kmo turbo

# Anti-Surge Control Valve

## with pneumatic actuation, exceptional dynamics and quick opening times of less than 1 second

- exceptional dynamics
- quick opening time <1 sec

- safe plug connection
- practically wear-free
- consistently low leakage rate
- suitable for oxygen
- certified in compliance with TA-Luft

- integrated positioner
- variable valve characteristics
- optimal performance even with cascaded control

- small dimensions and low weights
- simple installation
- flexible installation orientation
- no restrictions on inlet/outlet piping
- easy change-over of safe-position

- very low maintenance costs
- excellent cost/performance ratio
- standard delivery within 3 to 4 weeks

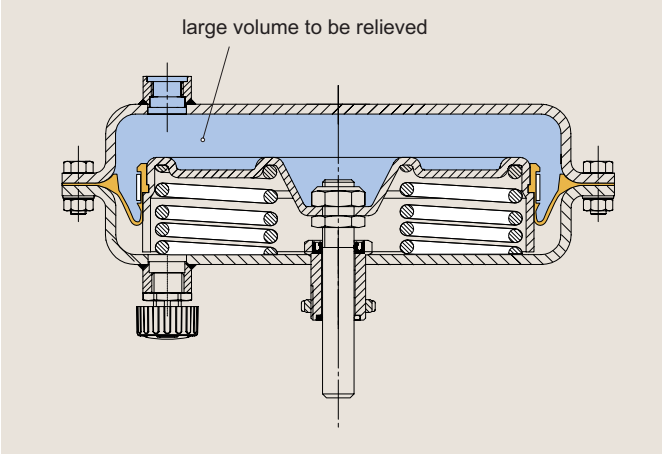
**Trendsetting I N N O V A T I O N for Turbocompressors**

# "Dead Time", the Main Challenge of Anti-Surge Control

Triggered by the anti-surge controller, the blow-off or by-pass valve should open without delay if the operating point exceeds the response line. A great disadvantage of pneumatic actuators is that there is always a significant time lag before the valve opens. Response times of up to 10 seconds and more are not unusual. During this time though, the pressure continues to approach the surge limit without any release of the increasing pressure.

## Why does the valve not open immediately?

If the valve is closed, the supply air pressure (typically 5 bar) acts on the diaphragm. Approximately 2.5 bar are required to keep the valve closed; the remaining 2.5 bar are to overcome friction when closing the valve and to maintain sufficient contact pressure. Once the response line is exceeded, the anti-surge controller itself reacts without delay. But before the valve begins to open, however, the contact pressure will have to be relieved.




## Fastest possible relief of the contact pressure

A valve positioner is designed for the stable control under normal operating conditions but not for the quikkest possible relief of the contact pressure. Furthermore, a positioner will relieve pressure with its full capacity only in case of a relatively large control deviation. Since this control deviation is not reached instantly, the contact pressure is at first relieved with a reduced capacity.

The pressure will reduce slower, the bigger the actuator, the bigger the stroke, the smaller the control deviation and the smaller the air capacity of the positioner are. A butterfly control valve in closed position will even have to be turned by several degrees before having control effects.

## The weak spot in the control loop: the pneumatic actuator

There are manufacturers of turbocompressors who postulate a response time of less than 1 msec (!) for the anti-surge controller. This disregards the fact that within this control loop, the positioner with the actuator – and not the controller – is the weakest element. It is irrelevant to favor a controller with a reaction time of 1 msec if a pneumatic actuator with a reaction time of more than 3000 msec is used at the same time.

## The anti-surge control valve of the future

For the use in anti-surge control valves, **kmo turbo** prefers a pneumatically actuated slotted disc valve of an established German manufacturer.

The reason why slotted disc valves were not employed earlier as anti-surge control valves might be that the overlapping discs required for sealing (represents approx. 20% of the total stroke) were interpretated as a disadvantange: inevitably this overlap causes an unwanted opening delay.

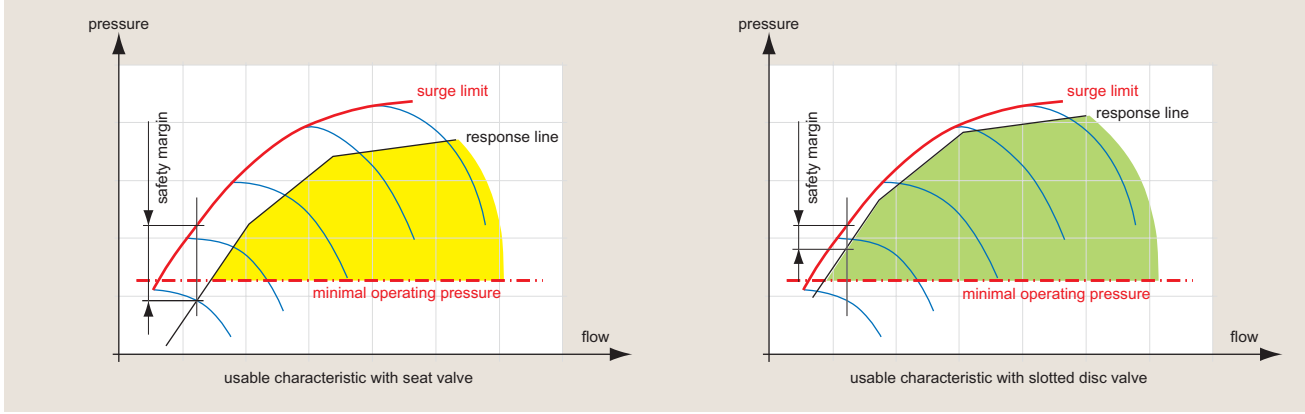
For the first time the control developed by **kmo turbo** (patent pending) passes the overlapping range in a time < 0.5 sec. Thus the valve will intervene practically without delay.

