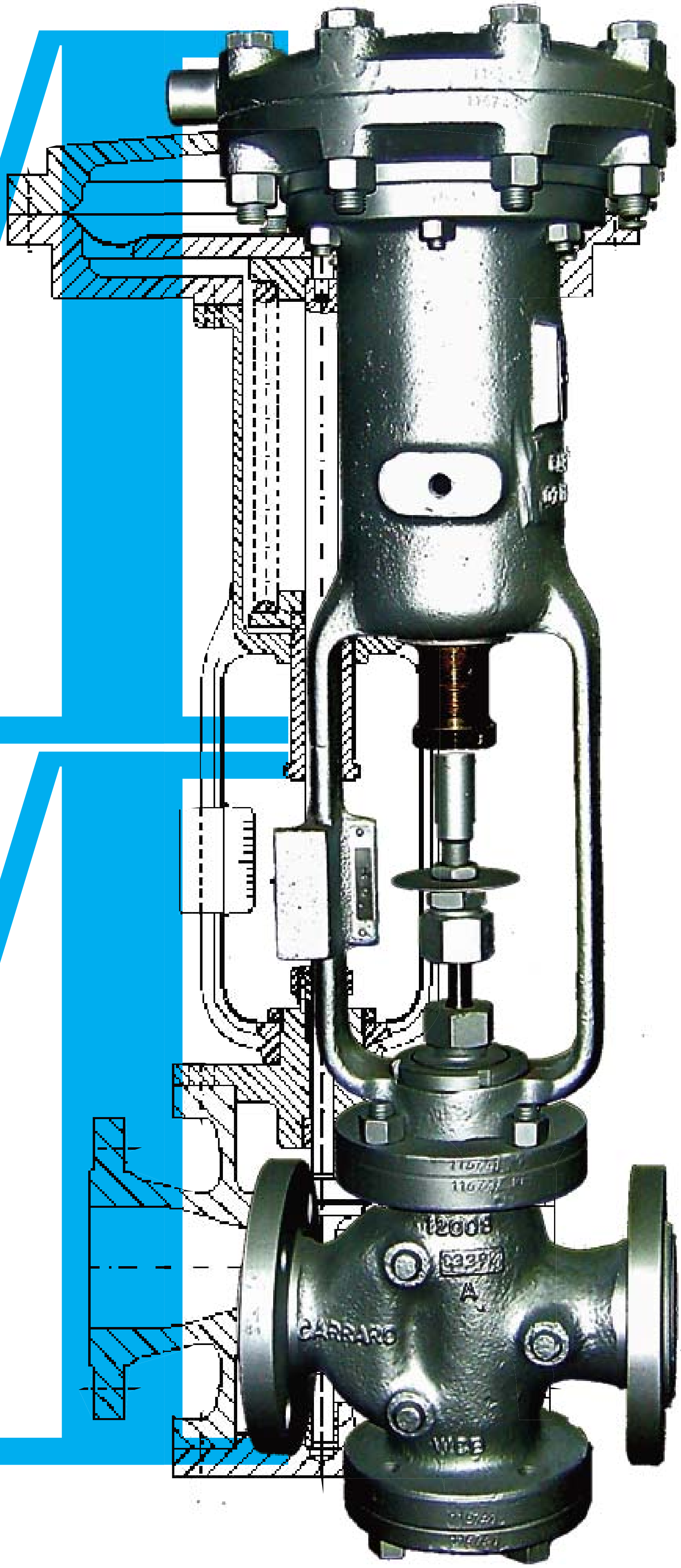
CARRARO MM



CARRARO®

CC0030E
REV. 00

MM CATALOG

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CARRARO MM REGULATORS CATALOGUE >

Regulators are devices whose main function is to match the flow of the medium (gas,steam or liquid) through the regulator to the demand of the medium by the system. At the same time the regulator must maintain the system pressure at a requested pressure, or within an acceptable range of this pressure.
Regulators, in general, are very simple devices, they are simpler devices than control valves, and experience in general teaches us that the simpler a system is the more reliable it is, as long as it provides a control within the requested limits.
Regulators are self-contained, self-operated control devices which use energy from the controlled system to operate. They do not require any external resources like; power sources, transmitting instruments, external air or hydraulic supply.
Carraro, since 1924, produces a wide range of regulators covering the most typical applications in the air, steam, process gasses and liquid applications.
It also supplies tailor made products for specific applications like gas and steam turbine auxiliary systems (lubricating systems and air or hydraulic sealing systems) and tank blanketing & vapour recovery system for storage tanks. The MM series are direct-operated, single seat or double seat, spring and diaphragm actuated regulators. They are available only with external pressure sensing, this design comes from the regulators original application on steam.
The actuator design for high temperature applications has a layout so to keep the diaphragm and spring the farthest possible from the body and thus from the source of high temperature. The MM series are available with a wide range of actuators sizes and plugs so be able to match the optimum configuration for a very wide variety of operating conditions. Plugs are available with various flow characteristics ranging from quick open to equal percentage contoured design. The regulators are all available with soft seats, so to allow a zero leakage shutoff.

MM SERIES SELF-OPERATED PRESSURE REGULATORS >

This series of regulators is suitable for saturated or superheated steam, gases and liquids.
They may be installed, if necessary, in a different position other than the usual one (vertical), with proper adjustments. The valve body may be of single or double seat type.
Sizes range from DN25(NPS 1”) to DN400 (NPS 16”) with flanged end connections according to EN 1092.1 (PN16÷160) or ASME BS16.5 (150÷300RF or RJ). The valves are engineered and manufactured in compliance with directive 97/23/EC (PED)
The MM series divide in three main groups; to follow the list with the identification codes:

GROUP A – Downstream pressure regulating valves (Pressure reducing valves):
- Single seat (MM61 – MM63)
- Double seat (MM51 – MM53)

GROUP B – Upstream pressure regulating valves (Backpressure valves)
- Single seat (MM62 – MM64)
- Double seat (MM52 – MM54)

GROUP C – Differential pressure regulating valves:
- Single seat with 1 diaphragm (MM61/D – MM63/D) – (MM62/D – MM64/D)
- Single seat with 2 diaphragms (MM61/D2 – MM63/D2) – (MM62/D2 – MM64/D2)
- Double seat with 1 diaphragm (MM51/D – MM53/D) – (MM52/D – MM54/D)
- Double seat with 2 diaphragms (MM51/D2 - MM53/D2) – (MM52/D2 - MM54/D2)

All listed types may be equipped with manual control and with different stem/bonnet seals, according to the fluid type and temperature. All types are available with elastomer inserts on the plug in order to assure a perfect tightness in the valve closed condition (type MM53, MM54, MM63, MM64).
Standard materials used for the elastomeric insert are CR or FKM/FPM. On request, other elastomers can be available.
Trims are available in a wide range of materials and with different flow characteristics (quick open, linear, parabolic or equal percentage).
The single seat valves are also available with cage trim of the balanced type (Special constructions manufactured on request according to customer needs). Special cages or trims can be supplied for noise reduction, cavitation and other particular flow conditions.

REGULATOR RULES >

On the last section of this catalog there is an introduction to the theory of regulators describing the principles of operation and some terminology like “offset” or “droop” very important in the correct sizing and selection of regulators. Here we give a small set of rules relative to regulators.
Their operation is similar to control valve but they are different devices and obey to different rules and this has to be kept in consideration.

- Pressure regulators control pressure; they do NOT regulate flow.
- Flow rate and controlled pressure are linked together; thus change in flow – change in pressure

Controlled pressure varies with flow.
The amount of variation in controlled pressure with a given change in flow is called:

Proportional Band:	Droop/Offset	[Reducers]
	Build/Accumulation	[Back pressure]

- Regulators are best used in systems where flow changes are small.
- Regulators are NOT shut off devices.
- DO NOT hydrostatically test a regulator
- Reducing regulators, in most cases, have two separate p pressure/temperature ratings for the inlet and outlet.
- Regulators DO NOT fail in the most frequently desired modes.

SELF OPERATED PRESSURE REGULATORS **SERIES MM**

[1] **External energy source independence**
Self-contained regulators use, as source of energy, the pressure contained in the regulated fluid, consequently they are independent from any connection with external power sources. This feature makes them ideal for application where no external power sources are available or where the environment makes difficult or impossible to reach the regulator with a source of energy. Having no external power connection, regulators guarantee operation even in case of power sources failures.

[2] **Easy Operation**
Self-contained regulators are basically simple to be installed a require very few operations for start-up.

[3] **Easy Maintenance**
Self-contained regulators are simple devices that need very little servicing, in addition the maintenance operations are easy and straight forward.

[4] **Environment resistance**
Self-contained regulators, due to their simplicity, are fit to be installed in unprotected, or dusty, or generically adverse environments.

[5] **Economical service**
Self-contained regulators, have an economical operation and servicing.

Body Sizes and End Connections:
See Tab. 1

Maximum outlet pressure:
See Tab. 2

Material Combinations:
See Tab. 3

Flow Coefficient:
See Tab. 4 to Tab. 9

Temperature ranges:
-10°C to 538°C (14°F to 1000°F)
See Tab. 10 to Tab. 13

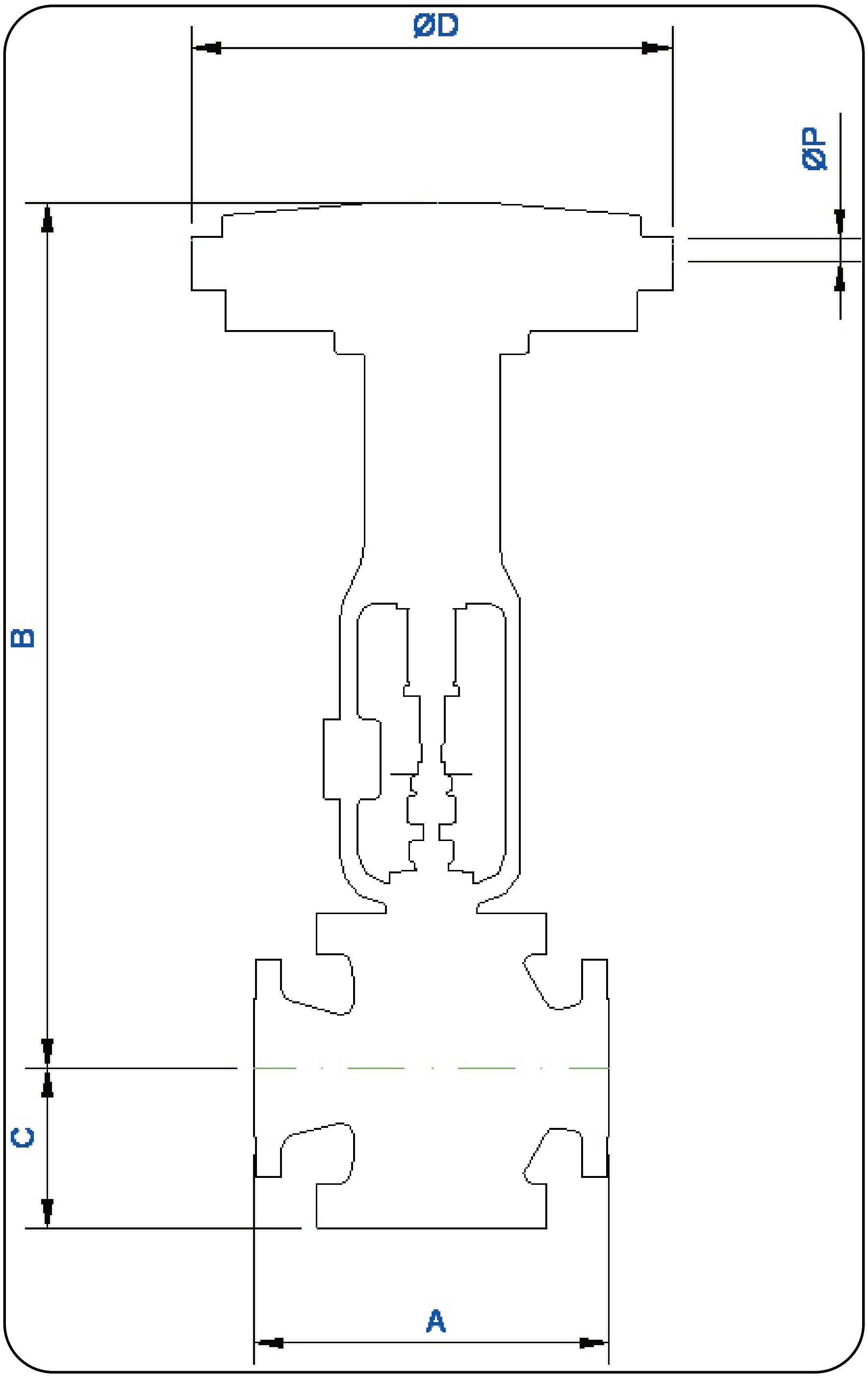
Pressure sensing:
Internal (external on request)

Weights:
See Tab. 14

Compliance to:
97/23/CE - **PED**
94/9/CE - **ATEX**

Versatility
In-line maintenance
High stability
Rugged construction
Wide range of special constructions

