INFORMATION SHEET

T 8000-6 EN

Packings for Globe Valves

Packing forms and their application ranges

Application

A packing is a dynamic sealing system that seals the moving plug stem to prevent the process medium escaping from the valve into the atmosphere. The packing must seal the moving plug stem, yet without impairing the valve's performance in any way.

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We attach great importance to occupational health and safety as well as environmental protection in the same way our customers do. Consequently, we offer solutions to meet the increasingly stricter emissions requirements.

Environmental requirements

Particularly strict requirements may apply to the fugitive emissions of a valve depending on the process medium and the environmental protection as well as occupational health and safety regulations in place. There are three factors that play a major role in a valve's compliance to environmental requirements:

- External leakage (fugitive emissions)
- Seat leakage
- Noise emissions

External leakage occurs when the process medium in a control valve (e.g. with pneumatic actuator) leaks to the atmosphere over the plug stem guide, body gasket or flanged joint. Seat leakage primarily concerns the internal leakage between the seat and plug as well as the joint between the seat and body (see Fig. 1). External leakage from the valve is termed "fugitive emissions".

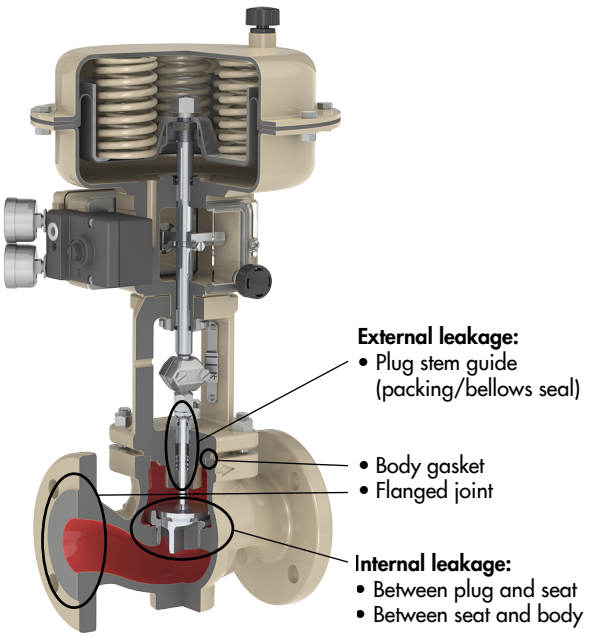

Fig. 1: *External and internal leakage in a control valve*

Measures to minimize external leakage are divided into two categories: static and dynamic seals. Body gaskets and flanged joints belong to the static seal category. Dynamic seals include packings, bellows and diaphragm seals.

The packing must seal the moving plug stem to ensure the process medium inside the valve cannot escape to the atmosphere, yet without impairing the valve's performance.

Requirements

Packings are contact seals which seal the opening between a moving and a stationary component. Due to the large area of contact between the packing and the plug stem as well as the high compression required to control leakage, the friction generated by the packing is relatively high when compared to mechanical seals. Nevertheless, packings are still commonly used to seal valves when they have the following properties:

- Pressure and temperature resistance
- Wear resistance
- Low friction
- High resistance to corrosive media
- Elastic and easily deformable

Installing the packing

The packing is either fixed in place in the valve body by a threaded bushing (central threaded fastening, see Fig. 1, Fig. 2 and Fig. 5) or using a packing flange and a threadless bushing (see Fig. 3 and Fig. 4). There are four basic packing designs:

- Adjustable, one central threaded fastening (see Fig. 5)
- Spring-loaded, one central threaded fastening (see Fig. 2)
- Adjustable packing flange (see Fig. 3)
- Packing flange loaded by external springs (see Fig. 4)

The sealing elements of the adjustable packing are compressed between the valve body and plug stem by gradually tightening the threaded bushing or packing flange. If the packing leaks, the threaded bushing or packing flange can be repeatedly tightened further until the sealing elements must be replaced.

Live-loaded packings are loaded by internal or external springs. A pre-loaded spring maintains a constant load on the sealing elements, which is automatically adjusted, even as the sealing elements wear down over time until they must be replaced.