For a conventional seat valve without complex and costly additional components the minimum opening delay would be >3 secs.

The principle of a slotted disc valve, however only in connection with the innovative control of **kmo turbo**, represents the optimal anti-surge control valve. Anti-surge control valves virtually always operate at supercritical pressure conditions. This always results in rapid wear caused by vibrations; this problem does not occur with a slotted disc valve. In addition the slotted disc valve is benficial for numerous other applications, e.g. where there is a risk of cavitation.

## Optimal use of compressor characteristic = maximum profitability

A large safety margin between the response line and surge limit results in a correspondingly large dead time. The larger the saftey margin, the earlier the positioner will start relieving the contact pressure, reducing the effective compressor characteristic and decreasing profitability.




The **smaller the dead time** and the **faster the dynamics** of the valve, the smaller the safety margin can be set.

## Functional principle of slotted disc valves

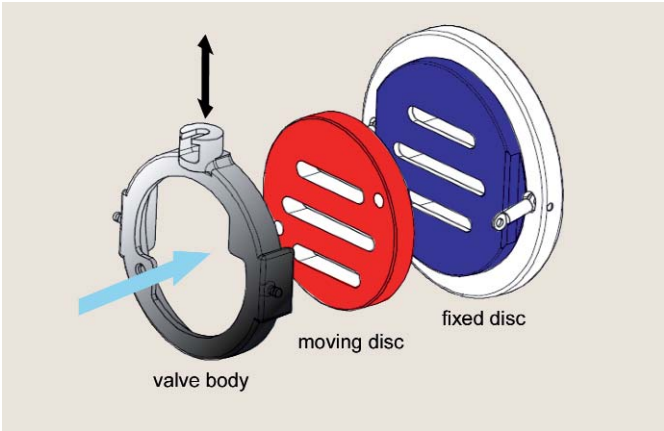
A disc fixed in a steel body across the flow direction has a number of slots of equal height. A further disc with the same arrangement of slots is moved across the fixed slots, thereby changing the flow cross section. The differential pressure presses the flexible disc against the fixed disc which leads to a high leak-tightness.

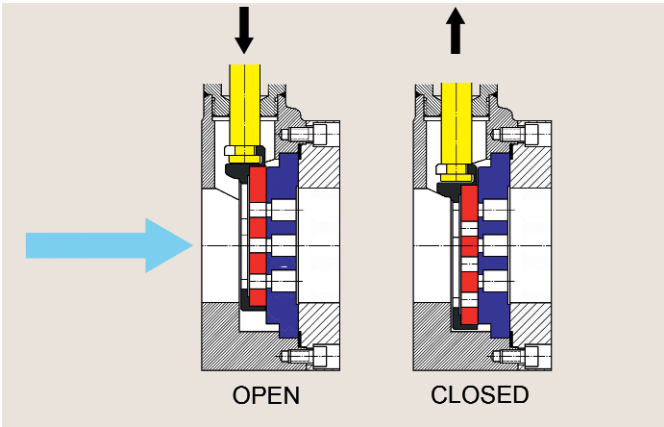
The traditional weak spot of a valve, the valve seat, does not exist in a slotted disc valve!

The slotted discs are available in three different material pairs:

- carbon - stainless steel
- fibre glass reinforced carbon - stainless steel
- Stellite - Stellite

Important selection criteria are: differential pressure, abrasiveness, sensitivity to condensate hammer and chemical resistance.