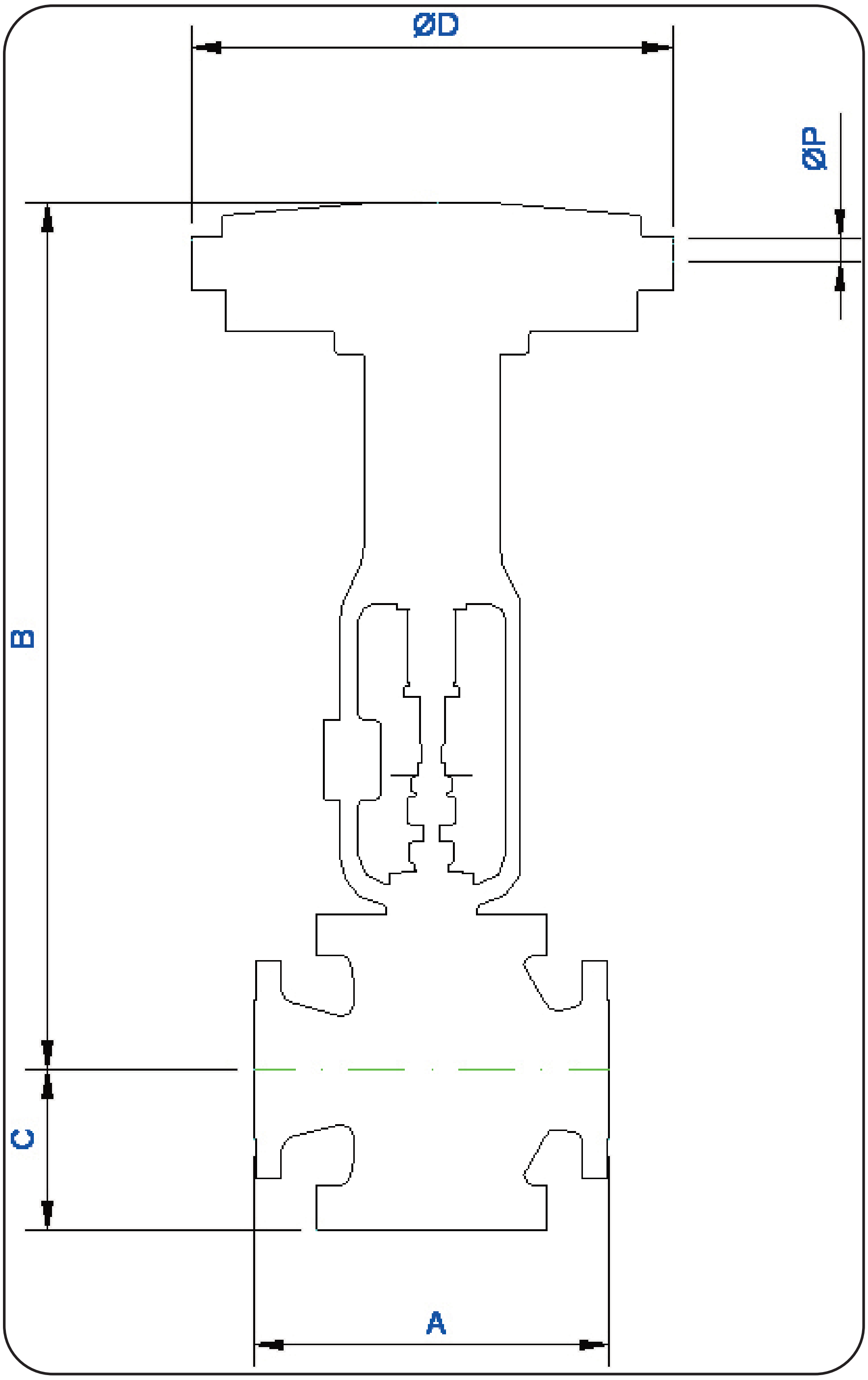
MM51 | MM52



ACTUATOR	Ø D
120	175mm (6⅞")
130	175mm (6⅞")
140	175mm (6⅞")
182	182mm (7¼")
245	245mm (9⅝")
320	320mm (12⅝")
420	420mm (16½")

Size (NPS)	Flanged				All end connections	
	ANSI 150RF	ANSI 300RF	ANSI 600RF	ANSI 900RF		
	A				B	C
DN25 (1")	184mm (7¼")	197mm (7¾")	210mm (8¼")	273mm (7¾")	737mm (29")	123mm (4⅞")
DN40 (1½”)	222mm (8¾")	235mm (9¼")	251mm (9⅞")	311mm (9¼")	750mm (29½")	140mm (5½")
DN50 (2”)	254mm (10")	267mm (10½")	286mm (11¼")	343mm (10½")	766mm (30⅛")	165mm (6½")
DN80 (3")	298mm (11¾")	318mm (12½")	337mm (13¼")	387mm (12½")	810mm (31⅞")	225mm (8⅞")
DN100 (4”)	352mm (11⅞")	368mm (14½")	394mm (15½")	464mm (14½")	830mm (32⅝")	255mm (10")
DN150 (6”)	451mm (17¾")	473mm (18⅝")	508mm (20")		890mm (35")	317mm (12½")
DN200 (8")	543mm (21⅜")	568mm (22⅜")	610mm (24")		1018mm (40")	407mm (16")
DN250 (10”)	673mm (26½")	708mm (27⅞")	752mm (29⅝")		1040mm (41")	439mm (17¼")

MM53 | MM54



ACTUATOR	Ø D
120	175mm (6⅞")
130	175mm (6⅞")
140	175mm (6⅞")
182	182mm (7¼")
245	245mm (9⅝")
320	320mm (12⅝")
420	420mm (16½")

Size (NPS)	Flanged				All end connections	
	ANSI 150RF	ANSI 300RF	ANSI 600RF	ANSI 900RF		
	A				B	C
DN80 (3")	298mm (11¾")	318mm (12½")	337mm (13¼")	387mm (12½")	810mm (31⅞")	225mm (8⅞")
DN100 (4”)	352mm (11⅞")	368mm (14½")	394mm (15½")	464mm (14½")	830mm (32⅝")	255mm (10")
DN150 (6”)	451mm (17¾")	473mm (18⅝")	508mm (20")		890mm (35")	317mm (12½")
DN200 (8")	543mm (21⅜")	568mm (22⅜")	610mm (24")		1018mm (40")	407mm (16")
DN250 (10”)	673mm (26½")	708mm (27⅞")	752mm (29⅝")		1040mm (41")	439mm (17¼")

TAB.[1] Body sizes and face to face dimensions

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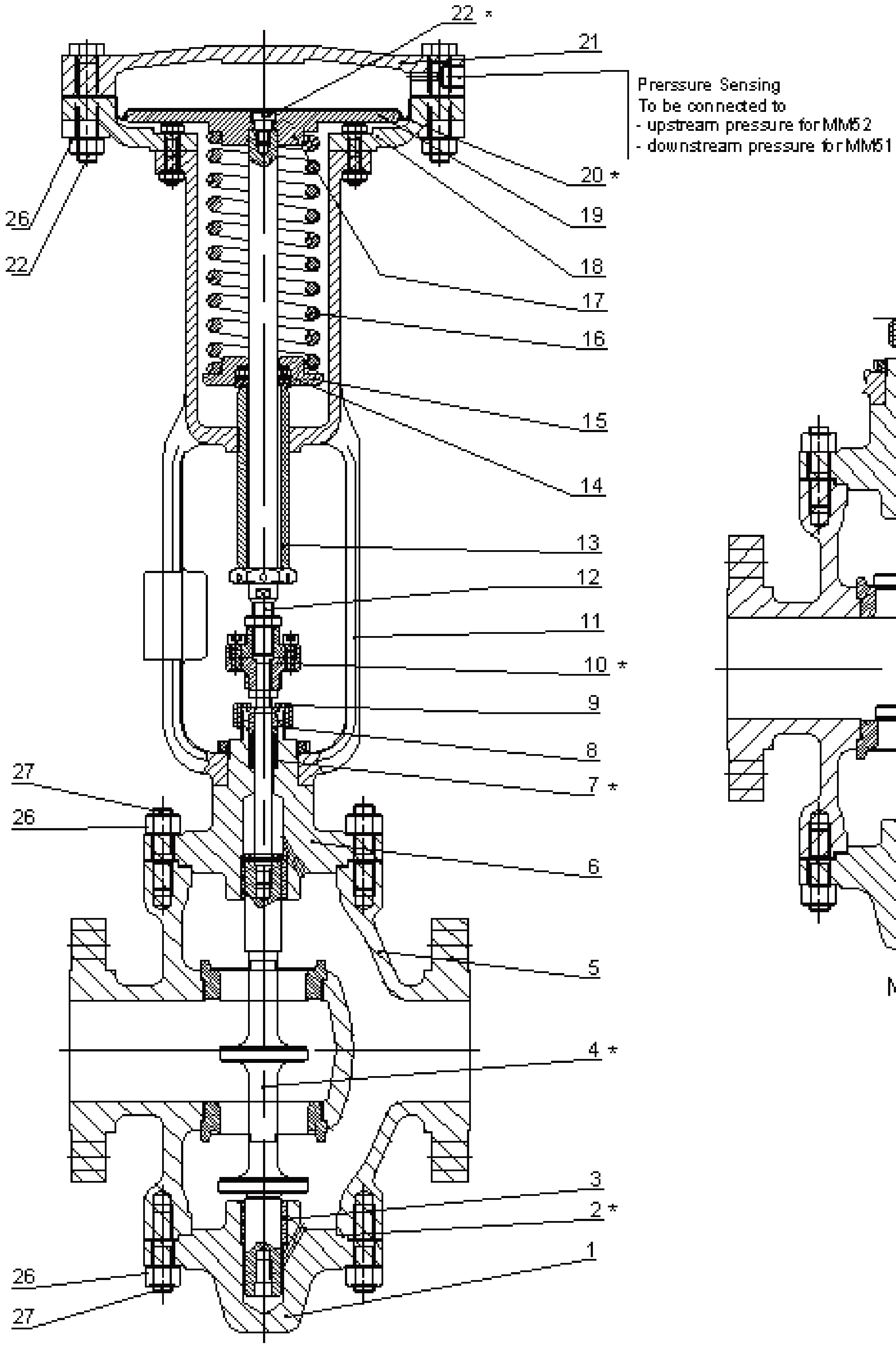
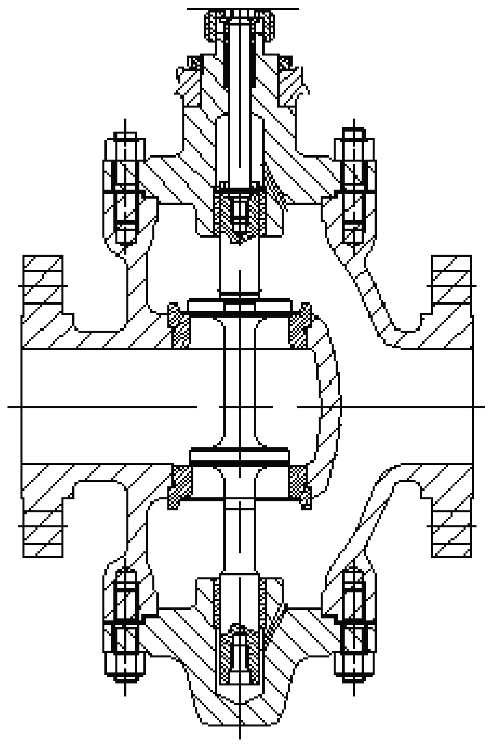
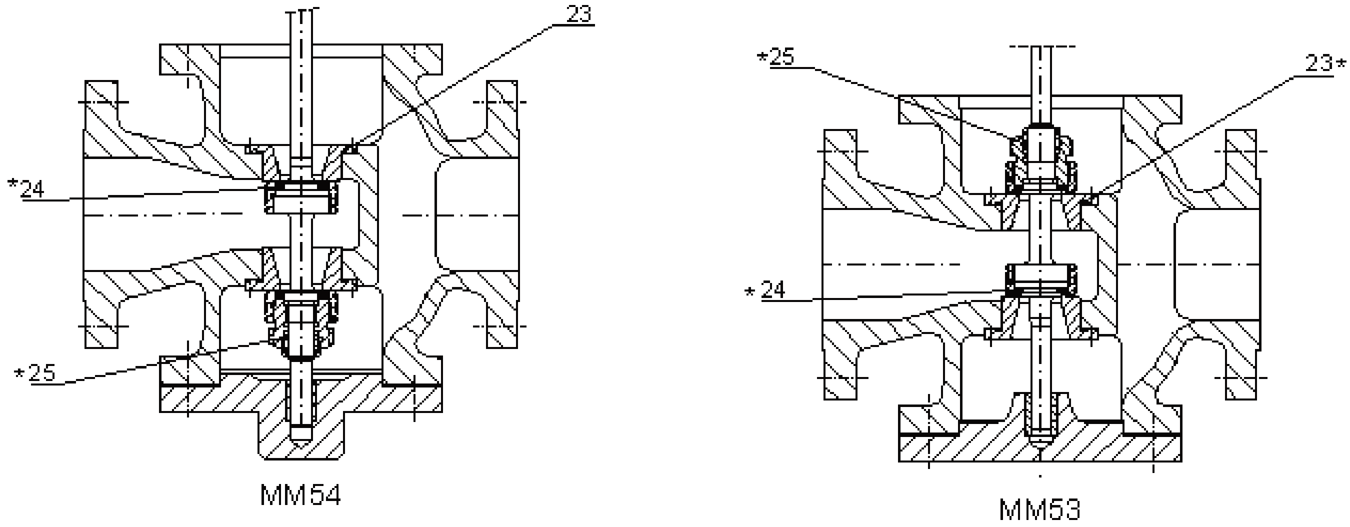