Composition and materials

Packings are available in various varieties and contain several rings, one or more bushings and washers. They may also include a spring to load the packing. The combination of parts and their material depends on the valve application as well as pressure, temperature and medium resistance properties etc.

There are different types of packing rings, which can be made of various materials. Typical packing ring types include smooth, V-shaped and braided rings that can be made of graphite, PTFE or modified PTFE material.

A stainless steel spring made of 1.4310 (standard), 2.4360 (Monel® 400) or 2.4610 (Hastelloy® C4) is used for the live-loaded packing.

Design and principle of operation

An installed packing seals the space between the valve body and plug stem after the threaded bushing or packing flange is tightened. This creates an axial force that is applied to the packing rings. As a result, the rings expand in the radial direction and are pressed against the plug stem. The compressive force applied to the packing seals off any potential paths of leakage.

Principle based on a live-loaded V-ring packing (see Fig. 7):

The guide bushing (9) is pressed fit at the bottom of the valve bonnet and surrounds the plug stem. The packing spring (3) is installed on top of it. The packing rings (1a) are arranged in a certain sequence above the spring in the packing chamber. The compressive force is created by tightening the threaded bushing (4) or packing flange on the valve bonnet. As a result, the packing rings (1b) are squeezed together. The V-rings are pushed into one another and spread out. This creates a tight seal in the space between the plug stem and valve bonnet. The same principle applies to other ring-type seals as well.

Excessive leakage can occur if the packing is installed incorrectly (e.g. uneven, insufficient or excessively high tightening torque) and/or the wrong packing materials are used. Over-tightening increases the friction between the packing and plug stem, which may lead to premature wear and unwanted jerky plug stem movement. It can also increase the actuator force required to position the valve.

Unlike the adjustable packing, a spring-loaded packing cannot be overtightened if the instructions are followed. The central threaded bushing is tightened as far as it will go. When using a packing flange, a visual indication is given on the correct tightening position. The spring ensures that an even and relatively optimal compressive force is applied to the packing.

The advantage of an adjustable packing is that it does not have any springs, making it free of cavities.