*The valve consists of two sliding discs*

# Why do we favor the slotted disc valve?

## 1. Because it starts to open without delay

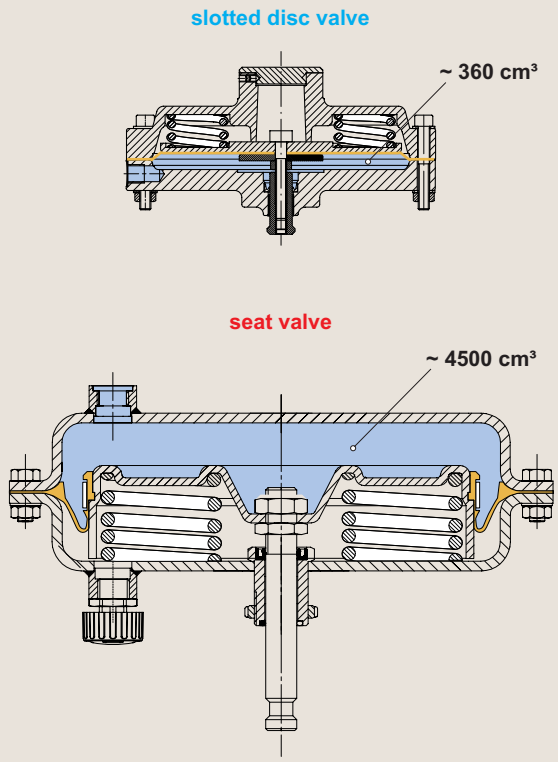
Combined with the control function developed by **kmo turbo**, a slotted disc valve starts to open without delay when the operating point reaches the response line. Consequently, the safety margin between response line and surge limit can be significantly reduced, which leads to an improved valve operating characteristic and improved profitability.

## 2. Because of its high dynamics

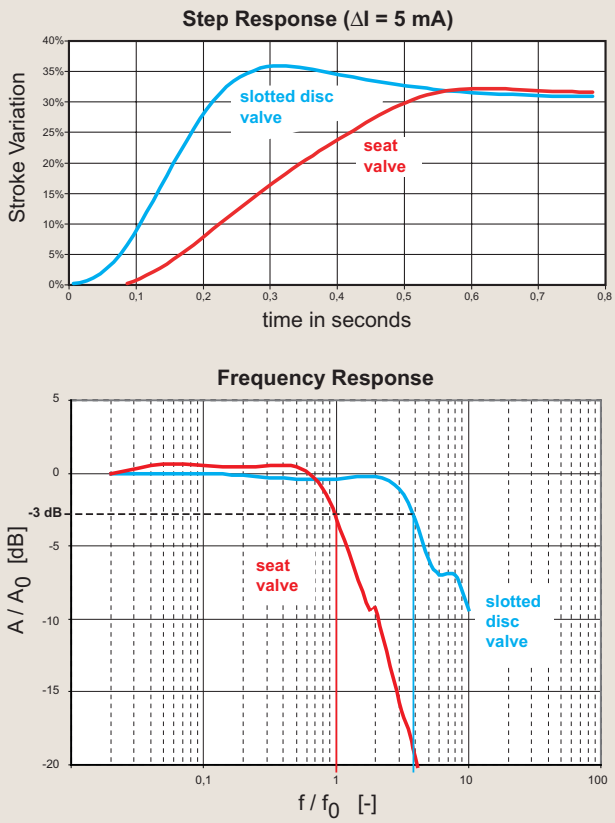
As described above, the quality of anti-surge control depends on the duration of the dead time until the valve starts opening. No other valve principle reacts as quickly as a slotted disc valve:

- A slotted disc valve closes across the flow. The actuating force has to overcome the friction force between the two discs but no closing force against the system pressure. This results in an actuating force which is only approx. 10% of the actuating force needed for a comparable seat valve
- The maximal stroke of a slotted disc valve is 9 mm, that is only approx. 20 - 50% of the stroke of a seat valve. This small stroke results in exceptional control dynamics, minimal wear and a virtually unlimited lifespan of the actuator diaphragm.
- A slotted disc valve does not seal by pressing a cone on a seat but by overlapping of the sliding discs and by pressing the moving disc on the static disc by the process pressure. Since no contact pressure has to be relieved, the slotted disc valve can leave the closed position without noticeable delay. There is virtually NO dead time!
- A conventional standard seat valve with a 20 mm stroke and a 700 cm² actuator has approximately seven times the stroke volume of an equivalent actuated slotted disc valve. Additionally, the dead storage capacity of a seat valve actuator is a multiple of that of a slotted disc valve simply due to its construction.

### Comparison of Actuator Volumes



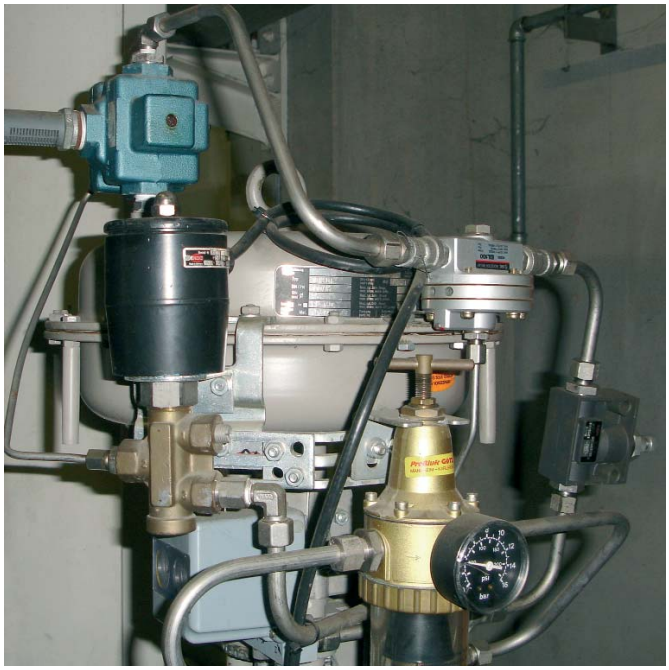

The following diagrams show the obvious advantages of the dynamics of a slotted disc valve in comparison to a conventional seat valve.