22 *
21
Prerssure Sensing
To be connected to
- upstream pressure for MM52
- downstream pressure for MM51
20 *
19
18
17
16
15
14
13
12
11
10 *
9
8
7 *
6
5
4 *
3
2 *
1
26
22
27
26
26
27

MM52

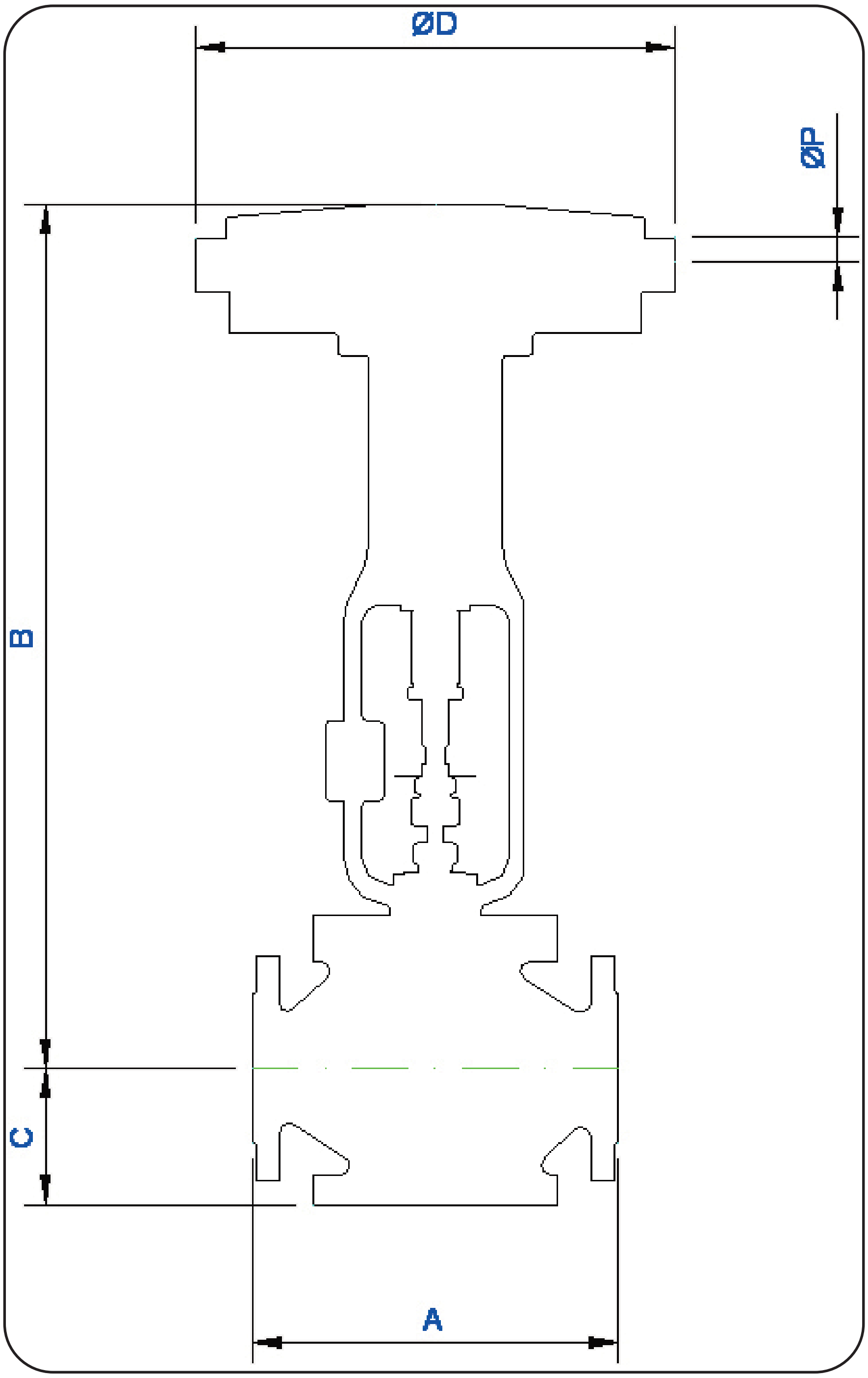


MM51



* 1-Blindhead
* * 2-Gasket
* 3-Lower guide
* * 4-Plug
* 5-Valve body
* 6-Bonnet
* * 7-Packing gland gasket
* 8-Packing gland bushing
* 9-Packing gland nut
* *10-Joint
* 11-Yoke
* 12-Stem
* 13-Adjustment screw
* 14-Bearing
* 15-Spring holder plate
* 16-Spring
* 17-Upper spring guide plate
* 18-Lower actuator flange
* 19-Diaphragm plate
* *20-Diaphragm
* 21-Upper actuator flange
* 22-Screw
* *23-Seat gasket
* *24-Plug gasket
* *25-Plug stem gasket
* 26-Nut
* 27-Stud

MM61 | MM62
MM63 | MM64

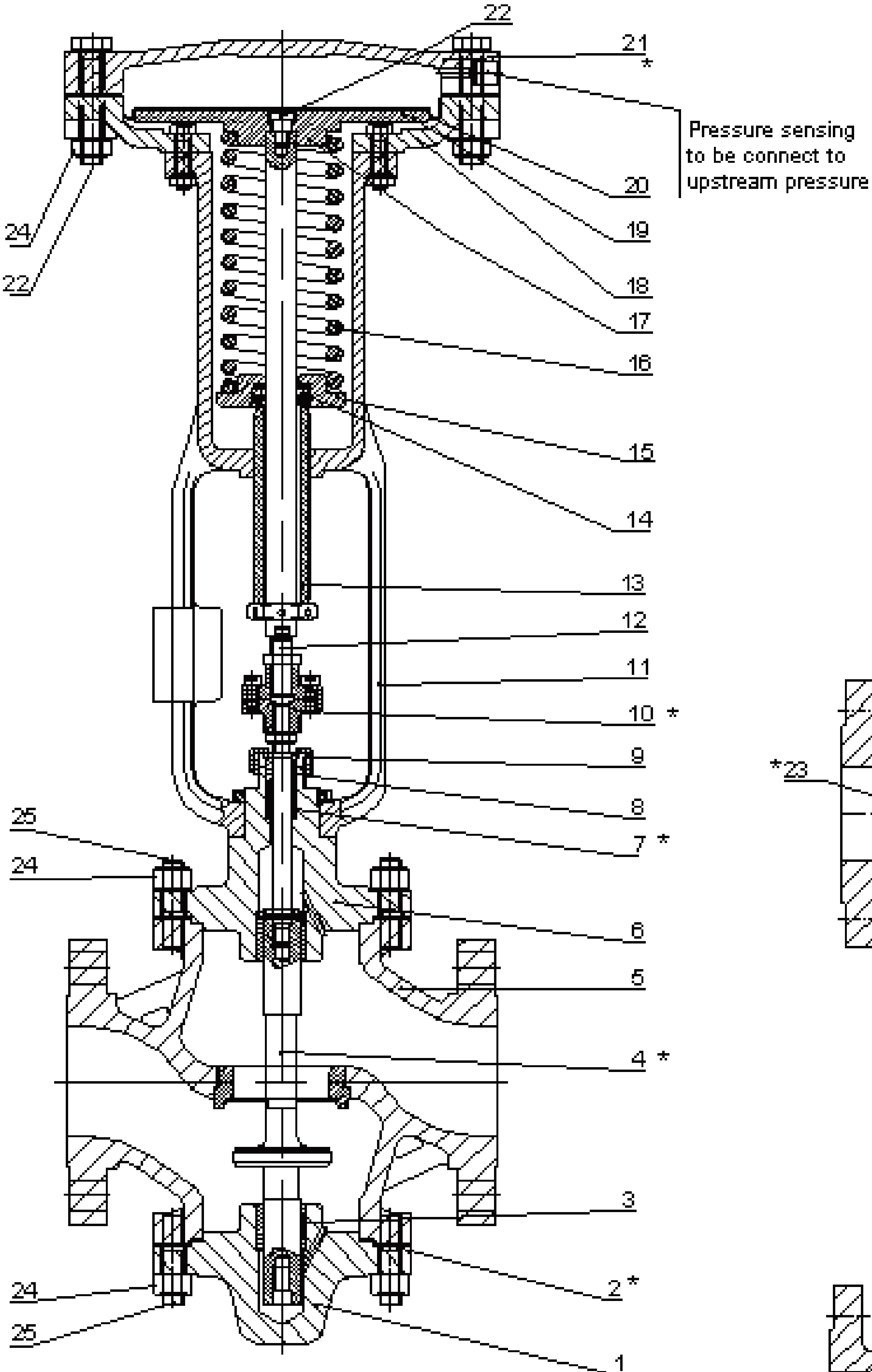


ACTUATOR	Ø D
120	175mm (6⅞")
130	175mm (6⅞")
140	175mm (6⅞")
182	182mm (7¼")
245	245mm (9⅝")
320	320mm (12⅝")
420	420mm (16½")

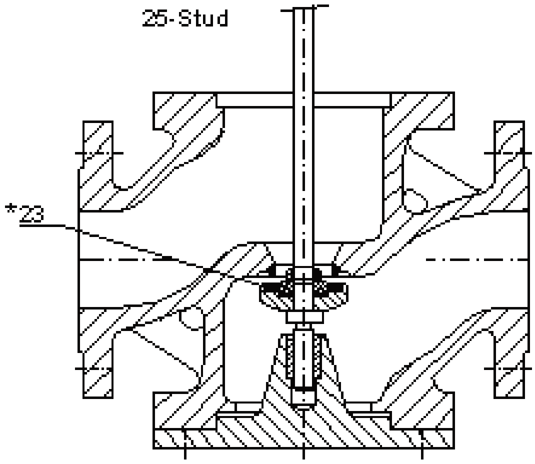
Size (DN)	Flanged				All end connections	
	ANSI 150RF	ANSI 300RF	ANSI 600RF	ANSI 900RF		
	A				B	C
DN25 (1")	184mm (7¼")	197mm (7¾")	210mm (8¼")	273mm (7¾")	716mm (28¼")	102mm (4")
DN40 (1½")	222mm (8¾")	235mm (9¼")	251mm (9⅞")	311mm (9¼")	733mm (28⅞")	122mm (4⅞")
DN50 (2")	254mm (10")	267mm (10½")	286mm (11¼")	343mm (10½")	745mm (29⅜")	145mm (5¾")
DN80 (3")	298mm (11¾")	318mm (12½")	337mm (13¼")	387mm (12½")	780mm (30¾")	194mm (7⅝")
DN100 (4")	352mm (11⅞")	368mm (14½")	394mm (15½")	464mm (14½")	785mm (31")	210mm (7¼")
DN150 (6")	451mm (17¾")	473mm (18⅝")	508mm (20")		835mm (32¾")	262mm (10⅜")
DN200 (8")	543mm (21⅜")	568mm (22⅜")	610mm (24")		923mm (30¼")	245mm (12¼")
DN250 (10")	673mm (26½")	708mm (27¾")	752mm (29⅝")		935mm (36⅞")	334mm (13⅛")

TAB.[1] Body sizes and face to face dimensions

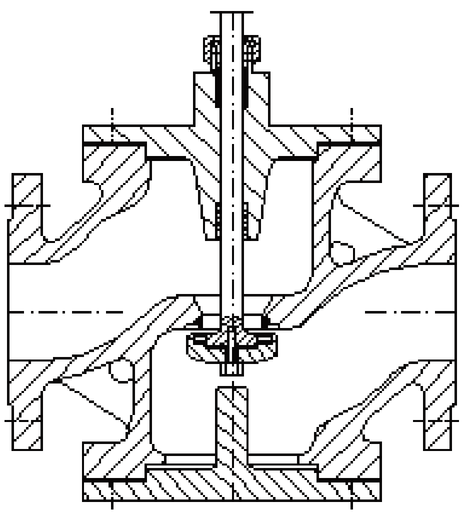
1-Blindhead
2-Gasket
*3-Lower guide
4-Plug
*5-Valve body
6-Bonnet
7-Packing gland gasket
*8-Packing gland bushing
9-Packing gland Nut
10-Joint
*11-Yoke
12-Stem
13-Adjusting screw
14-Bearing
15-Spring holder plate
16-Spring
17-Upper spring guide plate
18-Lower actuator flange
19-Diaphragm plate
20-Diaphragm
*21-Upper actuator flange
22-Screw
23-Gasket plug
*24-Nut
25-Stud