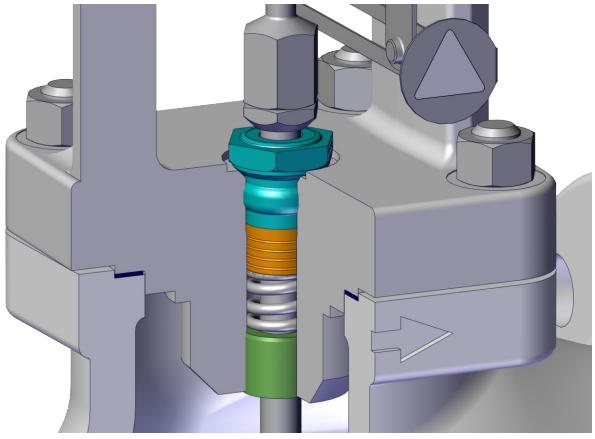

Fig. 2: *Live-loaded packing with threaded bushing (loaded by internal springs)*

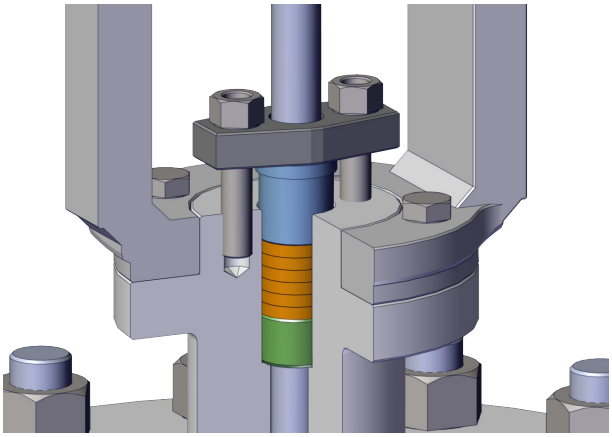

Fig. 3: *Adjustable packing flange (e.g. used in Type 3595 Valve)*

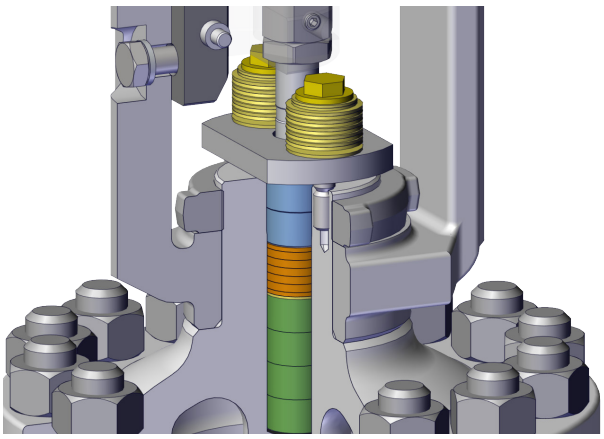

Fig. 4: *Live-loaded packing with packing flange (loaded by external springs) with tightening option*

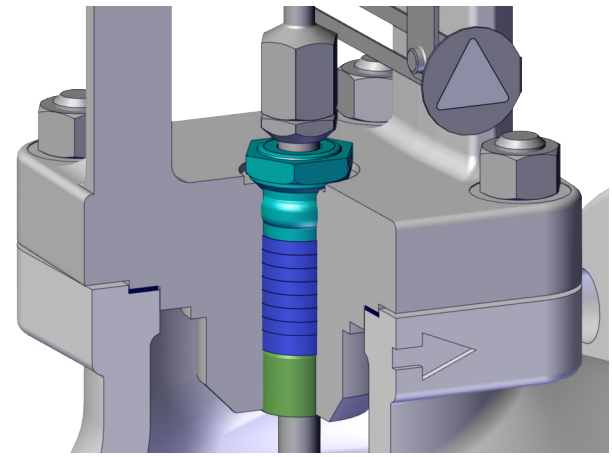

Fig. 5: *Adjustable packing with threaded bushing (without spring)*

Standards and regulations

It is impossible to achieve 100 % tightness in a control valve due to the laws of physics and chemistry (i.e. since atoms of a substance diffuse through a solid and/or as a result of dynamic forces created by the moving plug stem). Consequently, regulations and standards define the tightness of a packing based on permissible leakage limits depending on the process medium.

Such regulations include the German TA Luft (German technical instructions on air quality control). This regulation serves to protect the general public from the harmful effects of air pollution on the environment and to provide precautions against harmful effects of air pollution in order to attain a high level of protection for the environment altogether.

The TA Luft regulation requires that sliding-stem valves are fitted with a high-performance bellows seal with backup packing or use an equivalent gasket sealing system. In the TA Luft regulation dated 24 July 2002, a gasket sealing system can be regarded to be equivalent if the temperature-specific leakage rates are met in the verification procedure stipulated in VDI 2440:2000-11. Compliance is given when the construction of the sealing system is expected to continually fulfill its intended function under the operating conditions and the following specific leakage rates are met:

Temperature	<250 °C	≥250 °C
Specific leakage rate	$10^{-4}\ \frac{mbar * l}{(s * m)}$	$10^{-2}\ \frac{mbar * l}{(s * m)}$

The latest edition of the TA Luft regulation came into force on 23 June 2021. A transitional period for compliance with the new requirements will end on 1 January 2025. The latest edition of the TA Luft regulation refers to the international ISO 15848-1 standard concerning equivalent gasket sealing systems. This standard deals with the measurement, test and qualification procedures for fugitive emissions in industrial valves. It prescribes specific test procedures and test media. Packings are classified according to categories of tightness, temperature and endurance. The number of mechanical cycles (full strokes) is also classified since it is a relevant factor for packings.

The objective of DIN EN ISO 15848-1 is to enable a classification of the performance of different valve designs to reduce fugitive emissions. It defines the type test for evaluation and qualification of valves where fugitive emissions standards are specified.

Testing can only be performed on fully assembled valves. Helium gas (H) or methane (M) of 97 % minimum purity is prescribed as the test medium. After testing, the packing is assigned to a performance class (see Fig. 6).