## 3. Because of its exceptional quick opening time

In order to protect turbocompressors against surging, they are traditionally equipped with two independent monitoring systems, an anti-surge control and a reverse flow protection.

The anti-surge control ensures stable operation. On approaching the surge limit, the flow volume of the compressor is kept at the minimal possible value by a controlled opening of a relief valve. If this control fails, the compressor starts to surge and at this point the reverse flow protection is activated. Its task is to unload the compressor by a quick and full opening of the relief valve.



*Typical installation with seat valves: throttle, booster, exhaust amplifier and large solenoid valve. There is always a compromise between opening time and control quality.*

Typically, quick opening times of max. 3 seconds are specified. With conventional actuators, this requirement can only be met by using large-sized solenoid-operated relief valves.

**Note the difference:**

A quick opening time of 1 second is already achieved via the control signal. Using a solenoid operated relief valve NG6 achieves <0.5 seconds. These extremely short times are possible due to the small dead volume and stroke.

Thus the slotted disc valve is beneficial not only for the application as **surge protection valve** but also as rapidly responding **safety valve**.

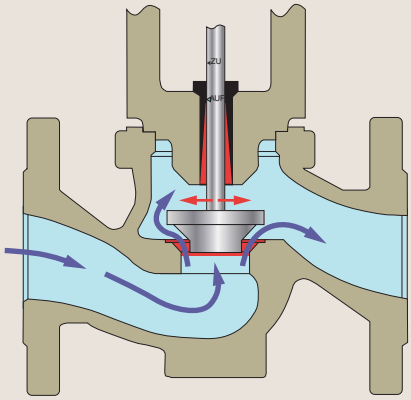

*Reaction without delay, quick opening time <0,5 sec with small solenoid valve and optimum control quality with a slotted disc valve*

## 4. Because of its safe plug connection

In order to connect the field cables it is not necessary to open the positioner housing. The positioner can be connected to the local junction box via two plug cables.

## 5. Because it is virtually wear-free

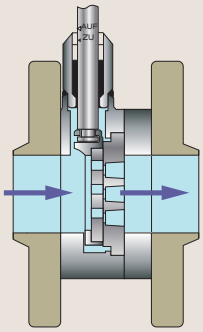
Anti-surge valves normally operate at supercritical pressure conditions, that is to say that at the narrowest throttle point there will be sonic flow speeds. With conventional seat valves, the high flow speed causes high vibrations and consequently a rapid wear of the valve seating and the guide sleeve.




repeatedly diverted flow
↓
high flow speed induces vibration
↓
wear of valve seating and guide sleeve

A worn valve seat leads to uneconomical operation due to high leakage. A worn guide sleeve causes higher friction, which in the worst case can result in jamming and consequently a total loss of the valve.

Both are the cause of expensive repairs and could lead to damage of the machinery or even the plant. The sliding discs of a slotted disc valve which are pressed together by the differential pressure cannot vibrate; consequently, there will be no wear caused by vibration!




Sliding discs are pressed against one another;
flow passes without change in direction
↓
no vibration - no wear

## 6. Because of consistently low leakage

A further advantage of the slotted disc valve is its low leakage rate. Typically, it is 10 times better than that of a conventional seat valve or butterfly valve, namely just 0,0001% Kvs (with material combination carbon to stainless steel)

The differential pressure presses the moving disc on the static disc. The sliding of the discs causes a self-cleaning; any deposits are removed by a shearing effect.

The sliding surfaces are lapped ex works and are constantly self-lapping during operation; as a result, the valve maintains its low leakage rate throughout a long service interval.

As a result of the valve design and the sealing across the flow, the slotted disc valve is not sensitive to fouling. Particles of rust, scales or welding beads virtually will not damage the sealing surfaces.

## 7. Because of its suitability for oxygen

The simple design of the valve body can easily and reliably be kept free of oil and grease during assembly. All materials are approved for use with oxygen.

## 8. Because of its compliance with TA-Luft

With its self-adjusting sealing system, the slotted disc valve complies with TA-Luft, specially designed models with a bellow seal are available; there is no change in the installation height.

## 9. Because the valve is available with an integrated positioner

A slotted disc valve can be fitted with any available positioner.

