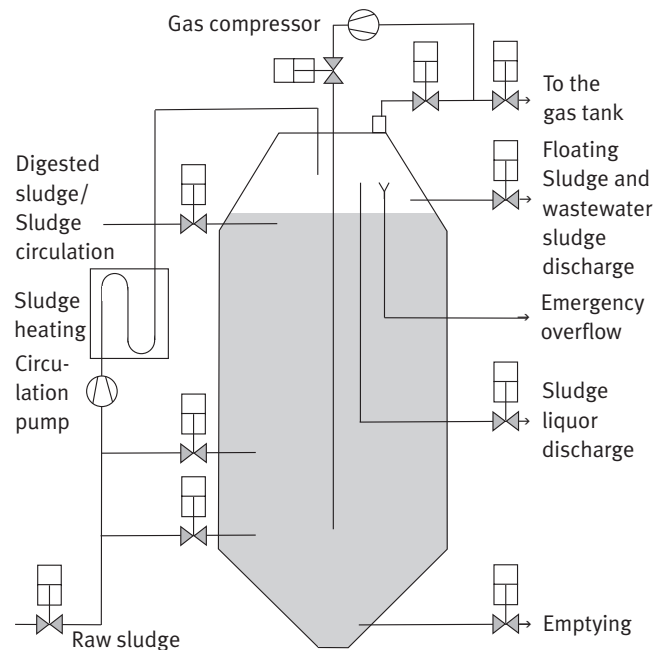
The pressure vessel must be larger than 100 litres.

Nominal size	Process valve	Actuator type	Intake volume per stroke in litres	Intake volume in litres
8 x DN 250	Plunger valve	DRD-50	12	8 x 12
8 x DN 250	Butterfly valve	DRD-50	12	8 x 12
Total				192

Example for a digestion tank in a wastewater treatment plant

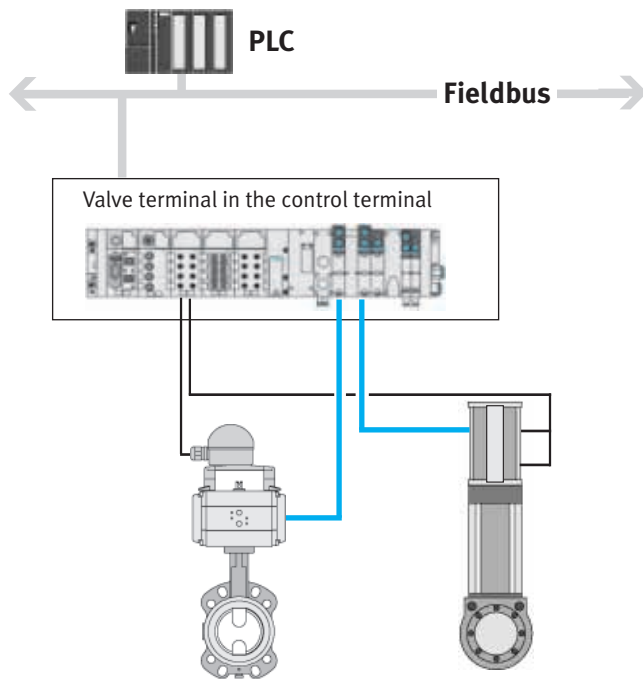
The process valves in a digestion tank will be automated. The required amount of compressed air for a total of 10 process valves must be calculated. It is assumed that the process valves are reversed once a week, i.e. they complete one cycle per week. The central compressed air system will cover this additional air requirement. A system with an intake volume of 300 litres per minute and a pressure vessel with a capacity of 350 litres is available. The system is operated with a maximum volume of 10 bar, and compressed air network pressure is set to 8 bar. One digester has already been automated. The existing process valves have the same nominal sizes as those which will be used for retrofitting.

The existing system is adequately dimensioned with an available intake volume of 350 litres per minute.



Nominal size	Process valve	Actuator type	Intake volume in litres per cycle	Intake volume per week
DN 300	Gate valve	DLP-200-300	127.2	127.2
DN 200	Gate valve	DLP-160-200	56.4	56.4
4 x DN 150	Gate valve	DLP-160-150	4 x 42.3	1169.2
DN 125	Gate valve	DLP-125-125	21.5	21.5
3 x DN 80	Gate valve	DRD-8	3 x 4.2	12.6
Total				≈390 l

Assembly, installation and commissioning



There are some special points to take into consideration when assembling and installing pneumatic actuators and automation systems. If there is already compressed air present in a system, individual elements can pose a risk. This work must therefore be carried out by appropriately qualified personnel.

The following notes as well as the procedures described do not claim to be complete. They are based on experience gained during the realisation of a large number of projects. Complete responsibility rests with the company carrying out the work. The Festo specialists can provide support and advice.

Allocation of the actuators on the valve terminal

Wiring of the limit switches and tubing of the actuators can commence after the process valves are mounted in the pipe system of a waterworks or in a wastewater treatment plant. The appropriate documentation is available for the connections at the valve terminal control cabinet. This then determines which limit switch is allocated to which digital input on the valve terminal. The same applies to the allocation of the actuators and the solenoid valves on the valve terminal.

Laying of the tubing

Tubing, like cables, can be laid in trays, cable channels or even in plastic pipes. Particular attention must be paid to the permitted bending radius, which is dependent on the nominal size and tubing material. The following values apply to the tubing type PLN used in waterworks and wastewater treatment plants:

- Nominal size 6
Min. bending radius 11 mm
- Nominal size 8
Min. bending radius 23 mm
- Nominal size 10
Min. bending radius 23 mm
- Nominal size 12
Min. bending radius 23 mm
- Nominal size 16
Min. bending radius 55 mm

The UV-resistant variant must be used when laying tubing outdoors. The tubing should be covered for additional protection.

Working on the control cabinet

All cabinets must first be mounted at their designated locations by securing them to a wall or rack. Additional weather protection, which is also available ex-works, is often useful for installations outdoors. Once all the cables and tubing for the actuators have been connected, the voltage and the central compressed air to the service unit are connected. The compressed air system should not be pressurised when this is done. The valve terminal and the actuators can be supplied with compressed air by opening the manual on/off valve.

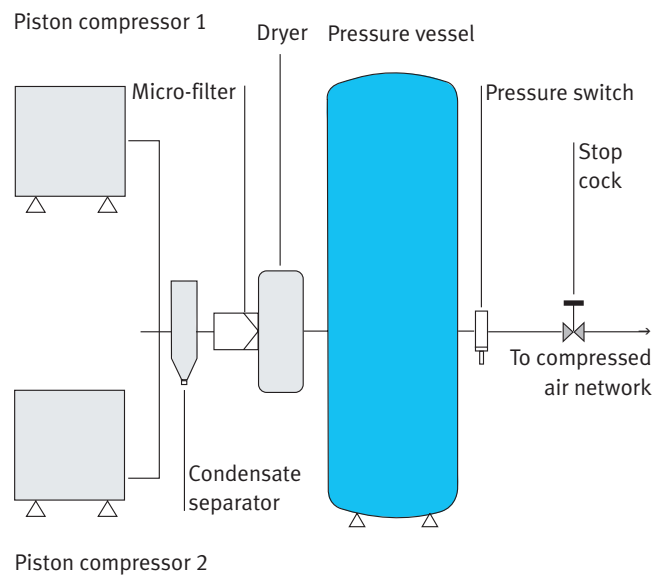
Closing the manual on/off valve slowly vents the actuators and the valve terminal.