Table 1: *Tightness classes according to ISO 15848-1 for helium as test medium*

		Tightness class		
		AH	**BH**	**CH**
Measured leakage rate (mass flow)	$mg * s^{-1} * m^{-1}$ Stem perimeter (information only)	≤10^{-5}	≤10^{-4}	≤10^{-2}

The endurance class is used to determine the classification according to the number of mechanical cycles. A differentiation is made between isolating valves and control valves. Isolating valves are classified according to CO endurance classes and control valves according to CC endurance classes. These endurance classes are subdivided into three stages depending on the minimum number of mechanical cycles. A certain sequence of cycles is performed for each endurance class. The endurance classes for control valves are listed below as an example:

- CC1: 20,000 mechanical cycles (10,000 cycles at room temperature and 10,000 cycles at test temperature in total)
- CC2: 60,000 mechanical cycles (CC1 + an additional 40,000 cycles consisting of 20,000 cycles at room temperature followed by 20,000 cycles at test temperature)
- CC3: 100,000 mechanical cycles (CC2 + an additional 40,000 cycles consisting of 20,000 cycles at room temperature followed by 20,000 cycles at test temperature)

If the leakage measured exceeds the values in Table 1 during typetesting, it is permissible to mechanically adjust (i.e. tighten) the packing once for each qualification stage performed (according to the endurance class). For example, a maximum of three adjustments is permissible for CC3.

The tightness test is always performed for a specific temperature and pressure. Fixed temperature classes are defined in ISO 15848-1. However, the standard permits a test temperature that deviates from the temperature class, which is specified in brackets after the temperature class in the performance class.

Fig. 7 to Fig. 9 show various packings.

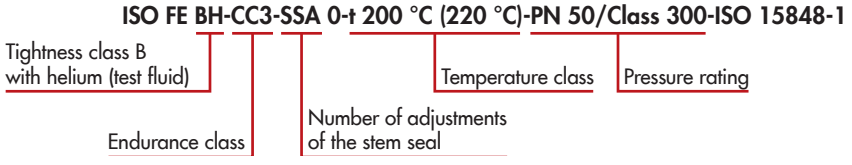

Fig. 6: *Typical performance class marking for Form LoE packing installed in a Series 240 Valve*

Legend for Fig. 7 to Fig. 9

1	Packing (entire)	6	O-ring
1a	V-ring packing	7	Seal
1b	Seals with square/ rectangular cross-section	8	Spacer
2	Washers	9	Guide bushing (PSA version: wiper ring)
3	Spring		
4	Threaded bushing		
5	Spacer		