*Slotted disc valves can be combined with positioners of all manufacturers.*

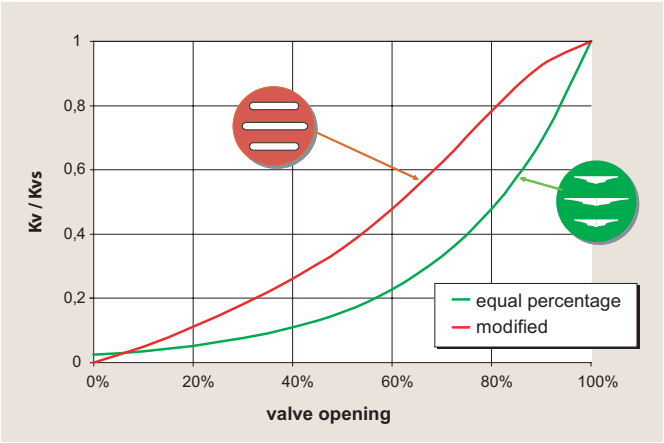
**kmo turbo** favours the integrated positioner provided by the valve manufacturer. With this unit there are no externally accessible moving parts.

*Slotted disc valve with integrated positioner*

The positioner is equipped with self-tuning function and an analogue feedback signal. From the analogue feedback signal two end position contacts are determined. Additionally inductive limit switches are provided.

## 10. Because of variable valve characteristics

The valve characteristics can be determined by the shape of the disc slots or the desired valve characteristic can be generated by a polygon stored within the position controller.




## 11. Because of an optimal performance even with cascaded controllers

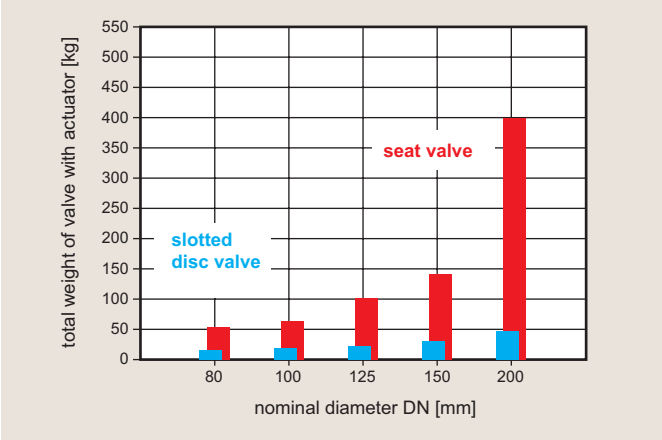
A turbocompressor never requires a high control performance of 100% flow, a control range of about 20% flow is sufficient.

For these 20%, the capacity of a slotted disc valve (max. DN200) is virtually always sufficient. For larger compressors, **kmo turbo** recommends the use of several slotted disc valves or a combination of slotted disc valves and other control devices of lesser performance.

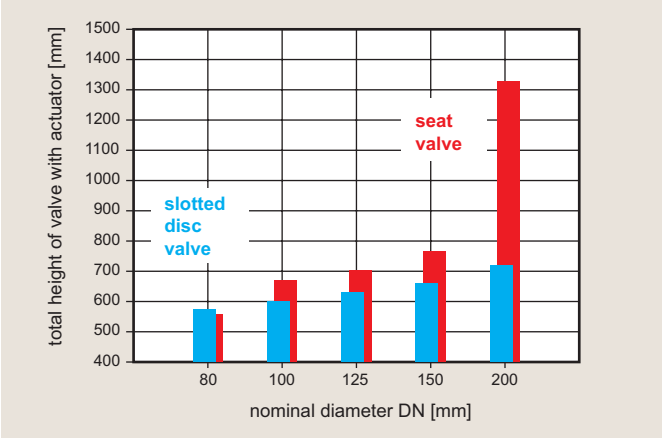
If, due to its high flow, a turbocompressor is equipped with two or more anti-surge controll valves of different performance and where a high performance of the overall flow is required (e.g. start-up of an air separation plant, start or stop of a furnace, ...) **kmo turbo** has created a control algorithm which enables the use of the high performance slotted disc valve for the entire range of flow.

## 12. Because of its small dimensions and low weight

A conventional seat valve DN200 weighs approx. 400 kg; a comparable slotted disc valve DN200 only 32 kg.




A conventional seat valve DN200 with actuator has a typical installation height of round about 2 m; a corresponding slotted disc valve measures less than 800 mm.




The installation of a slotted disc valve is much simpler due to small weight and low installation height.

## 13. Because of simple installation

The wafer-type slotted disc valves are relatively unaffected by tension. Using flanges without nozzles a slotted disc valve can be installed without an axial shifting of the piping.

## 14. Because of flexibility of installation

Even conventional seat valves can be mounted vertically or horizontally. Due to the weight of the actuator of a conventional seat valve it has to be made sure, however, that the pillars are directly above one another to be able to carry the weight of the actuator. The extremely lightweight actuator of a slotted disc valve enables an absolutely free choice of installation position without restrictions.