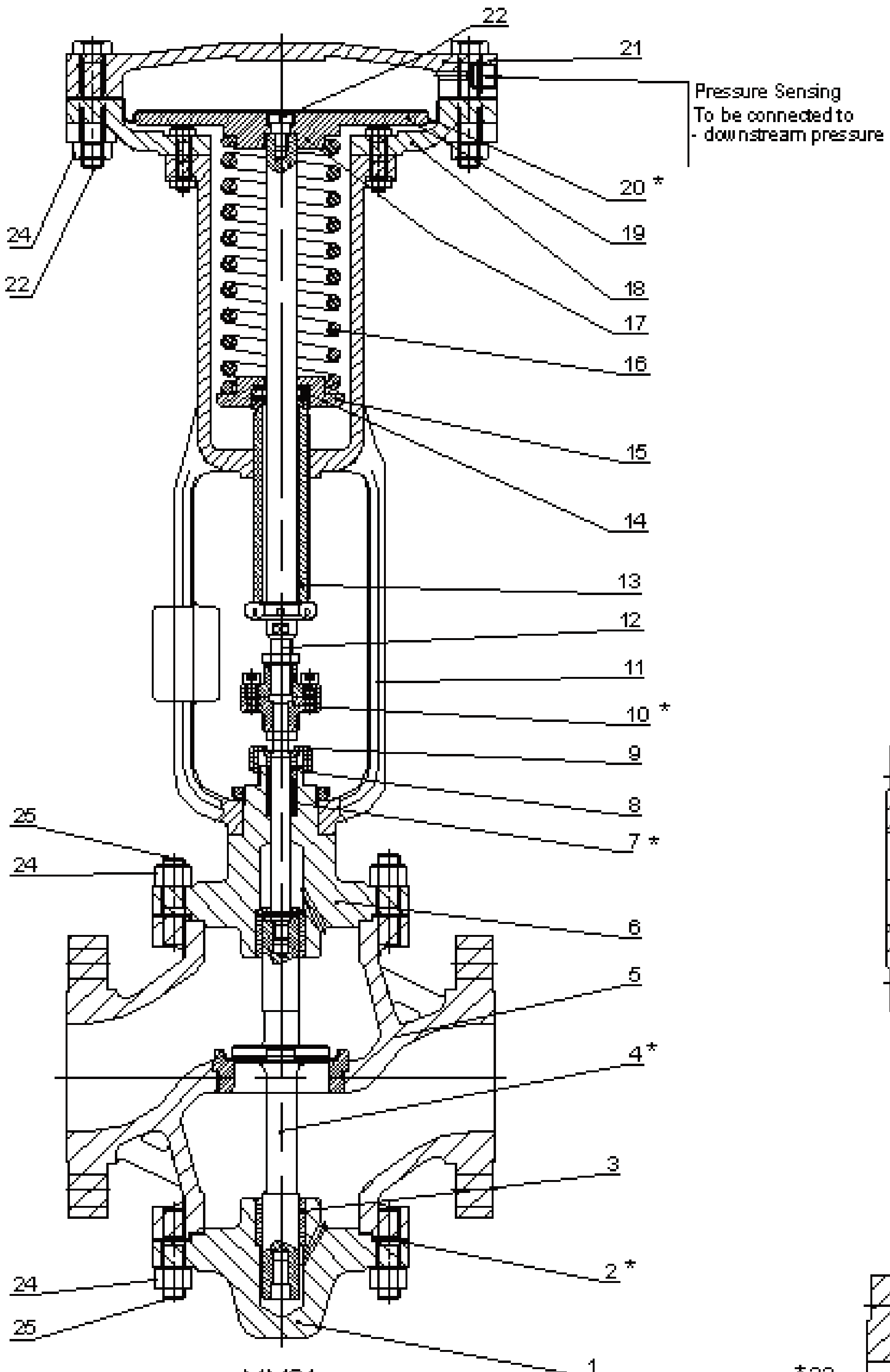
MM62



MM64
(over DN32)

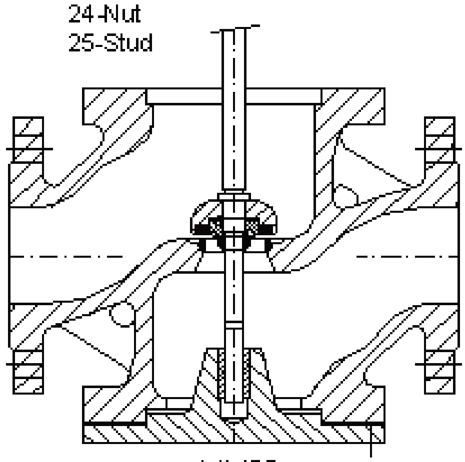


MM64
(up to DN32)

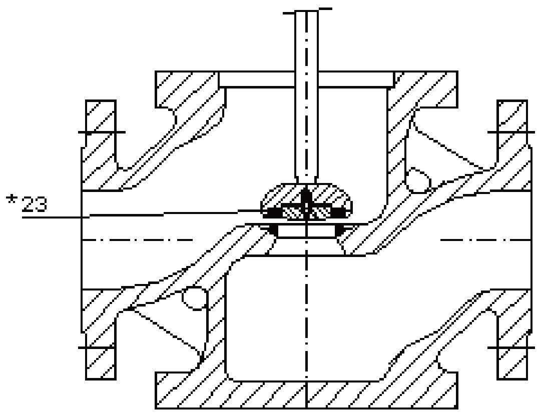


MM61

1-Blindhead
* 2-Gasket
3-Lower guide
* 4-Plug
5-Valve body
6-Bonnet
* 7-Packing gland gasket
8-Packing gland bushing
9-Packing gland Nut
*10-Joint
11-Yoke
12-Stem
13-Adjusting screw
14-Bearing
15-Spring holder plate
16-Spring
17-Upper spring guide plate
18-Lower actuator flange
19-Diaphragm plate
*20-Diaphragm
21-Upper actuator flange
22-Screw
*23-Gasket plug
24-Nut
25-Stud



MM63
(up to DN32)



MM63
(over DN32)

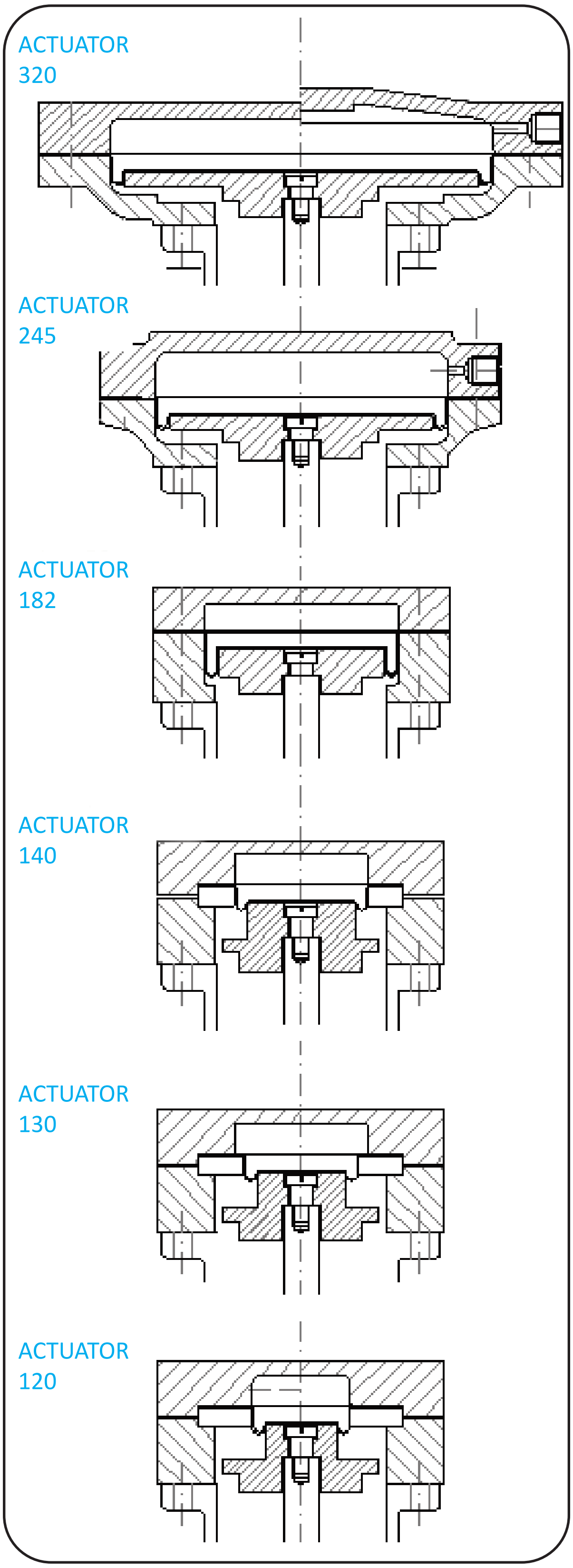


FIG. [4]

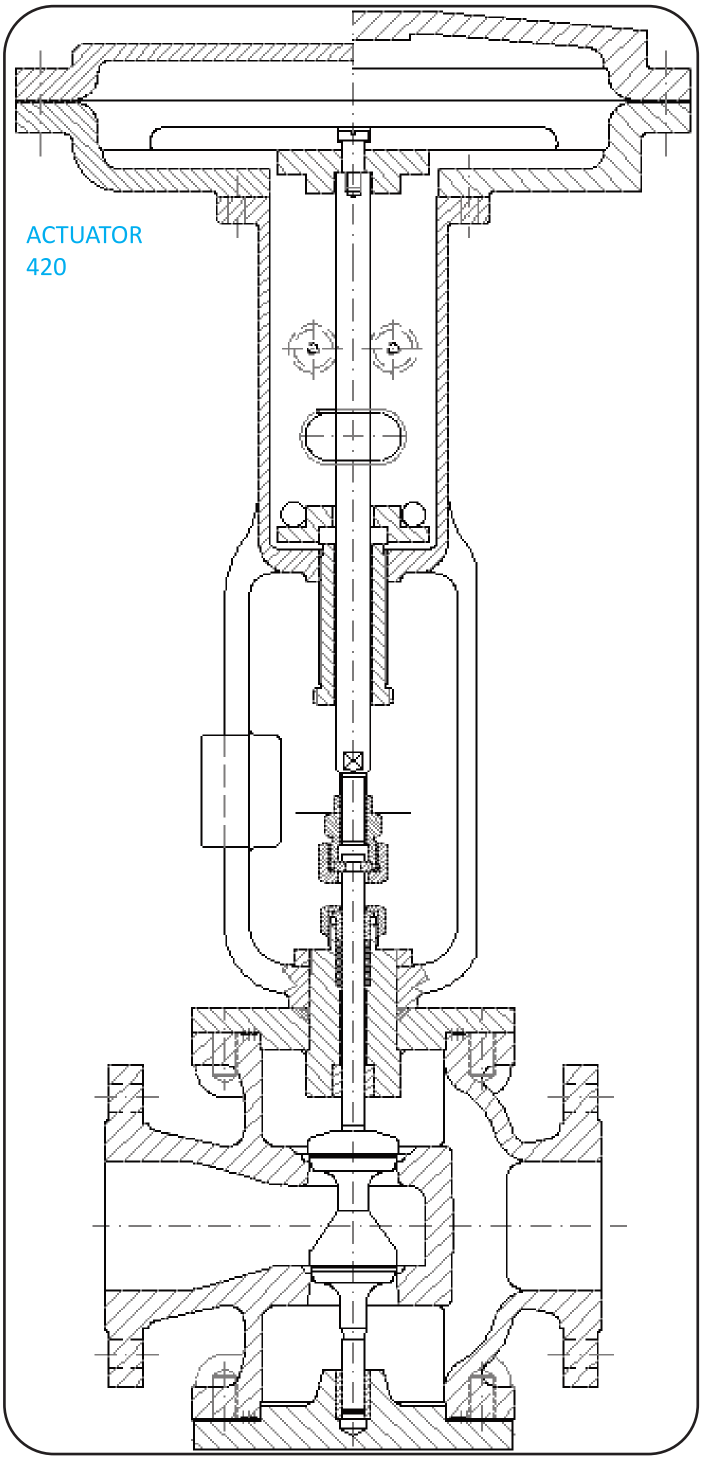
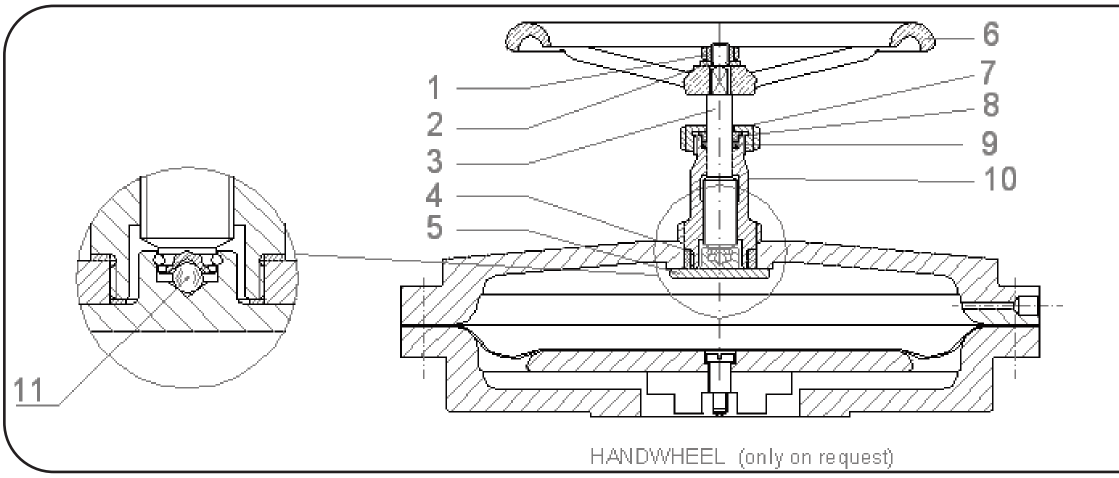


FIG. [5]

Actuators

Carraro offers a wide range of actuators such as shown on the fig[4] and [5]. This allows to select the optimum actuator for any set pressure within the available range.