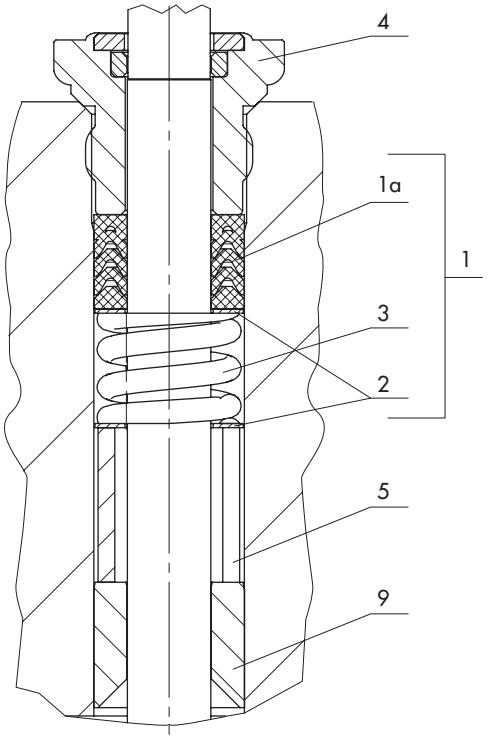

Fig. 7: *Standard packing · DN 65 to 80/NPS 2½ to 3*

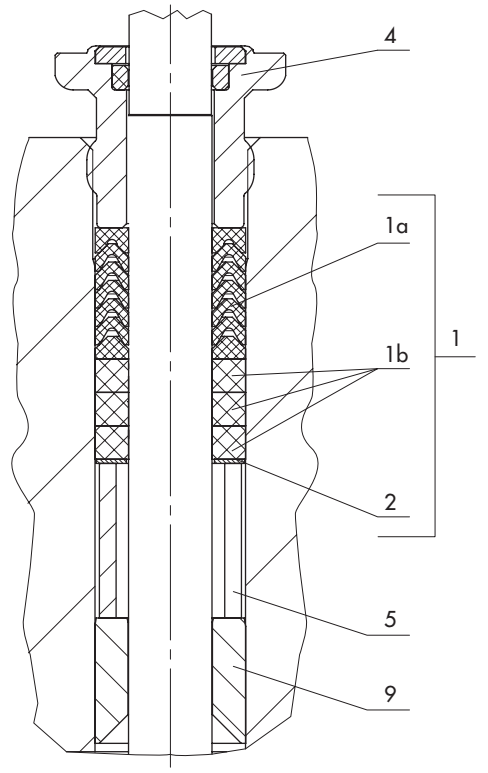

Fig. 8: *Form A packing · DN 65 to 80/NPS 2½ to 3*

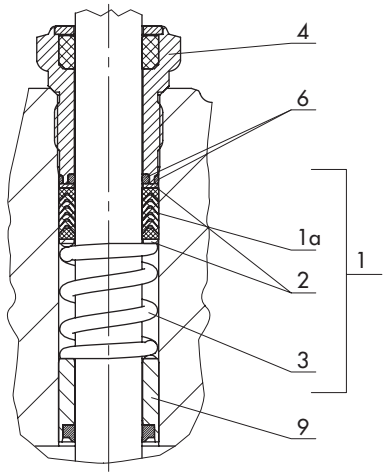

Fig. 9: *Form PSA packing · DN 15 to 50/NPS ½ to 2*

Table 2: *Overview of packing forms for* ***Series 240, 250, 280 and 290 Valves*** *– Part 1*

• = Standard version o = Optional version — = Not with this packing

Form			Standard	Standard NACE	LoE (low emissions)	LoE NACE
Style	Live-loaded (spring-loaded)		•	•	•	•
	Adjustable	Once	—	—	—	—
		Several times	—	—	—	—
	With packing flange		—	—	—	—
	With threaded bushing		•	•	•	•
Construction	Seals	V-rings	•	•	•	•
		Square cross-section	—	—	—	—
		Smooth	•	•	•	•
		Braided	—	—	—	—
	Bushing(s)	One	•	•	•	•
		Multiple	o	o	o	o
	Washer(s)		•	•	•	•
	Spring		•	•	•	•
	Packing	Single	•	•	•	•
		Double	o [5]	o [5]	o [5]	o [5]
Materials [1]	Seals		PTFE-carbon (Pure) PTFE	PTFE-carbon (Pure) PTFE	PTFE-carbon (Pure) PTFE	PTFE-carbon (Pure) PTFE
	Bushing(s) and washers		• 1.4301 o 1.4360 o 1.4404 o 2.4610	• 2.4610	• 1.4404	• 2.4610
	Spring		• 1.4310 o 2.4360 o 2.4610	• 2.4610	• 1.4310	• 2.4610
Lubricants			Yes	Yes	Yes	Yes
Suitability for process medium	pH range		0 to 14	0 to 14	0 to 14	0 to 14
Temperature range	Medium		–10 to +220 °C [2] 14 to 428 °F [2]	–10 to +220 °C [2] 14 to 428 °F [2]	–50 to +220 °C [6] –58 to +428 °F [6]	–50 to +220 °C [6] –58 to +428 °F [6]
	Ambient		–25 to +120 °C –13 to +248 °F	–25 to +120 °C –13 to +248 °F	–50 to +120 °C –58 to +248 °F	–50 to +120 °C –58 to +248 °F
Service life (mechanical cycles)			>500,000	>500,000	>500,000	>500,000
Certification	DIN EN ISO 15848-1:2017 [7] [9]		—	—	•	•
	FCI 91-1 (ANSI)		—	—	—	—
Requirements (met)	TA Luft 2021 [8] [9]		—	—	•	•
	NE 167 [8]		—	—	•	•
Other certification (e.g. in the food and beverage as well as pharmaceutical industries)			—	—	—	—
Suitable for valves		**Design**	240, 250, 290	240, 250, 290	240: only listed valve models. Otherwise, 250 only	240: only listed valve models. Otherwise, 250 only
		Type	3591, 3510	3591, 3510	3241, 3244	3241, 3244
Applications/suitability/special features			High level of sealing performance with low maintenance requirements	– High level of sealing performance with low maintenance requirements – Suitable for sour gas and sour water	– For nominal sizes DN 15 to 300 – No maintenance – Particularly suitable for valves that must have an effective sealing performance over the entire temperature range.	– For nominal sizes DN 15 to 300 – No maintenance – Particularly suitable for valves that must have an effective sealing performance over the entire temperature range.