## 15. Because there are no requirements for inlet/outlet

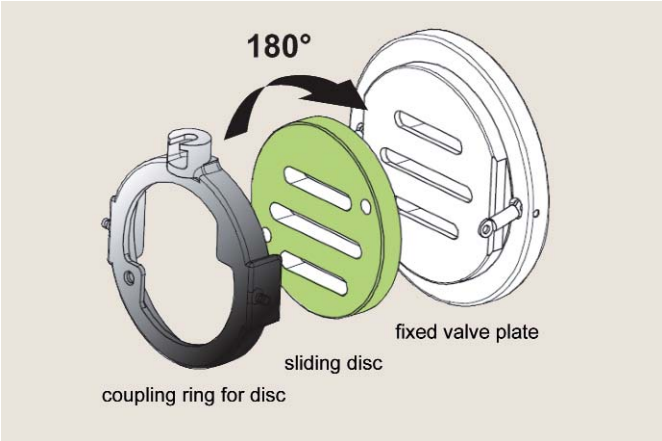
In order to achieve quoted specification of a control valve, manufacturers of seat valves insist on straight inlet and outlet sections.

Since, with a slotted disc valve, the throttling is done across the flow, turbulences do not affect the performance of the flow control. There is no requirement for straight inlet and outlet sections. Thus the design of piping is simplified significantly.

*By-pass valve of an oxygen compressor*

## 16. Because of the easy change-over of the safe-position

The many suberb features of slotted disc valves suggest their use in many other fluid control applications. Should it thereby become necessary to change the safe-position, this task can be simply realized by turning the sliding disc through 180°.




## 17. Because of very low maintenance costs

The simple design of a slotted disc valve eliminates most maintenance problems. The dismantling of the valve is very easy since the sliding disc is not welded to the actuating stem.

The main wear of a seat valve is caused by vibrations due to gas dynamics. Thanks to its design a slotted disc valve is not sensitive to vibrations. No vibration, no wear!

Due to the small stroke and minimal wear, lifespan of the actuator diaphragm is virtually unlimited. The small stroke also has a positive effect on the lifespan of the guide sleeves.

## 18. Because of an excellent cost/performance ratio

The standard version of a seat valve with a valve rod guided only on one side should never be used when supercritical pressure conditions exist. Due to high vibrations, its valve seat will be worn out within a few hours of operation. Even expensive special valves with double guided valve rod do not have an adequate lifespan before wear out.

The price of a slotted disc valve is round about that of a standard seat valve, but its performance is even superior to expensive special designs of a seat valve!

The anti-surge control valve of **kmo turbo** furthermore allows a smaller safety margin between response line and surge limit. Depending on the mode of operation, this could represent a significant factor for improving the operating efficiency.

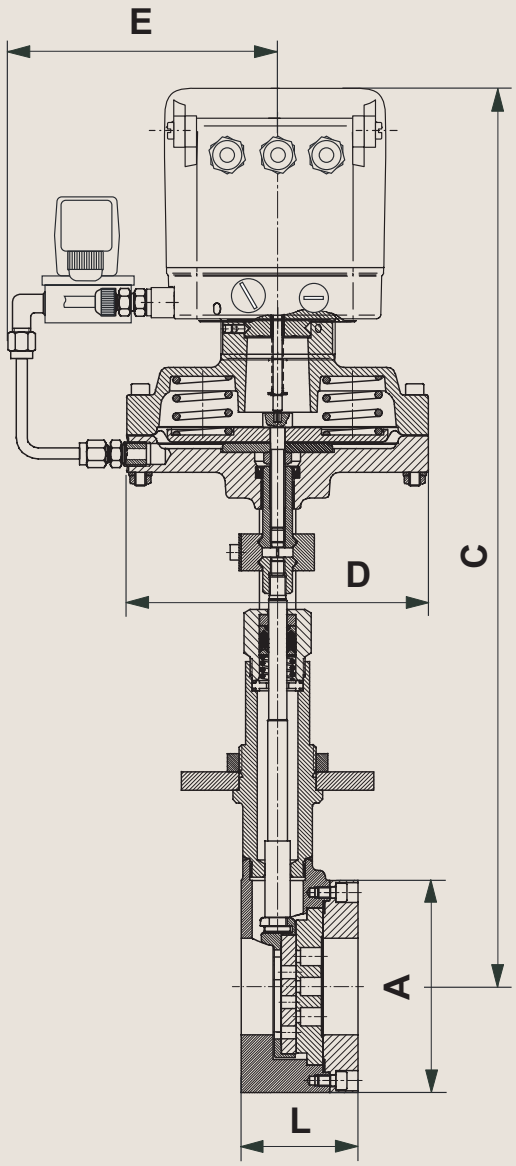
Even if the compressor is seldom operated at the blow-off line, the consistently low leakage rate creates a considerable additional economic benefit.

The low maintenance costs of a slotted disc valve should also be considered when judging the cost/performance ratio. The maintenance costs for a seat valve usually exceed the purchase price after only a short period of operation.