Starting up the compressed air system

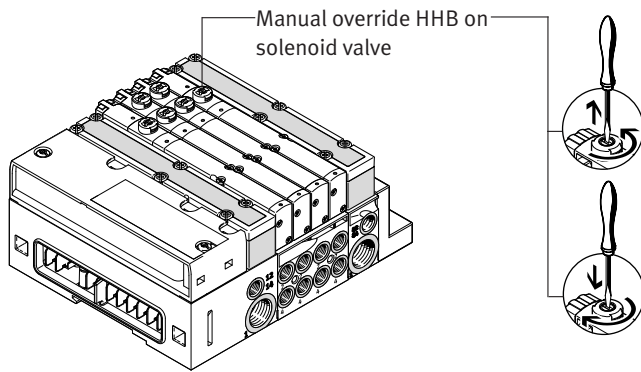
The operating instructions of the respective manufacturer must be observed during commissioning. The stop cock at the end of the system, at the transition to the compressed air network, must be closed during commissioning. Otherwise the required pressure cannot build up since the air can escape via the network and other elements. This procedure must also be followed when the system is recommissioned following a power failure.

The compressed air quality must be checked particularly in case of lubricated compressors. If the air has not been sufficiently prepared, it must not be allowed to get into either the compressed air network or, by extension, the pneumatic control elements.

Before the compressed air network is supplied with air, the manual on/off valves of the service units must be set to closed. This prevents undesired actuation of the pneumatic actuators. The compressed air network can be gradually supplied with air once the set pressure of 7, 8, 9 or 10 bar has been reached in the reservoir. The individual segments should then be briefly vented by opening the stop cocks to blow out any particles and other residues from the compressed air network.



Assembly, installation and commissioning



Dry commissioning

The functioning of pneumatic actuators can be checked step by step before the complete system in the waterworks or wastewater treatment plant is commissioned. This is easiest to do before the system has been filled.

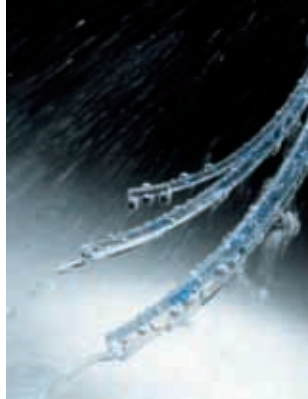
The most important steps in detail:

- Set the pilot pressure at the control cabinet to 6 bar using the pressure regulator of the service unit.
- Positioners or other control elements that should only have max. 7 bar should initially be kept pressureless by means of a stop cock. Only after the 6 bar has been set can these be supplied with compressed air.
- Check the normal position of the actuators. If it is not as stipulated, it can be corrected at the actuator or at the control cabinet by changing the tubing. Important: vent the cabinet first via the manual on/off valve.
- Calibrate the positioners at the actuator. If the positioners have not been set at the factory, this must be done on-site. Compressed air and a current or voltage signal must be applied for this. The operating instructions on calibration must be observed.
- Actuate the actuator using the open/close function. The individual actuators can be reversed and thus the control behaviour of the process valves can be checked using the manual override of the solenoid valves on the terminal. Single-solenoid valves have one manual override and double-solenoid valves have two manual overrides.
- Set the opening and closing times of the process valves via the exhaust air flow control valves in the actuator. Turning the adjusting screw or the knurl of the flow control valves to the right increases the times, turning it to the left decreases them. Repeat the reversal of the actuators a number of times with the manual override until the required switching times are achieved.
- Check the wiring of the limit switches. The corresponding LEDs on the input modules light up on the CPX terminal of the valve terminal. This is an easy way of checking the correct allocation of the limit switches. If communication between the controller and the valve terminal is already working, the correct allocation of the limit switches in the allocation list can also be checked via the programmer.



Tubing and accessories

Reliable installation of the pneumatic components is only guaranteed when using the corresponding tubing and the chosen accessories.



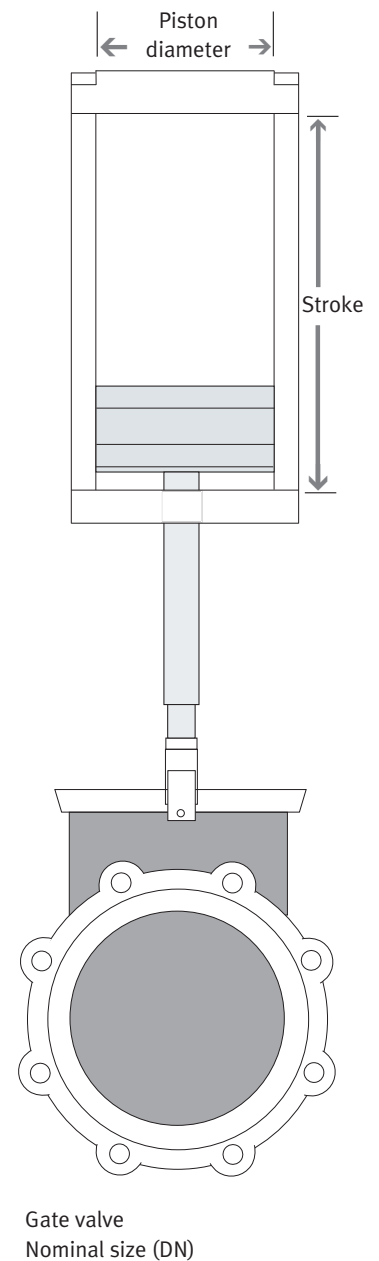
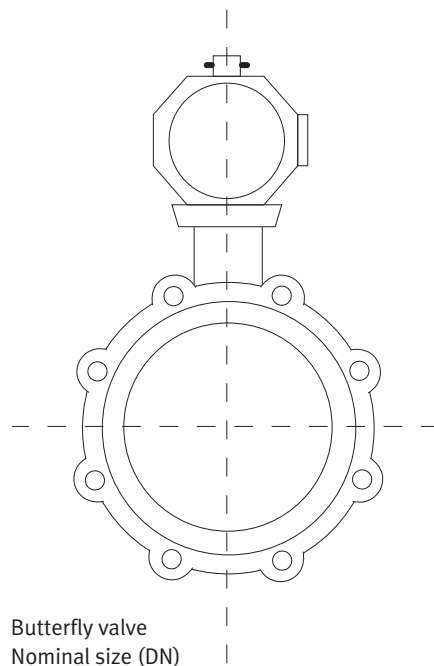
Standards in actual practice



The large number of manufacturers of actuators, process valves and accessories is often confusing for the system operator. For this reason, the process industry has initiated standardisation of the various interfaces. This is intended to facilitate interchangeability of individual components. Standardisation has helped to reduce the great multitude of different interfaces. The interfaces included on Festo's quarter turn actuators and linear actuators comply with the following standards:

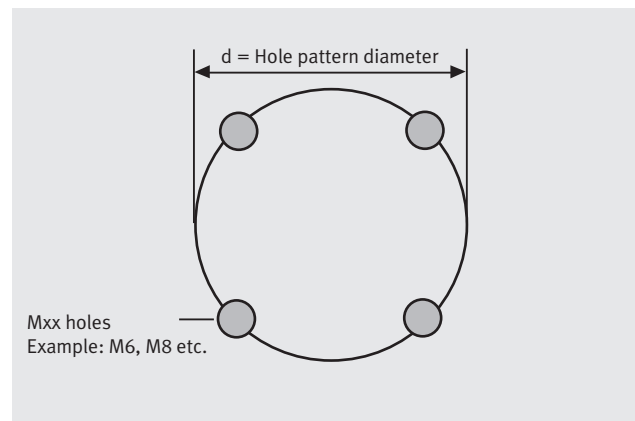
- Actuator to process valve
1505210/5211, DIN 3337
- Actuator to limit switch
module
VDI/VDE 3845, NAMUR
- Actuator to solenoid valve
VDI/VDE 3845, NAMUR

In each individual case, it must be ascertained whether or not correspondence is assured for the flange connection, as well as for the shaft of the quarter turn actuator. Festo has examined and coordinated these interfaces for a great number of process valves in cooperation with well-known manufacturers. This applies in particular to butterfly valves, gate valves and ball valves.