A	B	D	H			Form
—	—	•	—	Live-loaded (spring-loaded)		Style
—	—	—	—	Once	Adjustable	
•	•	—	•	Several times		
—	—	—	—	With packing flange		
•	•	•	•	With threaded bushing		
• Up to DN 150/NPS 6	•	•	—	V-rings	Seals	Construction
• Up to DN 150/NPS 6 • DN 200/NPS 8 and larger	•	—	•	Square cross-section		
•	•	•	•	Smooth		
•	•	—	—	Braided		
•	—	•	—	One	Bushing(s)	
o	•	o	•	Multiple		
•	•	•	•		Washer(s)	
—	—	•	—		Spring	
•	•	•	•	Single	Packing	
	o [5]	o [5]	o [5]	Double		
PTFE-carbon PTFE-silk	(Pure) PTFE PTFE with silk cord	(Pure) PTFE	(Pure) graphite		Seals	Materials [1]
• 1.4404	1.4404	• 1.4301 o 1.4360 o 1.4404 o 2.4610	Carbon		Bushing(s) and washers	
—	—	• 1.4310 o 2.4360 o 2.4610	—		Spring	
Yes	Yes	Yes	No			Lubricants
0 to 14	0 to 14	0 to 14	0 to 14		pH range	Suitability for process medium
–10 to +220 °C [2] 14 to 428 °F [2]	–10 to +220 °C [2] 14 to 428 °F [2]	–10 to +220 °C [2] 14 to 428 °F [2]	≤350 °C [2] ≤662 °F [2]		Medium	Temperature range
–25 to +120 °C –13 to +248 °F	–25 to +120 °C –13 to +248 °F	–29 to +120 °C –20 to +248 °F	–50 to +120 °C –58 to +248 °F		Ambient	
>500,000	>500,000	>500,000	>200,000			Service life (mechanical cycles)
—	—	•	—	DIN EN ISO 15848-1:2017 [7] [9]		Certification
—	—	—	—	FCI 91-1 (ANSI)		
—	—	•	—	TA Luft 2021 [8] [9]		Requirements
—	—		—	NE 167 [8]		(met)
—	—	o FDA o Regulation (EC) No. 1935/2004		Other certification (e.g. in the food and beverage as well as pharmaceutical industries)		
240, 250	240, 250	240, 250	240, 250	Design		Suitable for valves
				Type		
Cavity-free packing suitable for process media that crystallize or polymerize	Cavity-free packing suitable for process media that crystallize or polymerize and for which discoloration is not permitted	– High level of sealing performance with low maintenance requirements – For process media that are not permitted to discolor	– Suitable for high-temperature range (e.g. for superheated steam) – To fulfill graphite purity requirements ≥98 %	Applications/suitability/special features		

1) Materials that are interdependent as well as being dependent on other factors, such as valve body material, temperature ranges, medium properties etc.
2) Medium temperature at the valve inlet (applies to versions without insulating section and/or bellows seal)
3) Manufacturer's Declaration for stem seal exists
4) Braided end rings made of pure expanded graphite yarn with edges reinforced with carbon fibre, highly compressed washers and specially impregnated adapter rings made of high-density, expanded pure graphite
5) Depending on the valve series
6) Depending on the valve, the use of an insulating section is prescribed for low temperatures down to –50 °C (see the data sheet of the corresponding valve).
7) Tightness class, test medium, endurance class, temperature class and pressure rating on request
8) Pressure rating and temperature class on request
9) Certification for Type 3510 Micro-flow Valve on request

Table 3: *Overview of packing forms for* ***Series 240, 250, 280 and 290 Valves*** *– Part 2*