1 - Nut
2 - Washer
3 - Handwheel stem
4 - Gasket
5 - Washer
6 - Handwheel
7 - Ring nut
8 - Packing gland
9 - Gasket
10 - Sleeve
11 - Ball

FIG. [1]

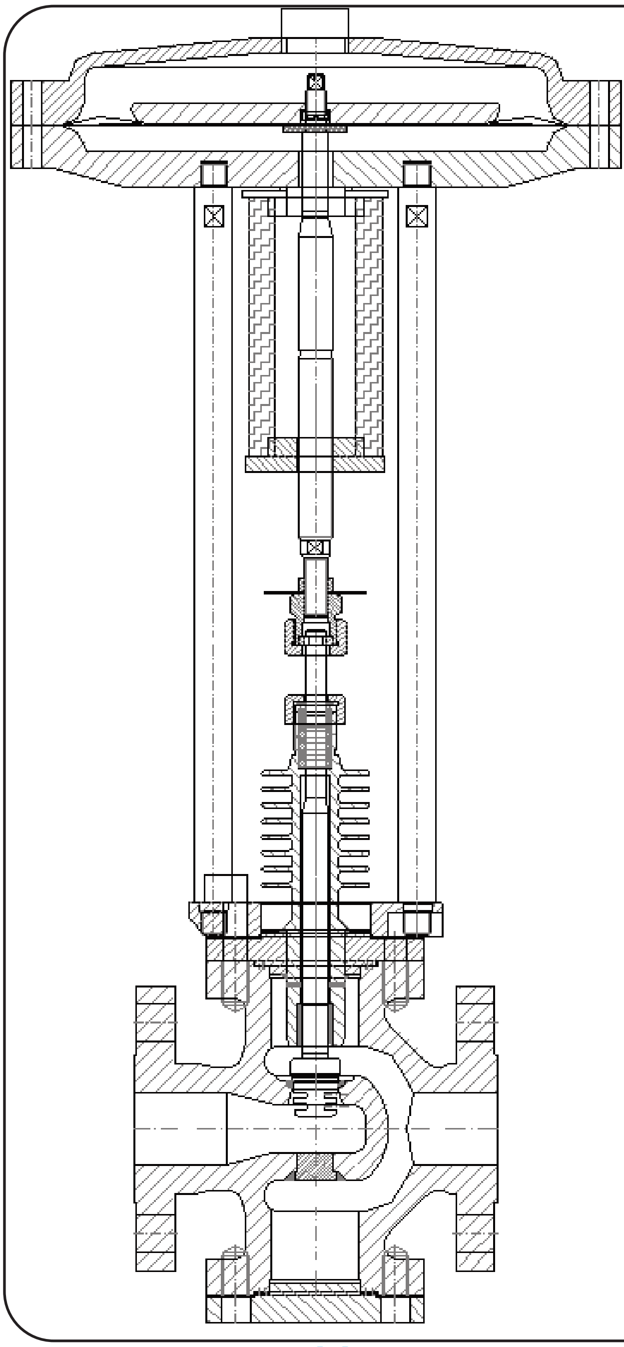


FIG. [2]

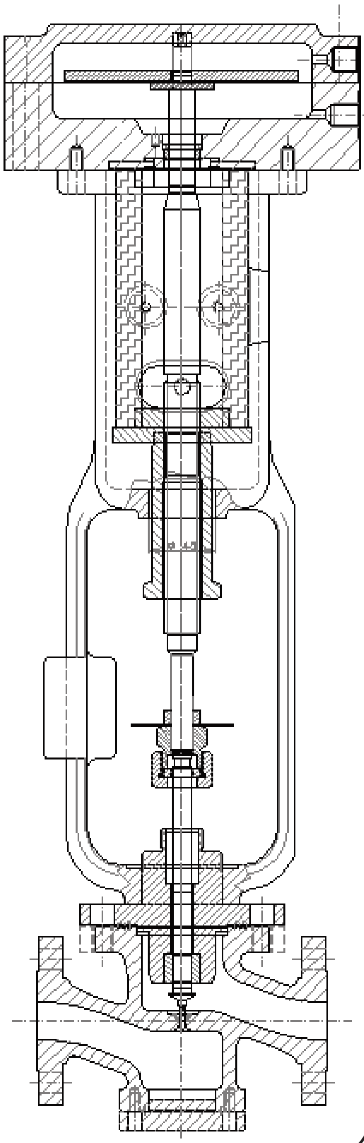


FIG. [3]

Actuator options

The actuators can be supplied with a hand wheel Fig [1], used to limit the stroke of the reducing regulators or to shut the regulator closed. The standard actuators have the spring pushing away from the valve body and the pressure pushing towards the valve body, on request regulators can be supplied with reverse action, therefore the spring pushing towards the valve and the pressure pushing away Fig.[2] and Fig.[3]. Fig [2] shows the use of a finned bonnet, used for very high temperature with steam. A special actuator is supplied for these types of applications as shown on the drawing.

DOUBLE DIAPHRAGM

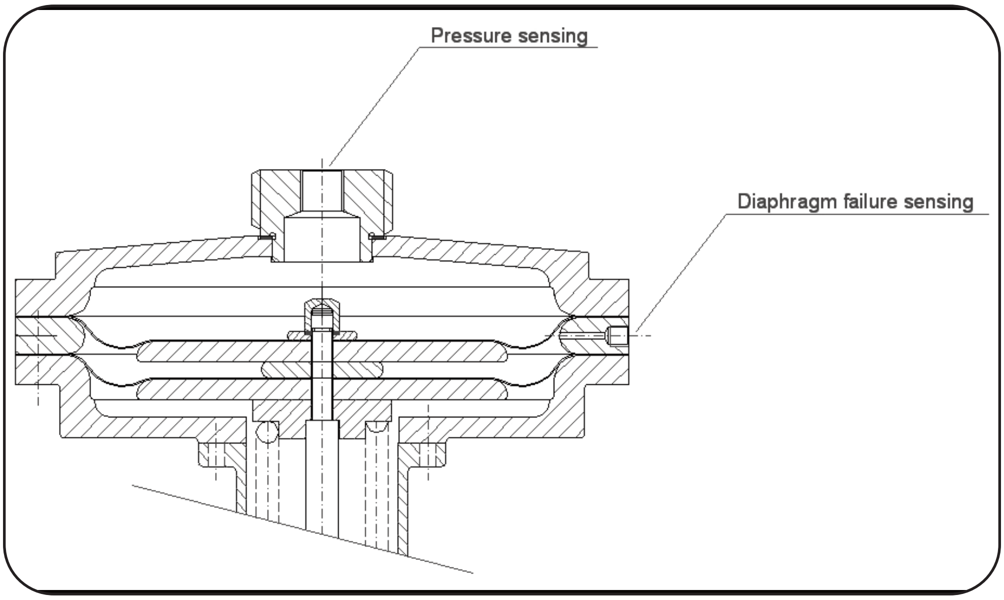


FIG. [2]

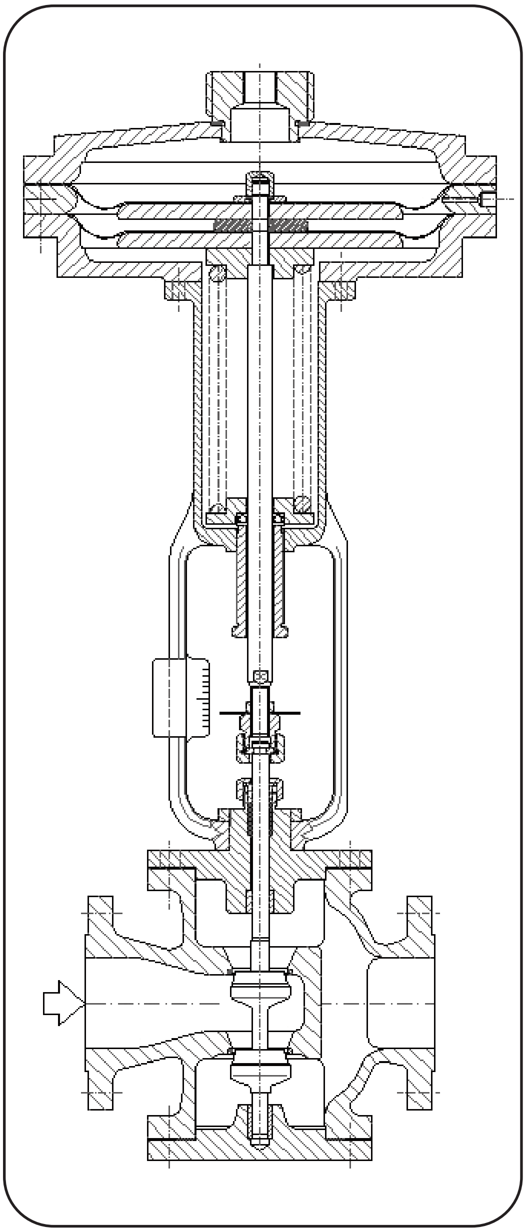


FIG. [1]

Double diaphragm actuator for dangerous fluids

The use of dangerous fluids introduces the risk of fluid escape in the outer environment in case of failure of the diaphragm. This can be prevented by piping the spring casing vent in a controlled area or in a safety vessel, but in any case this prevents only the environment contamination and doesn't guarantee the operation integrity. The double diaphragm construction solves both the problems. As shown in Fig 2 the double diaphragm actuator has an additional volume between the two diaphragms, the upper and the lower areas are analogous to the standard actuator, the spring side is in contact with the atmosphere or any reference pressure fluid and the other side is in contact with the process fluid. The intermediate area vent can have a pressure gauge or a pressure sensor connected to the DCS. During standard operation the actuator has the same performance as a single diaphragm variant, but in case of failure of the working diaphragm the process fluid will fill the intermediate area, this will be detected by the gauge or the sensor connected to the DCS calling for the failure and the request for servicing the regulator. The second diaphragm will act in two ways, it will prevent the fluid from escaping and it will continue regulating giving the same performance as a single diaphragm actuator. The double diaphragm actuator is the best choice where operational integrity is requested and no escape of process fluid is wanted because of its danger to the outside environment.

Actuator	Area		Maximum outlet pressure	
	cm²	in²	barg	psig
120	20,9	3,24	30,7	445
130	29	4,5	24,6	357
140	42,4	6,6	17,2	249
182	63	9,8	7,70	112
245	225,6	35	3,24	47,0
320	399,7	62	1,83	26,5
420	677	105	1,08	15,7

TAB.[2] Maximum outlet pressure

Body				
	Carbon steel (AF1)	Full Carbon steel (AF2)	316 SS (IF2)	Full 316 SS (IF3)
	-10°C ≤ T ≤ 425°C*	-29°C ≤ T ≤ 425°C*	-29°C ≤ T ≤ 540°C*	(-196°C[1]) -50°C ≤ T ≤ 540°C*
	(14°F ≤ T ≤ 800°F*)	(-20°F ≤ T ≤ 800°F*)	(-20°F ≤ T ≤ 1000°F*)	((-321°F[1])-58°F ≤ T ≤ 1000°F*)
Body	ASME WCC / EN 1.0625	ASME WCC / EN 1.0625	ASTM CF8M / EN 1.4408	ASTM CF8M / EN 1.4408
Bonnet	ASME WCC / EN 1.0625	ASME WCC / EN 1.0625	316 SS	316 SS
Blind flange	ASME WCC / EN 1.0625	ASME WCC / EN 1.0625	316 SS	316 SS
Guide Bushing	Carbon steel	Carbon steel	316 SS	316 SS
Studs	B7	B7	B7	B8M/A4
Nuts	2H	2H	2H	8M/4
Gasket	PTFE	PTFE	PTFE	PTFE
Trim				
Plug stem	316 SS	316 SS	316 SS	316 SS
Seat	316 SS	316 SS	316 SS	316 SS
Packing	PTFE	PTFE	PTFE	PTFE
Actuator				
Yoke	Cast iron	Carbon steel	Carbon steel	316 SS
Actuator casing (lower)	Cast iron	Carbon steel	Carbon steel	316 SS
Actuator casing (upper)	Carbon steel	Carbon steel	316SS	316SS
Spring	CrV steel	CrV steel	CrV steel	316SS
Diaphragm	Ethyl Prophyl (EPDM)			
* For temperatures above 200°C (390°F) the condensation tank has to be used				
[1] with stainless steel diaphragm				
Special constructions are available in LCB, WCC (N.A.C.E.), WC6, 316L, Duplex, Superduplex, Monel, Hastelloy B/C				

TAB.[3] Standard material combinations

DN (NPS) Plug	TAB.[4] - Quick Open (QO) Metal Seat Plugs for MM51 and MM52													
	20 (¾")	25 (1")	32 (1¼")	40 (1½")	50 (2")	65 (2½")	80 (3")	100 (4")	125 (5")	150 (6")	200 (8")	250 (10")	300 (12")	400 (16")
1	4,7	4,7	4,7											
2	6,0	6,0	6,0											
3		8,0	8,0											
4		9,5	10,3	10,3										
5				18,0	18,0									
6					28,0	28,0								
7						45	45							
8							83	83	83					
9								166	174	174				
10										240	240			
11											320	320		
12												420	420	
13													560	560

DN (NPS) Plug	TAB.[5] - Quick Open (QO) Soft Seat Plugs for MM53 and MM54					
	65 (2½")	80 (3")	100 (4")	125 (5")	150 (6")	200 (8")
7	45	45	45			
8		83	83	83		
9			112	112	112	
10				123	123	123
11					197	197
12						253