## 19. Because of standard delivery within 3 to 4 weeks

Slotted disc valves are of a modular design. On receipt of an order, the valves are assembled from off-the-shelf components, which as a rule leads to extremely short delivery times; usual are 3 to 4 weeks. In urgent cases it is possible to realize an even shorter delivery time.

## Technical Data of Slotted Disc Valve




### Technical Details

| | |
|---|---|
| Design | Flangeless, wafer-type construction |
| Nominal diameters | DN 15 - DN 200, ½" - 8" (DN 250 on request!) |
| Flow coefficient | Kvs 0.04 - 560 , Cv 0.046 - 626 |
| Nominal pressure | PN 16: DN 15 - DN 200<br>PN 40: DN 15 - DN 150<br>PN 100: DN 15 - DN 80<br>ANSI 150: DN 15 - DN 200<br>ANSI 300: DN 15 - DN 150<br>ANSI 600: DN 15 - DN 80 |
| Media temperature | Carbon steel body -10°C up to + 300°C<br>Stainless steel body -60°C up to + 350°C<br>Low temperature version down to - 200°C<br>High temperature version up to + 530°C |
| Ambient temperature | -10°C bis + 75°C |
| Rangeability | 40 : 1 |
| Leakage rate of disc pair | Carbon - stainless steel < 0.0001 % of Kvs<br>Stellite - Stellite < 0.001 % of Kvs |

### Dimensions & Weights

| DN | A | C 250 cm² | C 500 cm² | D | E | L | weight 250 cm² | weight 500 cm² |
|---|---|---|---|---|---|---|---|---|
| 50 | 116 | 490 | 538 | 222 | 161 | 64 | 12,7 | 16,4 |
| 80 | 153 | 587 | 634 | 222 | 161 | 70 | 15,6 | 19,3 |
| 100 | 184 | 612 | 660 | 222 | 161 | 75 | 19,1 | 22,8 |
| 125 | 212 | 641 | 689 | 222 | 161 | 80 | 23,3 | 27,0 |
| 150 | 242 | 671 | 719 | 222 | 161 | 80 | 27,0 | 30,7 |
| 200 | 302 | 731 | 779 | 222 | 161 | 93 | 43,9 | 47,6 |

### Kvs Values

| DN | 50 | 80 | 100 | 125 | 150 | 200 |
|---|---|---|---|---|---|---|
| Kvs | 45 | 92 | 154 | 237 | 338 | 560 |

### Admissible Differential Pressures (up to 120°C)

(higher differential pressures on request)

| DN | 50 | 80 | 100 | 125 | 150 | 200 |
|---|---|---|---|---|---|---|
| Carbon - stainl. steel | 100 | 48 | 33 | 23 | 16 | 15 |
| Stellite - Stellite | 66 | 32 | 20 | 13 | 9 | - |

## Ordering Example for an Anti-Surge Control Valve (system kmo turbo)

| 8 | K | 2 | 1 | / | 1 | 2 | 5 | V | G | G | 1 | 1 | 5 | M | - | - | B | - | - | 1 | Z | C | 0 | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

- S: DTM-function *)
- 0: Limit switches
- C: Digital positioner
- Z: Equal percentage characteristic
- 1: Kvs-value 100%
- -: Fixed disc stainless steel 1.4571 coatet
- -: Sliding disc carbon material fibre enforced
- B: PTFE-V-shaped seal, self adjusting
- -: Standard springs
- 5: Diaphragm actuator 500cm²
- M: Spring to open
- 5: Body material: stainless steel 1.4571 / 1.4581
- 1: GS3 flangeless design according DIN, PN 10 - 40
- 1: GS control valve with pneumatic actuator
- G: Valve
- G: Nominal diameter 125 mm
- V
- 8
- K
- 2
- 1
- /
- 1
- 2
- 5

*) Dead Time Minimizer: reduces the dead time before valve starts to open

## Anti-surge control and surge protection by kmo turbo

A turbocompressor "surges" if its operating point is forced out of the stable range of its characteristic diagram due to a too low flow or a too high discharge pressure.

Continuous surging may lead to severe damage of the compressor. The break-down of flow may result in damage to the downstream process.

Turbocompressors should be equipped with two independent systems. An anti-surge control for holding up a stable operation and a reverse flow protection to protect the compressor against ongoing surging.

Anti-surge control and reverse flow protection from **kmo turbo** on the basis of the Siemens S7 are field-proven for all types of turbocompressors. Due to their compact design and flexible application, these systems are particularly suitable for the retrofit of aged compressors. Since 1994, numerous compressors of worldwide manufacturers such as Atlas Copco, Borsig, Demag, Escher Wyss, GHH, Ingersoll Rand, Joy, KKK, MAN Turbo, Nouvo Pignone, PGW, Siemens PGI, Sulzer, ... have been fitted with these systems.