• = Standard version o = Optional version — = Not with this packing

Form			HT	HG	PG
Style	Live-loaded (spring-loaded)		—	—	•
	Adjustable	Once	•	•	—
		Several times	—	—	•
	With packing flange		—	—	—
	With threaded bushing		•	•	•
Construction	Seals	V-rings	—	—	•
		Square cross-section	—	—	•
		Smooth	•	—	•
		Braided	•	•	—
	Bushing(s)	One	•	•	•
		Multiple	o	—	o
	Washer(s)		•	•	•
	Spring		—	—	•
	Packing	Single	•	•	•
		Double	o [5]	—	o [5]
Materials [1]	Seals		(Pure) graphite [4]	(Pure) graphite	PTFE-carbon (Pure) PTFE Graphite
	Bushing(s) and washers		(Pure) graphite [4]	(Pure) graphite	
	Spring		—	—	
Lubricants			No	No	Yes
Suitability for process medium	pH range		0 to 14	0 to 14	0 to 14
Temperature range	Medium		≤400 °C [2] ≤752 °F [2]	≤450 °C ≤842 °F	–10 to +220 °C [2] 14 to 428 °F [2]
	Ambient		–50 to +120 °C –58 to +248 °F	–50 to +120 °C –58 to +248 °F	–25 to +120 °C –13 to +248 °F
Service life (mechanical cycles)			>500,000	>500,000	>200,000
Certification	DIN EN ISO 15848-1:2017 [7] [9]		—	•	—
	FCI 91-1 (ANSI)		—	—	—
Requirements (met)	TA Luft 2021 [8] [9]		—	•	—
	NE 167 [8]		—	—	—
Other certification (e.g. in the food and beverage as well as pharmaceutical industries)					
Suitable for valves		**Design**	240, 250	240	240, 250
		Type		3241, 3244, 3246	
Applications/suitability/special features			Suitable for high-temperature range (e.g. for superheated steam)	– Suitable for high-temperature range – Packing and certification only for nominal size ≤DN 150/≤NPS 6	Special application-specific version for HyCO plants

PSA	W	Loaded by external spring	Form		
•	—	•	Live-loaded (spring-loaded)		**Style**
—	—	—	Once	Adjustable	
o	•	—	Several times		
—	—	•	With packing flange		
•	•	—	With threaded bushing		
• Additional O-ring acting as a seal between threaded bushing and valve bonnet	—	—	V-rings	Seals	**Construction**
•	•	—	Square cross-section		
•	•	—	Smooth		
—	•	•	Braided		
•	•	•	One	Bushing(s)	
o	o	o	Multiple		
•	o	•		Washer(s)	
•	—	•		Spring	
•	•	•	Single	Packing	
o [5]	o [5]	—	Double		
PTFE-carbon (Pure) PTFE Graphite	Synthetic fiber Carbon	PTFE-carbon (Pure) PTFE		Seals	**Materials** [1]
		1.4404/1.4310	Bushing(s) and washers		
		1.4310		Spring	
Yes	Yes	Yes			**Lubricants**
0 to 14	0 to 14	0 to 14		pH range	**Suitability for process medium**
–10 to +150 °C 14 to 302 °F	–10 to +220 °C [2] 14 to 428 °F [2]	–10 to +220 °C [2] 14 to 428 °F [2]		Medium	**Temperature range**
–10 to +120 °C 14 to 248 °F	–10 to +120 °C 14 to 248 °F	–10 to +120 °C 14 to +248 °F		Ambient	
	>200,000	>500,000			**Service life (mechanical cycles)**
—	—	• [3]	DIN EN ISO 15848-1:2017 [7] [9]		**Certification**
—	—	—	FCI 91-1 (ANSI)		
—	—	—	TA Luft 2021 [8] [9]		**Requirements** (met)
—	—	—	NE 167 [8]		
					Other certification (e.g. in the food and beverage as well as pharmaceutical industries)
240, 250	240, 250	250	Design		**Suitable for valves**
		3251	Type		
PSA (Pressure Swing Adsorption) plants	– Cavity-free packing for fresh and service water – Carbon bushings serve as wipers – Especially suitable for hard water and any process media that may cause deposits to form on the plug stem	– Cavity-free packing – Low maintenance required – Certification available for nominal sizes ≤DN 150/≤NPS 6 and pressure rating ≤PN 40/≤Class 300 – Larger nominal sizes and higher pressure ratings on request			**Applications/suitability/special features**