DN (NPS) Plug	TAB.[6] - Quick Open (QO) Metal Seat Plugs for MM61							
	20 (¾")	25 (1")	32 (1¼")	40 (1½")	50 (2")	65 (2½")	80 (3")	100 (4")
0	2,3	2,3	2,2					
1	3,0	3,0	3,0					
2	5,5	5,5	5,5					
3	6,0	6,0	6,0	6,0				
4		10,5	10,5	10,5	10,5			
5			16,5	16,5	16,5	16,5		
6				24	24	24	24	
7					38	38	38	38
8						45	45	45

DN (NPS) Plug	TAB.[7] - Quick Open (QO) Metal Seat Plugs for MM62							
	20 (¾")	25 (1")	32 (1¼")	40 (1½")	50 (2")	65 (2½")	80 (3")	100 (4")
2	4,4	4,4	5,5	5,5	5,5	5,5	5,5	5,5
3	7,4	7,4	6,0	6,0	6,0	6,0	6,0	6,0
4	9,5	9,5	10,5	10,5	10,5	10,5	10,5	10,5
5			14,8	14,8	14,8	14,8	14,8	14,8
6			21,5	21,5	21,5	21,5	21,5	21,5
7				33	33	33	33	33
8					42	42	42	42

DN (NPS) Plug	TAB.[8] - Quick Open (QO) Soft Seat Plugs for MM63				
	20 (¾")	25 (1")	32 (1¼")	40 (1½")	50 (2")
1	2,3				
2	3,0	3,0			
3	5,7	5,7	5,7		
4		8,2	8,2	8,2	
5			16,5	16,5	16,5
6				24	24
7					37

DN (NPS) Plug	TAB.[9] - Quick Open (QO) Soft Seat Plugs for MM64				
	20 (¾")	25 (1")	32 (1¼")	40 (1½")	50 (2")
2	2,3				
3	4,4	4,4			
4	7,4	7,4	7,4		
5		9,5	9,5	9,5	
6			21,5	21,5	21,5
7				33	33
8					42

Fluoroelastomer (FKM-FPM)	-10 to 200°C (-14 to 392°F)
Polytetrafluoroethylene (PTFE)	-200 to 250°C (-328 to 482°F)
Nitrile (NBR)	-25 to 90°C (-13 to 194°F)
Ethylene-Propylene (EPDM)	-35 to 150°C (-31 to 320°F)

TAB.[10] Temperature ranges for Plug Gasket Materials (MM53 series)

Chloroprene (CR)	-20 to 90°C (-4 to 194°F)
NBR	-25 to 90°C (-13 to 194°F)
Fluorocarbon (FKM-FPM) + polyester	-10 to 150°C (14 to 302°F)
Fluorocarbon (FKM-FPM) + Nomex	-10 to 200°C (14 to 392°F)
Ethylene-Propylene (EPDM)	-35 to 150°C (-31 to 320°F)
Fluorosilicone (FVMQ)	-50 to 150°C (-58 to 300°F)

TAB.[11] Temperature ranges for Diaphragms

Polytetrafluoroethylene (PTFE)	-200 to 250°C (-328 to 482°F)
Fluorocarbon (FKM-FPM)	-10 to 200°C (14 to 392°F)

TAB.[12] Temperature ranges for O-rings

Cast Iron	0 to 232°C (32 to 449,6°F)
Carbon Steel	-29 to 425°C (-20 to 797°F)
Stainless Steel	-196 to 455°C (-320,8 to 851°F)

TAB.[13] Temperature ranges for Metal Parts

Actuator	120/130/140	182	245	320	420
DN25 (1”)	42kg (93lbs)	39kg (86lbs)	44kg (97lbs)	46kg (101lbs)	60kg (132lbs)
DN32 (1¼”)	43kg (95lbs)	39kg (86lbs)	45kg (99lbs)	47kg (104lbs)	61kg (135lbs)
DN40 (1½”)	48kg (106lbs)	44kg (97lbs)	49kg (108lbs)	51kg (112lbs)	66kg (146lbs)
DN50 (2”)	50kg (110lbs)	46kg (101lbs)	51kg (112lbs)	53kg (117lbs)	68kg (150lbs)
DN65 (2½”)	72kg (159lbs)	68kg (150lbs)	73kg (161lbs)	75kg (165lbs)	90kg (198lbs)
DN80 (3”)	76kg (168lbs)	72kg (159lbs)	81kg (179lbs)	83kg (183lbs)	94kg (207lbs)
DN100 (4”)	86kg (190lbs)	82kg (181lbs)	87kg (192lbs)	89kg (196lbs)	104kg (229lbs)
DN125 (5”)	100kg (220lbs)	95kg (210lbs)	108kg (238lbs)	110kg (243lbs)	118kg (260lbs)
DN150 (6”)	130kg (287lbs)	126kg (278lbs)	131kg (289lbs)	133kg (293lbs)	148kg (326lbs)
DN200 (8”)	220kg (485lbs)	216kg (476lbs)	221kg (487lbs)	223kg (492lbs)	238kg (525lbs)
DN250 (10”)	334kg (736lbs)	331kg (730lbs)	336kg (741lbs)	338kg (745lbs)	353kg (778lbs)
DN300 (12”)	386kg (844lbs)	379kg (836lbs)	384kg (847lbs)	386kg (851lbs)	400kg (882lbs)
DN400 (16”)	525kg (1157lbs)	521kg (1149lbs)	526kg (1160lbs)	528kg (1164lbs)	43,2kg (1197lbs)

TAB.[14] Weights

Regulators Basics

The primary function of a regulator is to supply and match the flow to the demand of a load or user. At the same time the regulator must maintain the system pressure within certain limits. The figure below (fig. 1) shows a typical pressure system layout. The regulator is placed upstream of the user or device that has a variable demand of fluid in time.

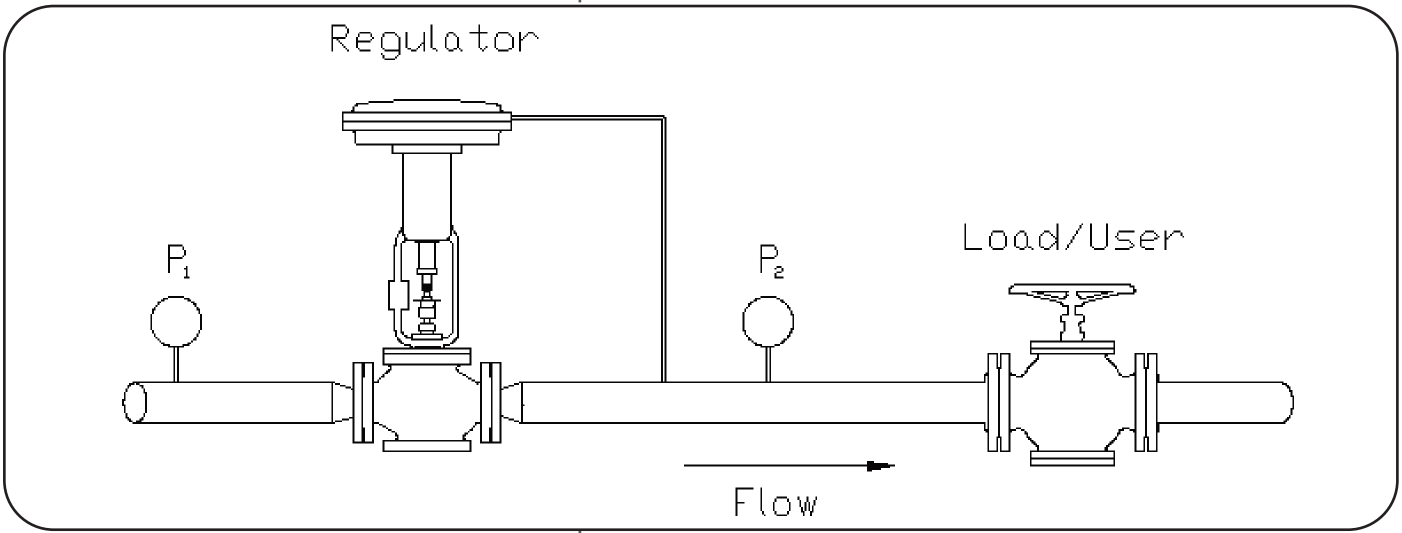


FIG.[1]

If the demand of the load decreases, the regulator supply must decrease too. Otherwise, the regulator would put too much fluid into the system and the pressure (P2) would tend to increase. On the other hand, if the demand increases, then the regulator must increase the supply in order to keep (P2) from decreasing due to shortage of gas in the system.

From this typical application example we see that the primary function of the regulator is to supply the correct amount of fluid as requested by the system, keeping the pressure constant or within a certain range. An ideal regulator could match instantly the amount of fluid requested by the system so keeping the pressure (P2) constant, but with real cases, as all devices have a certain inertia, the regulator will take some time to respond and adapt to the new conditions so introducing some fluctuations in (P2) whenever the system demand changes.

From the above example we see that to match the flow according to the demand of the system the regulator must be able to modulate the flow. This shows us that one of the essential elements of any regulator is a Restricting Element that will provide a variable restriction in the flow stream and thus modulate the fluid flow through the regulator.

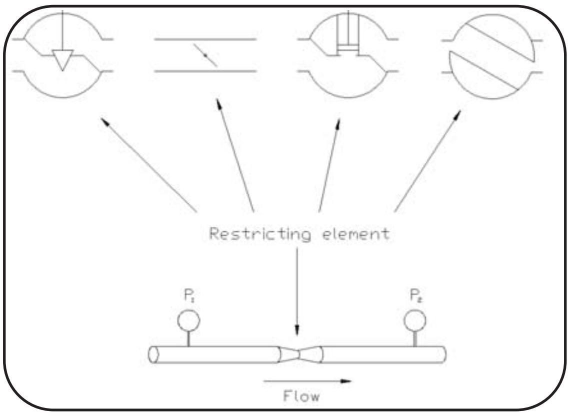


FIG.[2]

The restricting element can be any type of valve arrangement. A ball valve, a gate valve, a butterfly valve, a single or double port globe valve, or any other type of design that can modulate the flow of a fluid through the regulator.
The restricting element, in order to be varied in its position, will need to have some kind loading force to be applied on it. This shows that the other essential element for the regulator to operate in the Loading Elements that applies the needed force onto the restricting element. The loading element can be any type of device capable of applying a force. Some examples can be; a weight, a spring, a diaphragm or piston actuator, or even a simple handwheel.

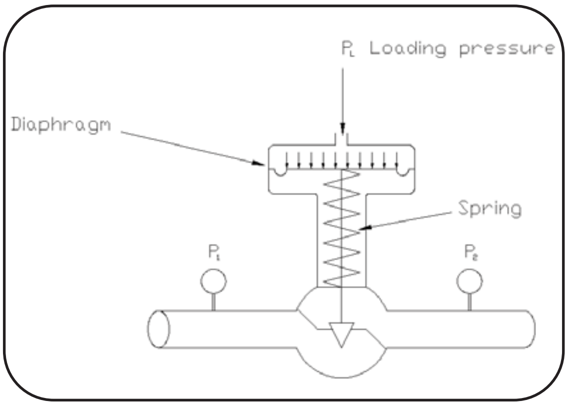


FIG.[3]

All the systems shown in Figure 4 are possible loading devices but the most commpn type of loading element that we are used to in everyday experience is the diaphragm actuator combined with a spring. As shown in figure 3 a loading pressure is applied to a diaphragm to produce a loading force that will act to open or to close, according to the desired operation, the restricting element.
The spring provides the reverse loading force. During compression phase it accumulates energy that will be released during extension. The spring has to provide a sufficient force to overcome the weight of the moving parts, the friction resistance and any possible unbalancing force due to pressure drop between upstream and downstream.

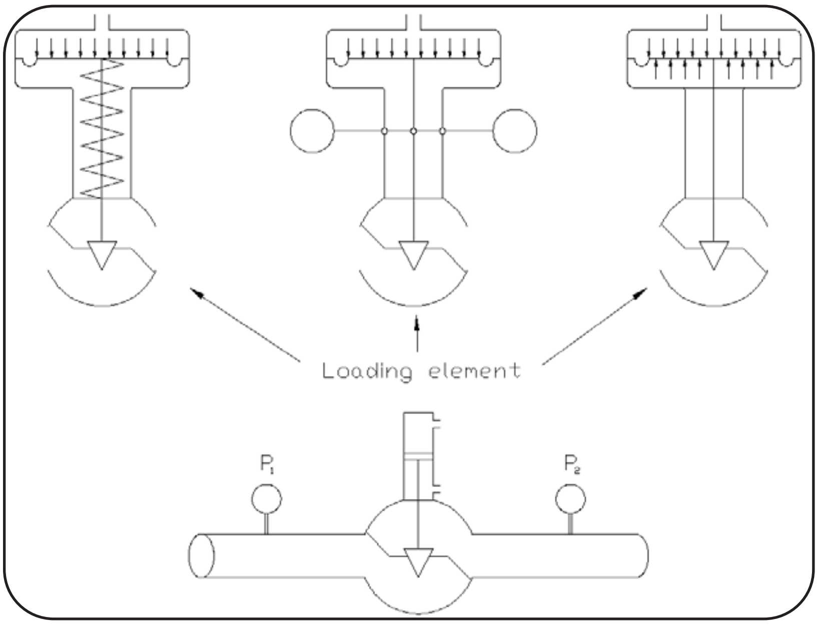


FIG.[4]

The layout in figure 4 shows a regulator with a restricting element to modulate the flow, and a loading element that can provide the necessary force to operate the restricting element.