ISO 5211

Flange dimensions quarter turn actuator with interface per ISO 5211



Bottom view of the quarter turn or linear actuator

d [mm]	Flange designation	Torque * [Nm]	Mounting screws
36	F03	32	4 x M5
42	F04	63	4 x M6
50	F05	125	4 x M6
70	F07	250	4 x M8
102	F10	500	4 x M10
125	F12	1000	4 x M12
140	F14	2000	4 x M16
165	F16	4000	4 x M20
254	F25	8000	8 x M16
298	F30	16 000	8 x M20

* Maximum permissible torque when using quarter turn actuators, which may be transmitted via the mounting flange and couplings. The specified values are based upon assumptions for screw tightness, permissible stressing, type of stressing and the coefficient of friction between the flanges.

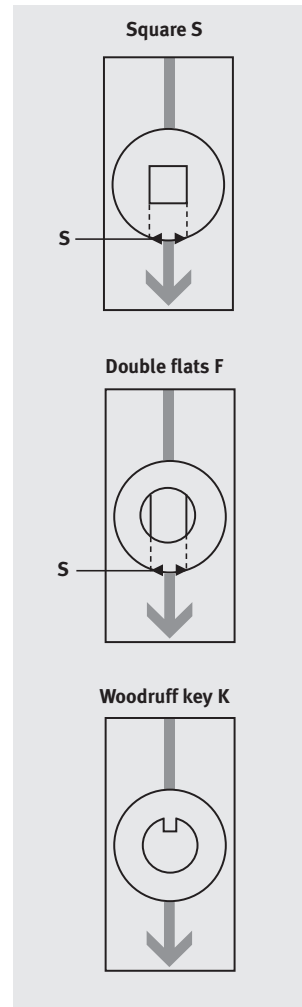
Shape and dimensions of actuators and components to be driven for quarter turn actuators

In accordance with ISO 5211, the component which transfers force or torque from the actuator to the process valve's shaft may have the following geometry: The most commonly used shape for the connecting element is a square, and a double-D shaft with two parallel flats is used less frequently. The dimension stipulated for the width of the square or the flats is specified in the following table. Dimension **s** applies to the square, as well as to double flats.

Flange	s* [mm]
F03	9
	10
F04	11
	12
F05	14
	16
F07	17
	19
F10	22
	24
	27
F12	32
F14	36
F16	46
F25	55
	60
F30	75

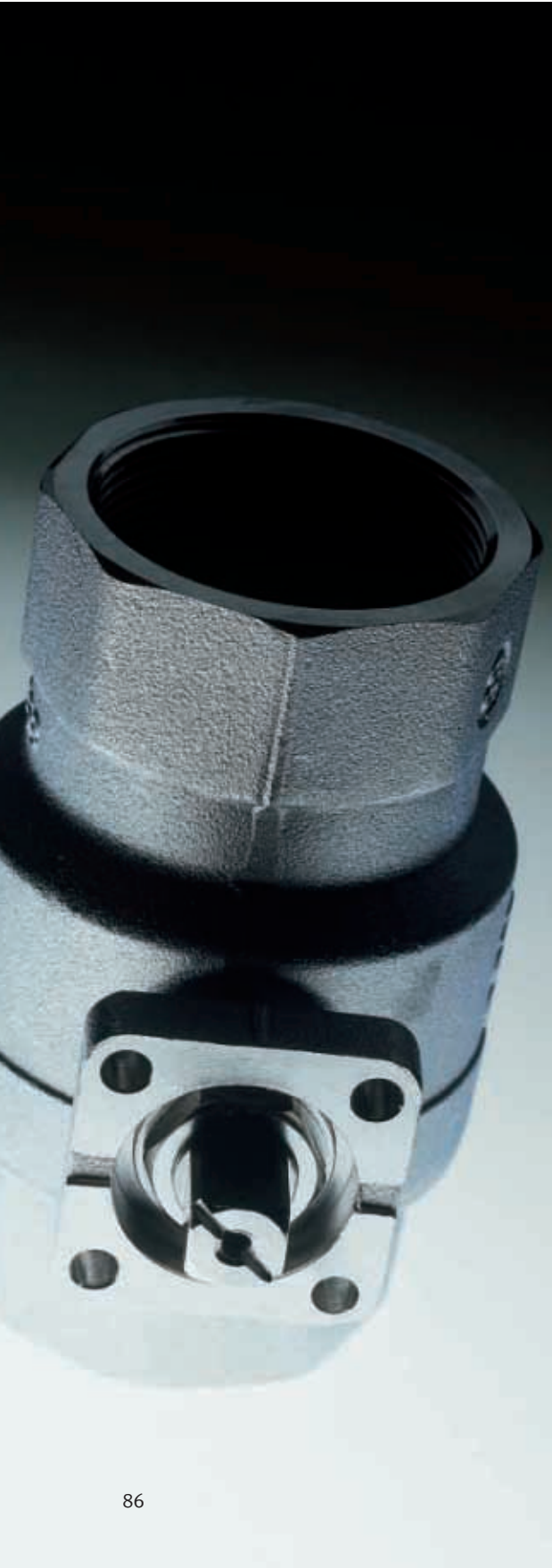
* Dimensional tolerance H11/h11
(per ISO/R 286)

Woodruff key shafts in a great variety of sizes are also frequently used for large process valves (butterfly valves) for which high torque values are required.



The arrow indicates the direction of flow in the pipe.

ISO 5211



Designation

Flanges are designated as follows:

- The letter F
- Two numeric digits

Example: flange F04,
pitch circle diameter: 42 mm,
4 ea. M6 mounting screws

The quarter turn actuators must be designated as follows:

- Flange designation
(see above)
- Designation of the type of connector using the following capital letters:
 - K for key shaft
 - S for square
 - F for double-flats
- In the case of quarter turn actuators with square or doubleflats, the s value specified in the following table must be included to the right of the letter.

Example: actuator with flange
F05 S14,
pitch circle diameter: 50 mm,
square with edge length of
14 mm, 4 ea. M6 mounting
screws

DIN 3337 defines semi-rotary actuator connections for process valves, as well as coupling and flange dimensions.

This standard includes all stipulations for flanges ranging from F05 to F25 from the DIN ISO 5211 standards, as well as the international standard ISO 5211/3: 1982.

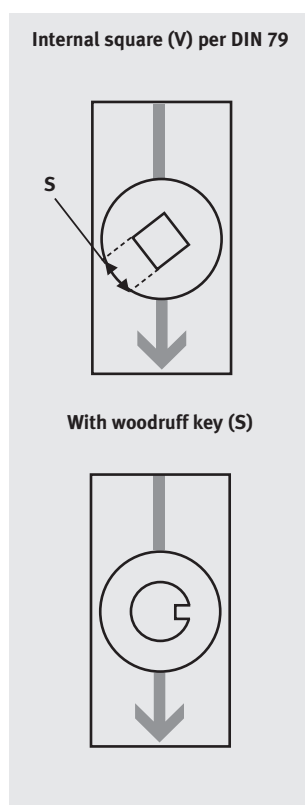
Supplementary stipulations h2, h3 and l3, as well as stipulations for F03 and F04 flanges, and the dimension in connection with the internal square coupling are national supplements to ISO 5211, part 3.