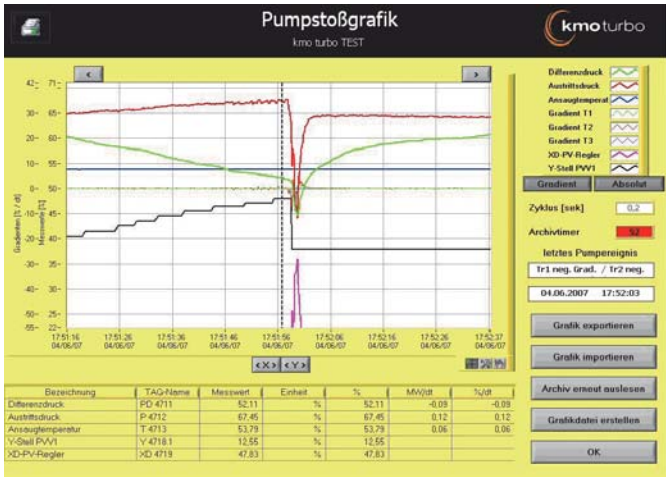
The anti-surge control of **kmo turbo** offers numerous unique practical functions which you won't find in other systems. All functions are pre-programmed; only the configuration and the parameters have to be set.

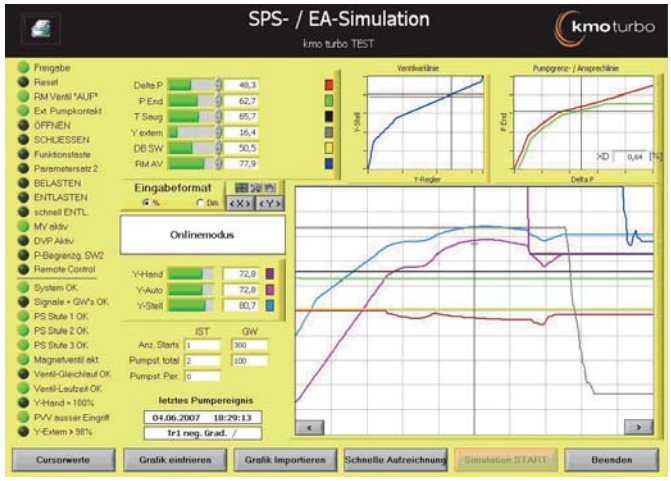
### Highlights of the kmo turbo Anti-Surge Control

- Remote control, also via bus
- Partial opening: activated by the first surging. The compressor is protected; the downstream process can continue with slightly reduced flow.
- DVP (Dynamic Valve Positioning): event-controlled an expected valve position is set directly.
- Event-controlled XP/TN-change-over
- Integrated pressure limiting control
- Optimized algorithm for controlling several valves of different performance levels
- Configuration and parameter-setting via intuitive operating software
- Operating software can be used as training tool: all signals can be simulated
- OVC (Optimized Valve Characteristic) optimization of valve characteristics

### Highlights of the kmo turbo Reverse Flow Protection

- Reliable detection of surging: 3 transmitter signals can be monitored with 4 criteria
- Multilevel reverse flow control: partial opening, full opening, shutdown
- Numerous diagnostic functions:
  - Date, time, values of the last 100 surges
  - Trend of the last surge
  - Counter for surges, surges since last start, starts, hours of operation



**kmo turbo** has decades of practical experience with turbocompressors and turbines. Apart from services such as troubleshooting, commissioning and optimizing of operations, we also design, manufacture and distribute innovative control and monitoring systems for turbo machinery. Our products have been well-proven in practice and are used in all sectors of industry.

- **Anti-surge control and reverse flow protection**
  realized with PLC Siemens S7
- **Anti-surge control valves**
  with pneumatic actuator, exceptional dynamics and quick opening times of less 1 second
- **Control cabinets for turbocompressors**
  equipped with PLCs Siemens S7 with unique functions. Short commissioning times due to a 100% function test before delivery.
- **”Flight recorder” for industrial use**
  datalogger with Ethernet and Profibus interface
  communication also via WLAN and Internet
- **Efficient transmitter solutions**
  for vibration measurement combined with a smart monitoring system
- **Low-pressure hydraulic actuators**
  new design or retrofit towards 4...20 mA control
- **Innovative probe holder for eddy-current vibration probes**
  - oil-tight
  - once-for-all GAP adjustment
  - insulated cable connector
  - protection sleeves for temporarily dismounted probes
- **Field calibrator for eddy-current vibration probes**
  Test of loop sensitivity without dismounting of the probe
- **GAP-Tester**
  Measurement tool for the quick GAP-adjustment of eddy-current vibration probes


**kmo turbo GmbH**

Friedrichstr. 59
88045 Friedrichshafen
Germany

phone: +49 7541 95289 0
fax: +49 7541 95289 20
mobile: +49 171 7432832

www.kmo-turbo.de
info@kmo-turbo.de


Karl Morgenbesser
CEO / Managing Director

Thorsten Neukamm
General Counsel / Deputy MD

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