But, how do we know if we are modulating the flow correctly≤ How do we know if the regulator matches the flow demand from the load or users≤ This shows that our device needs another essential element, the Measuring Element. This measuring element will determine when the regulator flow matches the user or load demand.

The beginning of this description stated that a regulators primary function was to match the flow of fluid through the regulator to the demand for fluid placed upon the system by the loads or users. At the same time, the regulator had to maintain the system pressure within a certain range. Now, lets use the layout in Figure 1 and look at the regulators operation much more in detail. Figure 5 shows the regulator with the restricting element and loading element as we have seen previously.

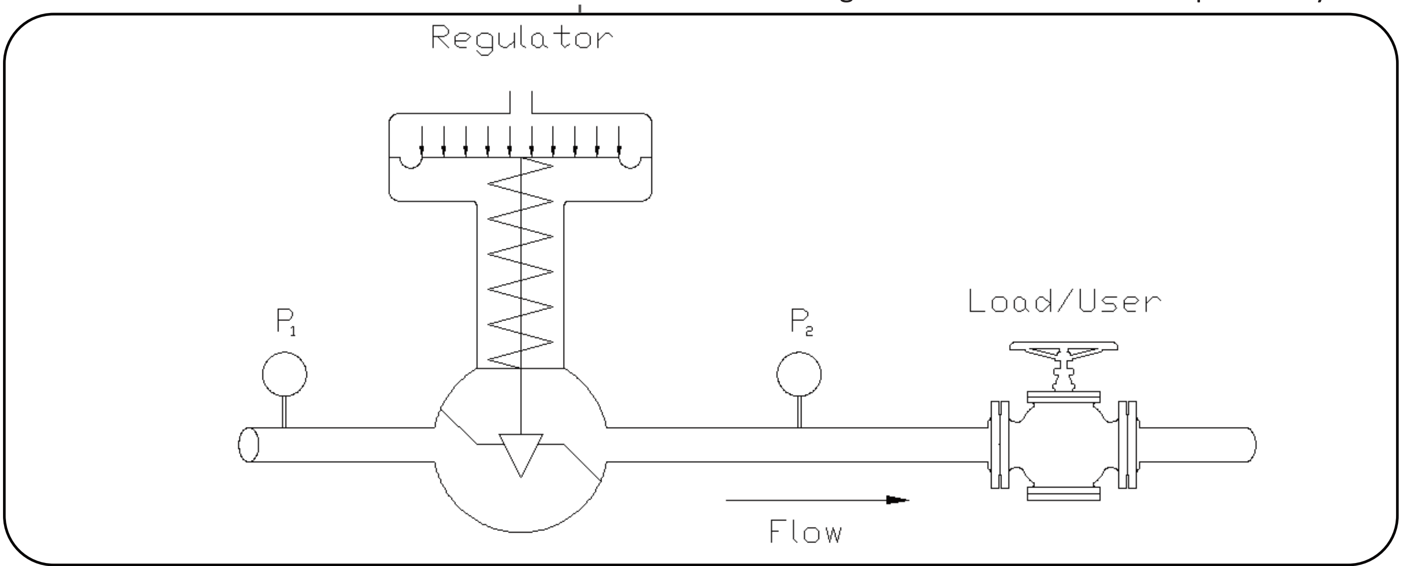


FIG.[5]

If the restricting element allows too much gas into the system, we will have a gas accumulation with a resulting pressure build-up, while if the restricting element allows too little gas into the system, there will be a gas shortage, thus we will have a pressure decrease. We can use this way of behaving of the system to provide a simple means of measuring whether or not the regulator is supplying the correct flow.

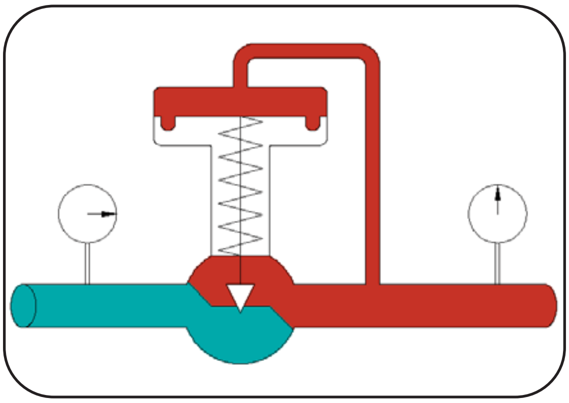


FIG.[6]

As we saw previously, the diaphragm, could be used as a loading element in combination with a spring, as by changing the loading pressure we could vary the loading force on the restricting element and thus modulate the flow. If we use the pressure fluctuations of the system and apply them on the diaphragm we can use the diaphragm as a measuring element too. As such, it provides a force to operate the restricting element that varies in response to changes in the measured pressure of the system. Now these three element put together, Restricting Element, Loading Element and Measuring Element, complete a gas pressure regulator as shown in Figure 6.

Let's review the operation of the regulator in figure 6. If the restricting element supplies too much fluid into the system, the pressure (P2) will increase. The diaphragm, acting as a measuring element, will respond to this increase in pressure by providing, as a loading element, a larger force that will compress the spring and therefore push the plug down, thus restricting the amount of fluid supplied to the system. In the opposite case, if the regulator doesn't supply enough fluid into the system, the shortage will produce a pressure (P2) drop. The diaphragm will react, by producing a lower force, thus enabling the spring to overcome the reduced force and relax, moving the plug upward and thus allowing more fluid in the system.

Concluding we can see that a regulator contains three essential elements:

- Restricting Element
- Loading Element
- Measuring Element

no matter how complex is the regulator, it must contain these three essential elements.

So far we have discussed the basics of self-operated regulators, more specifically of direct-operated regulators. Direct operated regulators are the class of regulators in which the measured pressure is directly applied as loading pressure on the loading element, differently from Pilot-Operated regulators in which the measured pressure is manipulated by intermediate hardware to obtain the loading pressure that therefore differs from the measuring pressure.
Direct operated regulators come into two basic configurations as shown in figure 7.

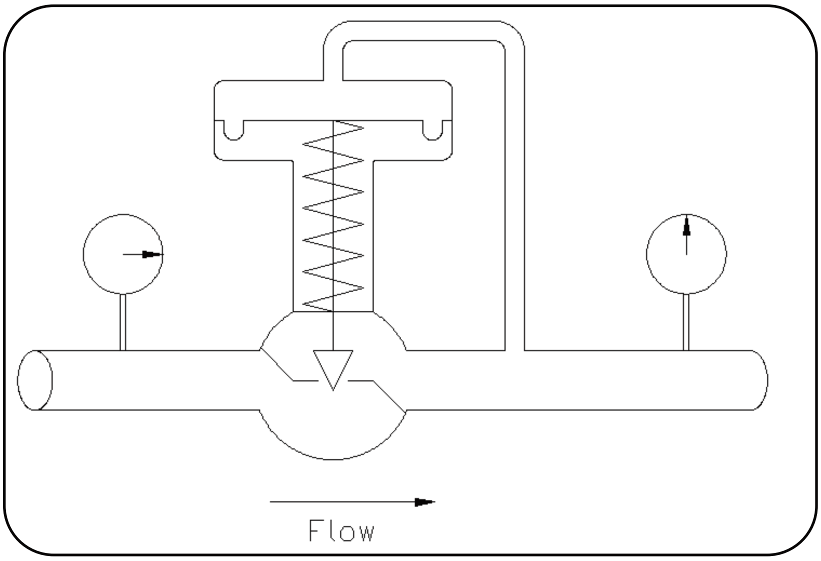


FIG.[7]

Regulator Definition

Any self-contained valve and actuator combination

Why use regulators?

There are many reasons for using regulators instead of other more sophisticated devices. As long as the regulator provides the requested service the more relevant reasons for the choosing regulators are listed below:

1. In general engineers, agree that the simpler a device is the more reliable it is. Every component has a probability of failure and the probability of failure of a system is the sum of all the probabilities of its components. The fewer and simpler the components the lower the failure probability.
2. Regulators are simple so they are cheap, and require simple maintenance so they have low servicing costs.
3. Regulators are self-contained and self-operated control devices. They don't need any type of external power supply, transmitting instruments on control instruments.

Regulator Operation

Regulators, can be configured in different layouts so to operate in a vide variety of modes. In general direct-operated and pilot-operated regulators can operate as follows;

- Pressure reducing regulators
- Backpressure regulators
- Pressure relief valves
- Differential pressure (flow) regulators
- Vacuum-breaking valves.

Pressure Reducing Regulators

A pressure reducing regulator maintains a desired downstream pressure while providing the required flow to satisfy the load or user demand. This pressure maintained by the regulator is the outlet pressure setting (setpoint) of the regulator. In general, as the outlet pressure changes with the variation of the flow demand, the downstream pressure setting is referred to as the downstream pressure when the regulator is supplying the standard flow requested in the most common operating conditions.
Direct-operated regulators are the simplest devices available for downstream pressure control. They are available with internal or external pressure sensing and can have a flow to open or flow to close design.
Direct-operated pressure reducing regulators can be designed only with a spring to open layout so the only possible failure modes are:

Spring failure	Regulator closes
Diaphragm failure	Regulator opens

Backpressure Regulators

A backpressure regulator maintains a desired upstream pressure by varying the flow in response to changes in upstream pressure. The upstream pressure maintained by the regulator is the pressure setting (setpoint) of the regulator. In general, changes in the flow cause variation in the inlet pressure, the upstream pressure setting is referred to as the upstream pressure the regulator has to maintain during standard operating flow conditions.Direct-operated backpressure regulators are available with internal or external pressure sensing and are limited to flow to close design. Flow to open design can be supplied only for special requests.

Relief Valves

A pressure relief valve prevents overpressure in a pressure system. The relief valve opens relieving the excess fluid so to prevent a rise of pressure over a desired limit. The pressure at which the relief valve begins to open is the relief pressure setting. Relief valves and backpressure regulators are the same devices. The type of application determines the name.
Backpressure regulators work open modulating the flow, relief valves work closed opening only in case of excess pressure.
Relief valves are NOT safety valves.
Direct-operated relief valves and backpressure regulators can be designed only with a spring to close layout so the only possible failure mode are:

Spring failure	Regulator opens
Diaphragm failure	Regulator closes

Differential pressure regulators

A differential pressure reducing regulator maintains a desired downstream pressure with respect to a reference pressure other than the atmospheric while providing the required flow to satisfy the load or user demand.
A differential pressure backpressure regulator maintains a desired upstream pressure with respect to a reference pressure other than atmospheric by varying the flow in response to changes in upstream pressure.
According to the two descriptions given above the two type of regulators operate as the regulatora described previously, but instead of having as reference the atmospheric pressure they can reference the set pressure to the pressure in a vessel or in a pipe. This pressure maintained by the regulator is the setting (setpoint) of the regulator, and it is relative to the reference pressure, it is NOT a gauge pressure as usually referred to.
The failure modes are analogous to the previously described relative to the pressure reducing and backpressure regulators.

high viscosity fluids

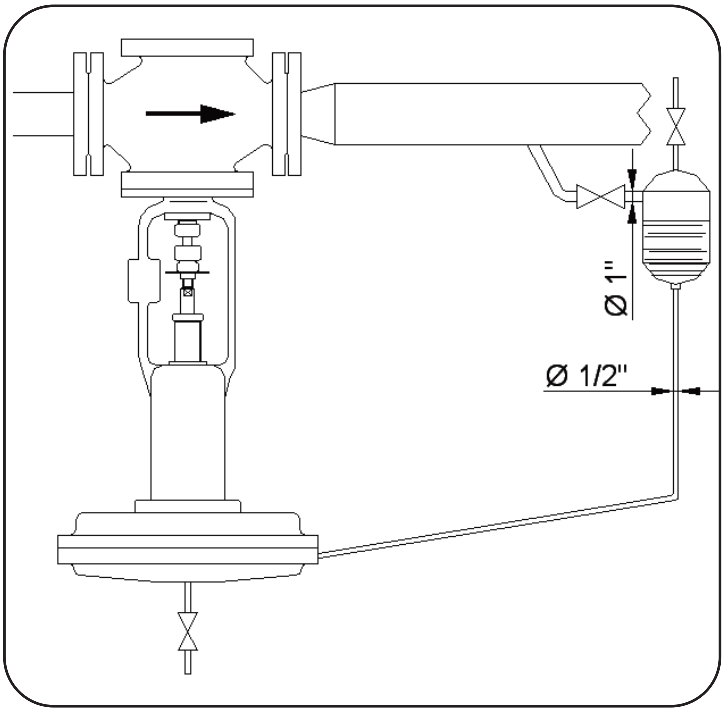


FIG. [1]