Scope of application

This standard applies to the dimensions of the elements at the interfaces of quarter turn actuators which are used to transmit force or torque to the component to be actuated (spindle at the process valve).

Dimensions, designation

A square is specified as the connecting element between the quarter turn actuator and the process valve in this standard, which has the same dimensions as specified in DIN ISO 5211 but is rotated 45° (see figure). Position is also specified identically in this standard for connection by means of a woodruff key (see figure).



Example: F07 S17,
pitch circle diameter: 70 mm,
4 ea. M8 mounting screws,
square rotated 45° with 17 mm
edge length

VDI/VDE 3845 NAMUR

Interfaces: final control element – actuator – accessories for actuating devices

Interfaces between final control elements, actuators and accessories are specified in this guideline. Reference is made to existing standards, and recommendations are included for the attachment of positioning controllers, control valves and signal generating devices to pneumatic actuators.

Purpose and scope

This guideline includes stipulations for uniform interfaces on basic function groups for actuators. These stipulations are intended to make it possible to assemble adjoining function groups from various manufacturers to each other.

Function groups in the spirit of the guideline include:

- The final control element which restricts or stops the flow of material by means of adjustable cross-section constriction (process valve)
- The actuator which sets or controls cross-section constriction by means of adjusting force or travel
- Control and signal generating devices for controlling the actuator and equipment for supplying auxiliary power (NAMUR valves, limit switch attachments)

Standards and recommendations for interfaces

Interfaces

Process valve to quarter turn actuator

Details regarding this connection are stipulated in the following standards and recommendations:

- DIN 3337 – connection of quarter turn actuators to process valves (coupling dimensions)
- NAMUR recommendation dated July 1985
- Connection of quarter turn actuators to process valves, Pr EN 12 116

Connection

Process valve to linear actuators

Details regarding this interface are stipulated in the following standards and recommendations:

- DIN 3358 – connection of linear actuators to process valves (connection dimensions for flange connection)
- DIN ISO 5210 – connection of rotary actuators to process valves (a rotary actuator is an electrical motor which turns a spindle, and not a pneumatic, quarter turn actuators)

Interfaces
 Quarter turn actuator to accessories for actuators

Mounting level 1

For attaching position controllers and signal generating devices with:

- Four 6.5 mm diameter holes for mounting a position controller
- Four M4 threaded holes for mounting a position controller and a central hole through which the connecting shaft can protrude

Mounting level 2

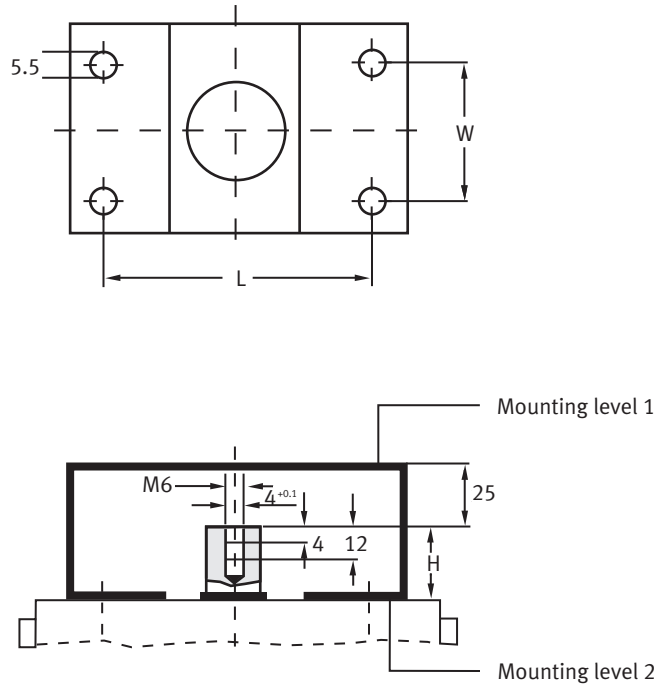
For attaching the bracket to the quarter turn actuator with four 5.5 mm diameter holes

Four M5 threaded holes with a depth of 8 mm must be included in the top surface of the flange of the quarter turn actuator used for mounting. The standard permits the following dimensions for brackets:

L	W	H
80	30	20
80	30	30
130	30	30
130	30	50

The following interfaces have established themselves as a “cold” standard for the following interfaces:

L 50	W 25	H 20
L 50	W 25	H 30



VDI/VDE 3845 NAMUR

Interfaces for solenoid valves (direct flange mounted)

Four M5 threaded holes with a depth of 8 mm must be included in the top surface of the flange used for mounting. Two of these threaded holes accept a threaded coding pin (one for each position of the solenoid valve), which assures that the control valve can only be mounted in the specified position (assurance of the actuator's specified direction of action). The coding pin must protrude 2 mm from the surface of the flange after being screwed in, and thus protrudes into the matching coding recess in the solenoid valve (one side only, minimum depth: 3 mm, diameter: 5.5 mm).

Connection of the pilot air ducts between the solenoid valve and the actuator are sealed with O-rings (16 x 2 mm). The O-ring seats are in the housing of the solenoid valve.

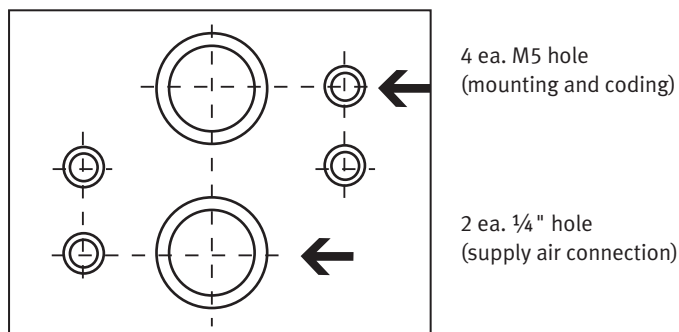
O-rings, mounting screws and the threaded coding pin are included in the scope of delivery for the solenoid valve.

If direct mounting is not possible (no NAMUR interface), an adapter must be furnished for flange mounting the solenoid valve. The adapter is rarely included as part of the scope of delivery for the quarter turn actuator, and is sometimes only available for an additional charge. The position of the NAMUR interface on the quarter turn actuator is not specified.

Connecting solenoid valves without NAMUR interface (not directly flange mountable)

If the solenoid valve cannot be directly flange mounted, G $\frac{1}{4}$ holes must be provided in accordance with DIN ISO 228, part 1, for connecting air supply lines to the quarter turn actuator and the solenoid valve.

If large volumes of air or very short pressurisation or exhaust times are required for controlling the actuators, the connection cross-sections and the connecting lines must be accordingly dimensioned.



Pneumatics and explosion protection

Directive 94/9/EC (ATEX)

The new directive on the use of equipment in potentially explosive areas came into force on 1 July 2003. This directive, which has the working title ATEX, harmonises the various requirements within the EU. The goal is to ensure a uniform safety standard and to remove obstacles to trade. Other directives apply to other regions, for example the USA.

The directive 94/9/EC also supplements earlier directives. One particular addition to the directive is that non-electrical devices such as pneumatic actuators now also have to be approved.

These changes mean that companies that previously used only pneumatic components in potentially explosive areas are now being forced to use certified pneumatic products.

The main changes at a glance

The main amendments to the new directive 94/9/EC are as follows:

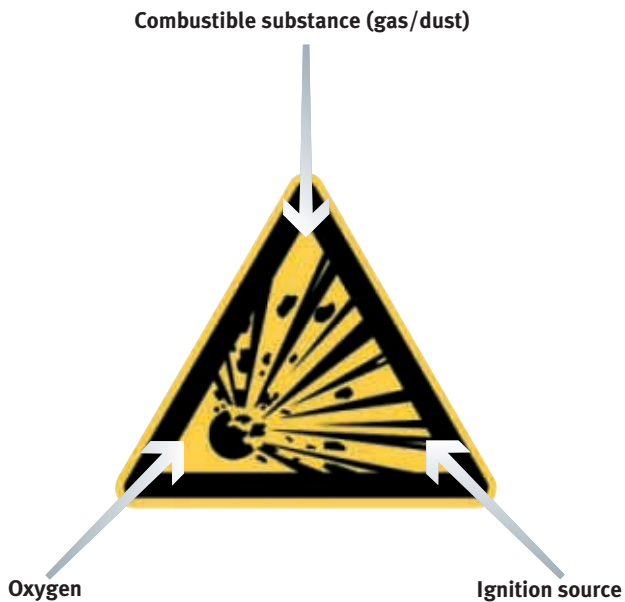
- Non-electrical equipment, for example actuators, is now also covered.
- Equipment is divided into categories, which in turn are assigned to corresponding zones.
- New identification with the CE mark.
- Each piece of equipment must be supplied with operating instructions and a conformity declaration.
- Dust explosion protection now also falls within the scope of this directive. The zones are broken down in the same way as for areas at risk of gas explosions.
- Applies to mining as well as all other potentially explosive areas.
- It specifies general safety requirements.
- Also applies to complete protective systems.

Note:

You can find the latest information as well as conformity declarations and documentation for the products at www.festo.com/en/ex.



Potentially explosive areas



Explosions can occur even when certain conditions are fulfilled.

An explosive mixture can develop wherever, for example, combustible gases, liquids or dust are manufactured, transported or stored. Such areas are called potentially explosive areas (ATEX zones). A small spark such as one that can occur when, for example, opening an electrical contact is all that is needed to ignite the explosive mixture.

Potentially explosive mixtures with gas, mist or vapours can form in:

- Chemical factories
- Fuel tank installations
- Refineries
- Wastewater treatment plants
- Airports
- Power stations
- Paint factories
- Paintshops
- Docks

Potentially explosive mixtures with dust can form in:

- Chemical factories
- Power stations
- Paint factories
- Flour mills
- Cement works
- Docks
- Animal feed factories
- Waste incineration facilities and many other areas in which bulk goods that form dust are processed or transported.

Explosion protection includes all the precautionary measures for protecting against risk to life and limb as well as machinery and equipment.

Electrical sources of ignition

- For example sparks when removing coil plugs (electric arcs, sparks)
- Electrical equalising currents
- Hot surfaces on solenoid coils

Mechanical sources of ignition

- Hot surfaces due to friction and compression losses
- Adiabatic compression
- Electrostatic discharge
- Mechanical sparks caused by hammering

Further possible sources of ignition

- Open fire or a flame (e.g. welding, smoking)
- Hot surfaces (e.g. hot-running bearings or brakes)
- Self-igniting reactions (exothermic connections)
- Self-igniting substances
- Ultrasonics
- Lightning strike

The directive in detail

The directive defines both the areas in which pneumatics should be used and which devices are suitable. In terms of the locations of use, a distinction is made between mining or comparable situations and non-mining applications.

If pneumatic equipment is intended for use in an ATEX zone, operators, system manufacturers as well as suppliers of the equipment must agree on the classification of the ATEX zones and equipment categories.

Explosion protection documentation from system manufacturer	Festo/ equipment supplier
System rated according to ATEX 137, Directive 99/92/EC	Equipment rated according to ATEX 95a, Directive 94/9/EC
	
Result: • Zone classification • Temperature classes • Explosion groups • Ambient temperature	Result: • Equipment categories • Temperature classes • Explosion groups • Ambient temperature
Zone	Category

Zone Gas	Zone Dust	Frequency	Equipment group	Equipment category	Area of application
0		Constant, frequent, long-term	I	M1 M2	Mining
1		Occasional	II		All non-mining applications
	20		II	1G	Gases, mist, vapours,
	21		II	1D	Dust
2		Seldom, short-term, in the event of a fault	II	2G	Gases, mist, vapours,
	22		II	2D	Dust
			II	3G	Gases, mist, vapours,
			II	3D	Dust



The classification of equipment group II

Zone 0
Equipment category 1

With equipment in this category the required level of safety is guaranteed even with infrequent equipment faults. It is used wherever potentially explosive atmospheres consisting of a mixture of air and gases, vapours or mist or dust and air are present continuously or long-term.

Additional identification

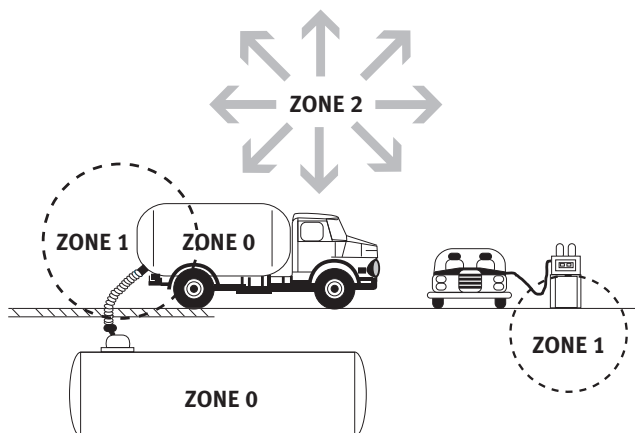
The categories in group II also feature a letter suffix (G for gases and D for dust).

Zone 1
Equipment category 2

With equipment in this category the required level of safety is guaranteed even with frequent equipment faults. It is used in areas where a potentially explosive atmosphere consisting of a mixture of air and gases, vapours or mist or dust and air is occasionally present.

Zone 2
Equipment category 3

This equipment exhibits the required level of safety under normal operation. It is used in areas where, in all probability, a potentially explosive atmosphere resulting from gases, vapours, mist or raised dust is not to be expected or only to be expected for a short time.



Documents supplied with the product

Products requiring approval

Products with their own potential ignition sources require approval. These products are subject to the Directive 94/9/EC ATEX. Depending on the type of products, they must conform to certain ignition protection types that are described in the standards.

Equipment in these product groups must be supplied with operating instructions and a conformity declaration. These products also require an explosion protection mark.

They include, for example:

- Actuators/cylinders
- Power valves
- Solenoid coils
- Switches
- Sensors

Products not requiring approval

Products not requiring approval are those that do not have their own potential ignition source. These products can be used in certain ATEX zones if our manufacturer specifications are taken into consideration. Festo has carried out an appropriate risk analysis.

Some product examples of this:

- Pneumatic accessories
- Tubing
- Fittings
- Pneumatic connecting plates
- Flow control and non-return valves
- Non-electrical service units
- Mechanical accessories

Festo voluntarily provides a manufacturer's certificate for the following zones:

Zone 0, 1, 2, 20, 21, 22

Zone 1, 2, 21, 22

Zone 1, 2

Products without manufacturer's certificate

The Festo range includes many non-electrical products that are not listed on any manufacturer's certificate, but that can be used in explosive atmospheres due to their design and application.

In this case users have the option of subjecting these products to a risk analysis themselves in the explosion protection document to ATEX 137.