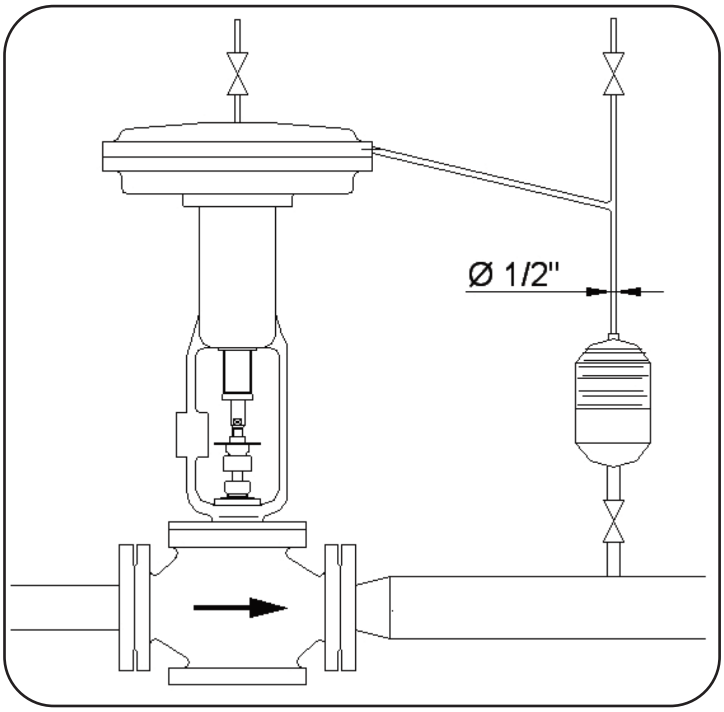


FIG. [2]

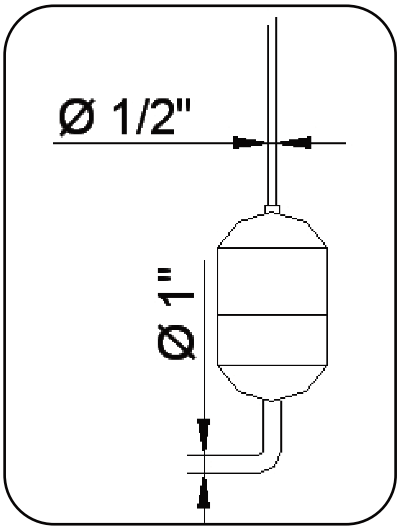


FIG. [3]

Separation tank high viscosity fluids regulator

Use of regulators for high viscosity fluids is limited by the loss in pressure through the pressure sensing pipe or in case of internal sensing through the sensing orifice. If viscosity is mild then the use of an increased diameter pipe or hole will solve the problem but if this solution is not enough a separation tank has to be used. This sensing technique requires the use of a low viscosity fluid as sensing fluid. The sensing fluid needs to be a non miscible with the process fluid. The Actuator and half of the separation tank are filled with this low viscosity fluid, the rest of the separation tank and pressure sensing pipe are filled with the process fluid. The separation tank is positioned near to the main pipe and connected to it with a large diameter pipe so to reduce to a minimum the pressure losses due to the high viscosity.

The two fluids are in contact in the separation tank and exchange their pressures Fig [3]. The low viscosity fluid flows in all the small diameter pipes carrying the pressure but with low pressure losses due to the low viscosity.

The two figures show the layouts for low viscosity fluid with a lower Fig. [2] and higher Fig. [1] density than the process fluid. The separation tank enables the use of regulators for controlling the pressure and flow of high viscosity fluids with very little of no loss in accuracy with respect to a low viscosity application.

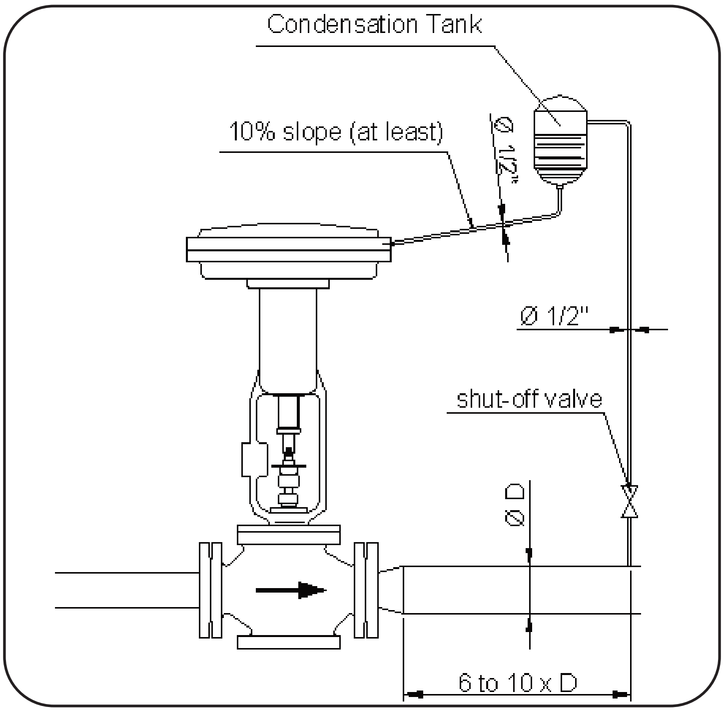


FIG. [1]

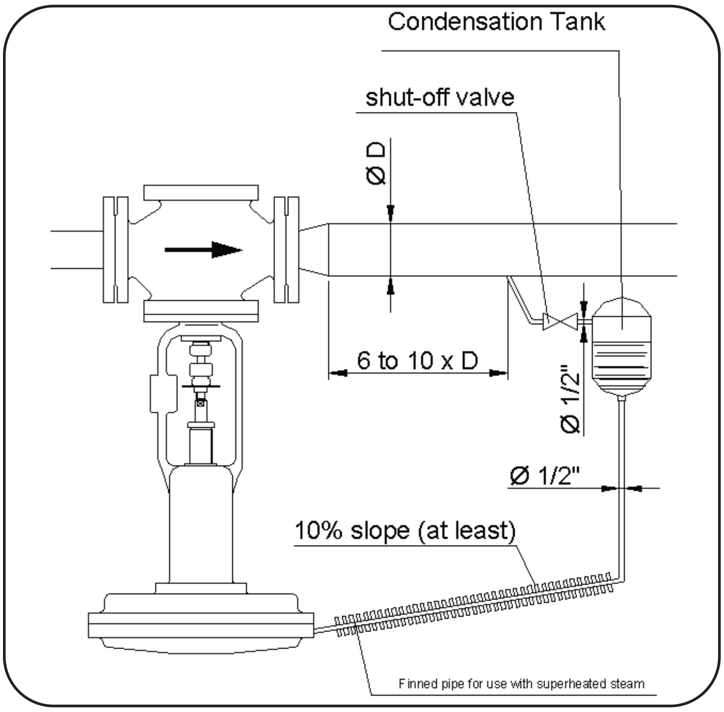


FIG. [2]

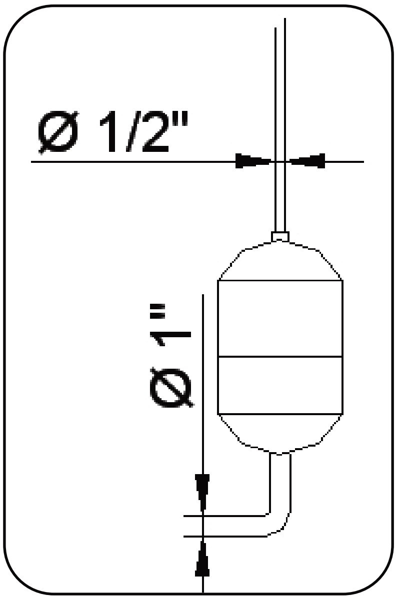


FIG. [3]

Condensation tank Steam regulator

Regulators are very commonly used for steam regulation. The rugged design of regulators well adapts to the severe conditions requested for steam regulation. For saturated steam where temperatures range from 130°C to 200°C (212°F to 392°F)) elastomer diaphragm actuators can be used, while for higher temperatures, due to elastomer limits, metal diaphragms have to be used limiting the capacities and giving a less accurate regulation.
These high temperature non compatibility for elastomers limit their use in common layouts. Condensation tank regulators use saturated steam properties so to enable the use of elastomer diaphragms for higher temperature than on common regulators.

How is this done?

Condensation tank steam regulators use the two phase equilibrium physical properties of the fluid they are controlling to reduce the contact temperature on the diaphragm.
A standard regulator would require a diaphragm with a high temperature resistance diaphragm to withstand the temperatures of superheated steam, although through the pressure sensing pipe there is no or very little movement of the fluid (the amount of movement is equal to the changes in volume of the actuator due to the diaphragm movement), and so no heat is carried by convection but only by simple conduction through the static fluid, the heat loss through the surfaces of the pipe can guarantee a temperature drop of 50°C (90°F). This would give a maximum temperature of 250°C (482°F) supposing the maximum operating temperature limit of the diaphragm was 200°C (392°F). An acceptable range of use but not enough to cover most steam applications.

Pressure	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig
	3,00	46,5	4,00	62,0	5,00	77,5	6,00	93,0	7,00	108,5	8,00	124,0	9,00	139,5
Temperature	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
Saturated	134	272	144	291	152	305	159	318	165	329	170	339	175	348
Superheated	426	800	426	800	426	800	426	800	426	800	426	800	426	800

TAB.[a] Superheated and Saturated steam temperatures comparison

Pressure	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig
	10,00	155,0	11,00	170,5	12,00	186,0	13,00	201,5	14,00	217,0	15,00	232,5	16,00	248,0
Temperature	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
Saturated	180	356	184	363	188	370	192	377	195	383	198	389	201	394
Superheated	426	800	426	800	426	800	426	800	426	800	426	800	426	800

TAB.[b] continued **TAB.**[a]

Pressure	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig	barg	psig
	17,00	263,5	18,00	279,0	19,00	294,5	20,00	310,0	21,00	325,5	22,00	341,0	23,00	356,5
Temperature	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
Saturated	204	400	207	405	210	410	212	414	215	419	217	423	220	427
Superheated	426	800	426	800	426	800	426	800	426	800	426	800	426	800

TAB.[c] continued **TAB.**[b]

The condensation tank uses the two phase equilibrium properties of the fluid to keep the same pressure acting on the diaphragm but with a lower temperature. The pressure sensing pipe connects the main steam pipe with a condensation tank, and another pipe connects the other end of the condensation tank to the actuator as shown in Fig. 1. The pipe from the main line connects to the upper part of the tank while the actuator pipe is connected to the lower part of the tank, this to make sure that condensed water flows always towards the actuator. To enhance this the pipe connection the tank with the actuator is mounted always with a slope so to direct the condensate to the actuator. During start-up the actuator and tank are filled with water up the half level of the tank so to prevent the initial contact of the steam with the actuator before the beginning of the condensation process (Fig. 3). The temperature of saturated steam is much lower than the superheated steam (see Table [a] for comparison), and keeps with the 200°C (392°F) limit with pressures up to 16 barg (248psig), considering that a further loss is present in liquid state the contact temperature remains well below the diaphragm maximum temperature limit. The pressure will remain constant through all the pressure sensing circuit supplying standard regulation performances.
For use with superheated steam, the pipes to be used are with a finned design so to further increase the heat loss on the tank-actuator connection as shown in Fig 2. Both upright or upside down operation is possible (Fig 1).

UBAS-HP

Function: Relief
Seat Type: Single - ANSI Class min. IV max VI
Line size: From ¹/₄" to ¹/₂"
Body material: Stailess steel - On customer request
End cennections: Threaded (F-NPT, GAS)
CV: From 0.033 to 1.9
Trim materals: Stainless Steel
Diaphragms: PTFE
Set Point: from 0,0035 to 5,80 Barg - Max inlet 70 Barg

UBAN

Function: Reducing
Seat Type: Single - ANSI Class min. IV max VI
Line size: From ¹/₂" to 2"
Body material: Carbon steel, Stailess steel, On customer request
End cennections: Threaded (F-NPT, GAS) or flanged (ANSI or DIN)
CV: From 0.033 to 12,8
Trim materals: Stainless Steel (std), Monel, Carbon Steel, Duplex
Diaphragms: Polychloroprene, PTFE, FKM, Steinless Steel
Set Point: from 0.0025 to 50 Barg

UBS

Function: Reducing
Seat Type: Single - ANSI Class min. IV max VI
Line size: From ¹/₂" to 2"
Body material: Carbon steel, Stailess steel, On customer reques
End cennections: Threaded (F-NPT, GAS) or flanged (ANSI or DIN)
CV: From 0.033 to 12,8
Trim materals: Stainless Steel (std), Monel, Carbon Steel, Duplex
Diaphragms: Polychloroprene, PTFE, FKM, Steinless Steel
Set Point: from 0.0025 to 50 Barg

Function: Temperature regulation
Seat Type: Single and Double - ANSI Class min. II max IV
Line size: From DN 15 to DN 50
Body material: Carbon steel, Stailess steel
End cennections: Flanged UNI PN 16-25-40 ANSI 150-300
CV: From 0.84 to 38
Trim materals: Stainless Steel
Set Point: from -2°C to 205°C

Function: Reducing / Relief
Seat Type: Single - ANSI Class min. II max IV
Line size: From DN 15 to DN 50
Body material: Carbon steel, Stailess steel
End cennections: Flanged UNI PN 16-25-40 ANSI 150-300
CV: From 0.84 to 34
Trim materals: Stainless Steel
Diaphragms: Polychloroprene
Set Point: from 0.5 to 7 Barg

Function: Reducing / Relief
Seat Type: Single and Double - ANSI Class min. II max VI
Line size: From DN 15 to DN 300
Body material: Carbon steel, Stailess steel, Alloy Steel
End cennections: Flanged UNI PN 40-64-100-160 ANSI 150-300-600
CV: From 2.3 to 560
Trim materals: Stainless Steel
Diaphragms: Polychloroprene, FKM,
Set Point: from 0.0015 to 50 Barg

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