Note:

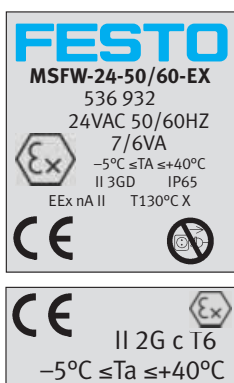
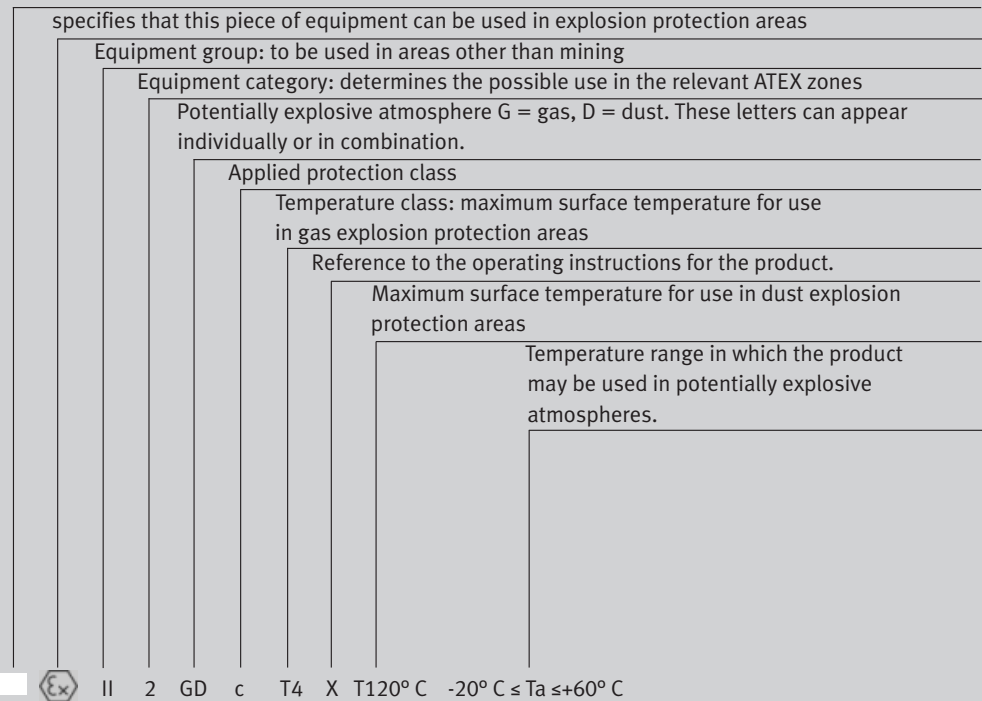
Please contact the Festo specialists if you have any questions relating to products without a manufacturer's certificate.

You can find current information as well as conformity declarations, manufacturer's certificates and documentation for the products on the website at www.festo.com/en/ex, under the "Products" link.

Explosion protection rating plates and their meaning

Mechanical equipment

CE mark:



Solenoid coil =
electrical equipment

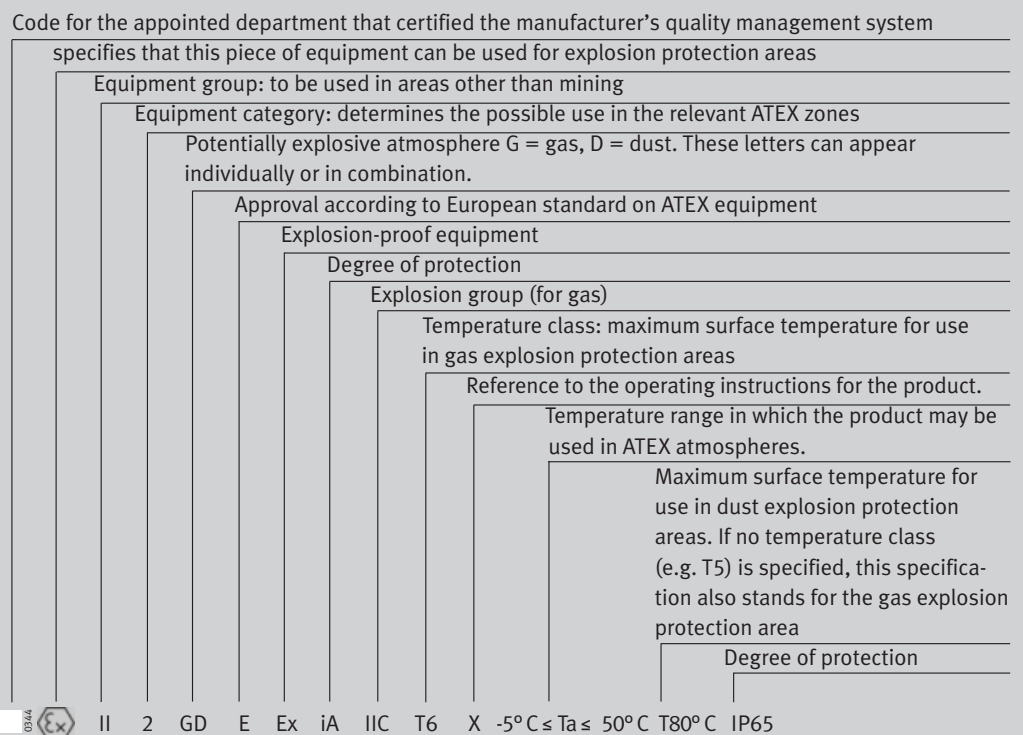
Non-electrical part
of the solenoid valve
(power valve) must
be approved

The rating plate is the key to reliable identification of explosion-protected pneumatic and electrical products. We have broken down the different type codes into their component parts to help you find your way more quickly.

The rating plates that will be used in future on products that are designed for use in ATEX zones are:

- Mechanical equipment
- Electrical equipment
- Explosion-protection type plates at Festo

Electrical equipment



Explosion-protection rating plates at Festo

Equipment groups	Equipment categories	Protection classes
Equipment group II not mining	2GD Equipment for use in Zone 1 and 21	ia Intrinsically-safe electrical ib equipment
	2G Equipment for use in Zone 1	nA Non-ignitable electrical equipment. Protection class not sparking
	3GD Equipment for use in Zone 2 and 22	d Pressure-resistant casing
	3G Equipment for use in Zone 2	m Moulded encapsulation c Constructional safety e Increased safety

ATEX-compliant products from Festo

Actuators and cylinders

An actuator is a module made up of two or more sub-devices that require approval:

1. Cylinder
2. Accessories, e.g. sensors

Zone	Equipment category	Explosive atmosphere
1	2G	Gases, Vapours
21	2D	Dust
2	3G	Gases, Vapours
22	3D	Dust

Note:

Actuators with direct part numbers (that cannot be configured) can be supplied with ATEX approval on request. The information in the data sheet on “ATEX identification”, “ATEX ambient temperature” and “CE marking” only refers to actuators with ATEX approval.

Solenoid valves

A valve is a module made up of two devices that require approval:

1. Power valve (non-electrical part)
2. Solenoid coil (electrical part)

Zone	Equipment category	Explosive atmosphere
1	2G	Gases, Vapours
21	2D	Dust
2	3G	Gases, Vapours
22	3D	Dust

Service units

A service unit is a module made up of devices that require approval and devices that do not require approval, for example:

1. Pressure regulator (does not require approval)
2. Electrical on/off valve (requires approval)

Note:

- All equipment is individually marked and documented with respect to its use as intended in an ATEX zone.

- The resulting application range for the module is determined by the lowest category of both sub-devices.

- This relates to the equipment category, ATEX atmosphere G or D, max. surface temperature T and explosion group (if present).

Guidelines for the American market



In North America, potentially explosive zones are divided into two divisions as per NEC 500. As in Europe (IEC standard), the basis for differentiating between the divisions is the probability of a hazardous, potentially explosive atmosphere occurring.

Division 1: If it is probable that a potentially explosive atmosphere will occur continuously, long-term or occasionally.

Division 2: If it is probable that a potentially explosive atmosphere will occur rarely or only for a short time.

The UL (“Underwriters Laboratories Inc.”) is an independent testing and certification organisation whose main goal is product safety. Headquartered in the U.S.A., it has to date set over 700 standards that are observed by many users worldwide. The UL standards relating to potentially explosive zones and electrical equipment divides all combustible materials into 3 classes:

Class I: Combustible gases, vapours and liquids
Class II: Combustible dust
Class III: Slightly combustible particles and substances

The table below shows the subdivision of the danger areas for gases, vapours, mists and dust into zones or divisions in accordance with European and American standards.

Potentially explosive atmosphere occurs:	EU (EN 60079-10)		USA (NEC 500)		USA (NEC 505)
	Gases, vapours, mist	Dust	Gases, vapours, liquids	Dust	Gases, vapours
Continuously or long-term	Zone 0	Zone 20	Class I	Class II	Class I, Zone 0
Occasional	Zone 1	Zone 21	Division 1	Division 1	Class I, Zone 1
Rarely or short-term	Zone 2	Zone 22	Class I Division 2	Class II Division 2	Class I, Zone 2

Festo worldwide

Argentina

Festo S.A.
Edison 2392
(B1640 HRV) Martinez
Prov. Buenos Aires
Tel. ++54 (0)11/47 17 82 00, Fax 47 17 82 82
E-mail: info_ar@festo.com

Australia

Festo Pty. Ltd.
Head Office (Melbourne)
179-187 Browns Road, P.O. Box 261
Noble Park Vic. 3174
Call Toll Free 1300 88 96 96
Fax Toll Free 1300 88 95 95
Tel. ++61(0)3/97 95 95 55, Fax 97 95 97 87
E-mail: info_au@festo.com.au

Austria

Festo Gesellschaft m.b.H.
Linzer Straße 227
1140 Wien
Tel. ++43 (0)1/910 75-0, Fax 910 75-250
E-mail: automation@festo.at

Belarus

IP Festo
220035 Minsk
Prospekt Masheraova , 78
Belarus
Tel. +375 (0)17/204 85 58, Fax 204 85 59
E-mail: info_by@festo.com

Belgium

Festo Belgium sa/nv
Rue Colonel Bourg 101
1030 Bruxelles/Brussel
Tel. ++32 (0)2/702 32 11, Fax 702 32 09
E-mail: info_be@festo.com

Brazil

Festo Automação Ltda.
Rua Guiseppe Crespi, 76
KM 12,5 - Via Anchieta
04183-080 São Paulo SP-Brazil
Tel. ++55 (0)11/50 13 16 00, Fax 50 13 18 68
E-mail: info_br@festo.com

Bulgaria

Festo EOOD
1592 Sofia
Bul. Christophor Kolumb 9
Tel. +359 (0)2/960 07 12, Fax 960 07 13
E-mail: info_bg@festo.com

Canada

Festo Inc.
5300 Explorer Drive
Mississauga, Ontario L4W 5G4
Tel. ++1 (0)905/624 90 00, Fax 624 90 01
E-mail: info_ca@festo.com

Chile

Festo S.A.
Avenida América Vespucio 760,
Pudahuel, Santiago
Tel. +56 2 690 28 00, Fax +56 2 690 28 60
E-mail: info.chile@cl.festo.com

China

Festo (China) Ltd.
1156 Yunqiao Road
Jinqiao Export Processing Zone, Pudong,
201206 Shanghai, PRC
Tel. +86 (0)21/60 81 51 00, Fax 58 54 03 00
E-mail: info_cn@cn.festo.com

Colombia

Festo Ltda.
Avenida El Dorado No. 98-43
Bogotá
Tel. ++57 (0)1/404 80 88, Fax 404 81 01
E-mail: festo@festo.com.co

Croatia

Festo d.o.o.
Nova Cesta 181
10000 Zagreb
Tel. ++385 (0)1/619 19 69, Fax 619 18 18
E-mail: info_hr@festo.com

Czech Republic

Festo, s.r.o.
Modranská 543/76
147 00 Praha 4
Tel. ++420 261 09 96 11,
Fax ++420 241 77 33 84
E-mail: info_cz@festo.com

Denmark

Festo A/S
Islevaldvej 180
2610 Rødovre
Tel. ++45 70 21 10 90, Fax ++45 44 88 81 10
E-mail: info_dk@festo.com

Estonia

Festo OY AB Eestli Filiaal
Laki 11B
12915 Tallinn
Tel. ++372 666 15 60, Fax ++372 666 15 61
E-mail: info_ee@festo.com

Finland

Festo OY
Mäkituvantie 9, P.O. Box 86
01511 Vantaa
Tel. ++358 (09)/87 06 51, Fax 87 06 52 00
E-mail: info_fi@festo.com

France

Festo E.U.R.L.
ZA des Maisons Rouges
8 rue du Clos Sainte Catherine
94367 Bry-sur-Marne cedex
Numéro Indigo Tel. 0820/20 46 40, Fax 20 46 41
Tel. ++33 (0)1/48 82 64 00, Fax 48 82 64 01
E-mail: info_fr@festo.com

Germany

Festo AG & Co. KG
Postfach
73726 Esslingen
Ruiter Straße 82
73734 Esslingen
Tel. ++49 (0)711/34 70, Fax 347 21 44
E-mail: info_de@festo.com

Greece

Festo Ltd.
40 Hamosternas Ave., P.C. 11853
Athens
Tel. +30 210/341 29 00, Fax 341 29 05
E-mail: info_gr@festo.com

Hong Kong

Festo Ltd.
6/F New Timely Factory Building,
497 Castle Peak Road,
Kowloon, Hong Kong
Tel. ++852/27 43 83 79, Fax 27 86 21 73
E-mail: info_hk@festo.com

Hungary

Festo Kft.
Csillaghegyi út 32-34.
1037 Budapest
Tel. ++36 1/436 51 11, Fax 436 51 01
E-mail: info_hu@festo.com

India

Festo Controls Private Ltd.
237B,
Bommasandra Industrial Area,
Bangalore Hosur Highway,
Bangalore 560 099
Tel. ++91 (0)80/22 89 41 00, Fax 783 20 58
E-mail: info_in@festo.com

Indonesia

PT. Festo
JL. Sultan Iskandar Muda No.68
Arteri Pondok Indah
Jakarta 12240
Tel. ++62 (0)21/27 50 79 00, Fax 27 50 79 98
E-mail: info_id@festo.com

Iran

Festo Pneumatic S.K.
2, 6th street, 16th avenue,
Teheran 1581975411
Km 8, Special Karaj Road,
P.O.Box 15815-1485
Teheran 1389793761
Tel. ++98 (0)21 44 52 24 09,
Fax ++98 (0)21 44 52 24 08
E-mail: Mailroom@festo.ir

Ireland

Festo Limited
Unit 5 Sandyford Park
Sandyford Industrial Estate
Dublin 18
Tel. ++353(0)1/295 49 55, Fax 295 56 80
E-mail: info_ie@festo.com

Israel

Festo Pneumatic Israel Ltd.
P.O. Box 1076, Ha'atzma'ut Road 48
Yehud 56100
Tel. ++972 (0)3/632 22 66, Fax 632 22 77
E-mail: info_il@festo.com

Italy

Festo SpA
Via Enrico Fermi 36/38
20090 Assago (MI)
Tel. +39 02/45 78 81, Fax 488 06 20
E-mail: info_it@festo.com

Japan

Festo K.K.
1-26-10 Hayabuchi, Tsuzuki-ku
Yokohama 224-0025
Tel. ++81 (0)45/593 56 10, Fax 593 56 78
E-mail: info_jp@festo.com

Korea South

Festo Korea Co., Ltd.
470-1 Gasan-dong, Geumcheon-gu
Seoul #153-803
Tel. ++82 (0)2/850 71 14, Fax 864 70 40
E-mail: info_kr@festo.com

Latvia

Festo SIA
A. Deglava iela 60
1035 Riga
Tel. ++371 67/57 78 64, Fax 57 79 46
E-mail: info_lv@festo.com

Lithuania

Festo UAB
Karaliaus Mindaugo pr. 22
3000 Kaunas
Tel. ++370 (8)7/32 13 14, Fax 32 13 15
E-mail: info_lt@festo.com

Malaysia

Festo Sdn.Berhad
10 Persiaran Industri
Bandar Sri Damansara, Wilayah Persekutuan
52200 Kuala Lumpur
Tel. ++60 (0)3/62 86 80 00, Fax 62 75 64 11
E-mail: info_my@festo.com

Mexico

Festo Pneumatic, S.A.
Av. Ceylán 3
Col. Tequesquinhuauc
54020 Tlalnepantla, Edo. de México
Tel. ++52 (01)55/53 21 66 00, Fax 53 21 66 55
E-mail: festo.mexico@mx.festo.com

Netherlands

Festo B.V.
Schieweg 62
2627 AN Delft
Tel. ++31 (0)15/251 88 99, Fax 251 88 67
E-mail: info_nl@festo.nl

New Zealand

Festo Limited
20 Fisher Crescent
MT. Wellington
Auckland NZ
Tel. ++64 (0)9/574 10 94, Fax 574 10 99
E-mail: info_nz@festo.com

Nigeria

Festo Automation Ltd.
Motorways Centre, First Floor, Block C
Alausa, Ikeja,
Lagos, NIGERIA
Tel. ++234 (0)1/794 78 20, Fax 555 78 94
E-mail: info@ng.festo.com

Norway

Festo AS
Ole Deviks vei 2
0666 Oslo
Tel. ++47 22 72 89 50, Fax ++47 22 72 89 51
E-mail: info_no@festo.com

Peru

Festo S.R.L.
Calle Amador Merino Reyna #480
San Isidro
Lima, Perú
Tel. ++51 (0)1/222 15 84, Fax 222 15 95
E-mail: festo.peru@pe.festo.com

Philippines

Festo Inc.
KM 18, West Service Road
South Superhighway
1700 Paranaque City, Metro Manila
Tel. ++63 (0)2/776 68 88, Fax 823 42 19
E-mail: info_ph@festo.com

Poland

Festo Sp. z o.o.
Janki k/Warszawy, ul. Mszczonowska 7
05090 Raszyn
Tel. ++48 (0)22/711 41 00, Fax 711 41 02
E-mail: info_pl@festo.com

Romania

Festo S.R.L.
St. Constantin 17
010217 Bucuresti
Tel. ++40 (0)21/310 29 83, Fax 310 24 09
E-mail: info_ro@festo.com

Russia

OOO Festo-RF
Michurinskiy prosp., 49
119607 Moscow
Tel. +7 495/737 34 00, Fax 737 34 01
E-mail: info_ru@festo.com

Singapore

Festo Pte. Ltd.
6 Kian Teck Way
Singapore 628754
Tel. ++65/62 64 01 52, Fax 62 61 10 26
E-mail: info@sg.festo.com

Slovakia

Festo spol. s r.o.
Gavlovicová ul. 1
83103 Bratislava 3
Tel. ++421 (0)2/49 10 49 10, Fax 49 10 49 11
E-mail: info_sk@festo.com

Slovenia

Festo d.o.o. Ljubljana
IC Trzin, Blatnica 8
1236 Trzin
Tel. ++386 (0)1/530 21 00, Fax 530 21 25
E-mail: info_si@festo.com

South Africa

Festo (Pty) Ltd.
22-26 Electron Avenue, P.O. Box 255
Isando 1600
Tel. ++27 (0)11/971 55 00, Fax 974 21 57
E-mail: info_za@festo.com

Spain

Festo Pneumatic, S.A.U.
Avenida Granvia, 159
Distrito Económico Granvia L'H
08908 Hospitalet de Llobregat, Barcelona
Tel. 901243660, Fax 902243660
Tel. ++3493/261 64 00, Fax 261 64 20
E-mail: info_es@festo.com

Sweden

Festo AB
Stillmångsgatan 1, Box 21038
200 21 Malmö
Tel. ++46 (0)20/38 38 40, Fax 38 38 10
E-mail: order@festo.se

Switzerland

Festo AG
Moosmattstrasse 24
8953 Dietikon ZH
Tel. ++41 (0)44/744 55 44, Fax 744 55 00
E-mail: info_ch@festo.com

Taiwan

Festo Co., Ltd.
Head Office
24450, No. 9, Kung 8th Road,
Linkou 2nd Industrial Zone
Linkou Hsiang, Taipei Hsien,
Taiwan, R.O.C.
Tel. ++886 (0)2 26 01-92 81,
Fax ++886 (0)2 26 01 92 86-7
E-mail: festotw@festo.com

Thailand

Festo Ltd.
67/1 Moo 6 Phaholyothin Road
Klong 1, Klong Luang,
Pathumthani 12120
Tel. ++66 29 01 88 00, Fax ++66 29 01 88 33
E-mail: info_th@festo.com

Turkey

Festo San. ve Tic. A.S.
Tuzla Mermerciler Organize
Sanayi Bölgesi 6/18
34956 Tuzla - Istanbul/TR
Tel. ++90 (0)216/585 00 85, Fax 585 00 50
E-mail: info_tr@festo.com

Ukraine

Festo Ukraina
DP Festo
ul. Borisoglebskaya, 11
Kiev, 04070, Ukraina
Tel. +380 (0)44/239 24 33, Fax 463 70 96
E-mail: info_ua@festo.com

United Kingdom

Festo Limited
Applied Automation Centre, Caswell Road
Brackmills Trading Estate
Northampton NN4 7PY
Tel. ++44 (0)1604/66 70 00, Fax 66 70 01
E-mail: info_gb@festo.com

United States

Festo Corporation (New York)
395 Moreland Road, P.O. Box 18023
Hauppauge, N.Y. 11788
Call Toll-free 800/993 3786
Fax Toll-free 800/963 3786
Tel. ++1(0)314/770 01 12, Fax 770 16 84
E-mail: customer.service@us.festo.com

Venezuela

Festo C.A.
Av. 23, Esquina calle 71, No. 22-62
Maracaibo, Edo. Zulia
Tel. ++58 (0)261/759 09 44, Fax 759 04 55
E-mail: festo@festo.com.ve

Vietnam

Festo Co., Ltd (Cong Ty TNHH Festo)
No. 206 Tran Nao Street
Ward Binh An, District 2
Ho Chi Minh City, Vietnam
Tel. +84 (0)8/740 69 09, Fax 740 69 10
E-mail: info_vn@festo.com