1) Materials that are interdependent as well as being dependent on other factors, such as valve body material, temperature ranges, medium properties etc.
2) Medium temperature at the valve inlet (applies to versions without insulating section or bellows seal)
3) Manufacturer's Declaration for stem seal exists
4) Braided end rings made of pure expanded graphite yarn with edges reinforced with carbon fibre, highly compressed washers and specially impregnated adapter rings made of high-density, expanded pure graphite
5) Depending on the valve series
6) Depending on the valve, the use of an insulating section is prescribed for low temperatures down to –50 °C (see the data sheet of the corresponding valve).
7) Tightness class, test medium, endurance class, temperature class and pressure rating on request
8) Pressure rating and temperature class on request
9) Certification for Type 3510 Micro-flow Valve on request

Table 4: *Overview of packing forms for* ***Series SMS Valves***

• = Standard version o = Optional version — = Not with this packing

Form			PZS0	PZS1	PXS1	GXA1
Code	**P**	PTFE	•	•	•	—
	G	Graphite	—	—	—	•
	Z	Centrally fastened (threaded bushing)	•	•	—	—
	X	With packing flange	—	—	•	•
	S	Spring load (live-loaded)	• (without adjusting option)	• (without adjusting option)	• (with adjusting option)	—
	A	Adjustable (adjustable)	—	—	—	•
Materials [1)]	Seals		(Pure) PTFE PTFE-carbon	(Pure) PTFE PTFE-carbon	(Pure) PTFE PTFE-carbon	(Pure) graphite
	Bushing(s) and washers		1.4404 2.4610	1.4404 2.4610	1.4404 2.4610	1.4404 2.4610
	Spring		1.4310 2.4610	1.4310 2.4610	1.4310 1.4568 Inconel® 718	—
Lubricants			Yes	Yes	Yes	No
Suitability for process medium	pH range		0 to 14	0 to 14	0 to 14	0 to 14
Temperature range	Process medium [2)]		–10 to +220 °C 14 to 428 °F	–50 to +250 °C –58 to 482 °F	–50 to +250 °C –58 to 482 °F	–10 to +425 °C 14 to 797 °F
	Ambient		–25 to +120 °C –13 to +248 °F	–50 to +120 °C –58 to +248 °F	–50 to +120 °C –58 to +248 °F	–10 to +120 °C 14 to 248 °F
Certification	DIN EN ISO 15848-1:2017 [3)]		—	•	•	—
	FCI 91-1 (ANSI)		—	—	—	—
Requirements (met)	TA Luft 2002 (VDI 2440)		•	•	•	•
	TA Luft 2021 [4)]		—	•	•	—
	NACE version possible		•	•	•	•
Suitable for valves			All valve models within the SMS Series	All valve models within the SMS Series	All valve models within the SMS Series	All valve models within the SMS Series

PZS2	PXS2	GXA2			Form
•	•	—	PTFE	**P**	**Code**
—	—	•	Graphite	**G**	
•	—	—	Centrally fastened (threaded bushing)	**Z**	
—	•	•	With packing flange	**X**	
• (without adjusting option)	• (with adjusting option)	—	Spring load (live-loaded)	**S**	
—	—	•	Adjustable (adjustable)	**A**	
(Pure) PTFE	(Pure) PTFE	Graphite cord ring	Seals		**Materials** [1]
1.4404 2.4610	1.4404 2.4610	1.4404 2.4610	Bushing(s) and washers		
1.4310 2.4610	1.4310 1.4568 Inconel® 718	—	Spring		
Yes	Yes	No			**Lubricants**
0 to 14	0 to 14	0 to 14	pH range		**Suitability for process medium**
–50 to +250 °C –58 to 482 °F	–50 to +250 °C –58 to 482 °F	–10 to +425 °C 14 to 797 °F	Process medium [2]		**Temperature range**
–50 to +120 °C –58 to +248 °F	–50 to +120 °C –58 to +248 °F	–10 to +120 °C 14 to 248 °F	Ambient		
—	—	•	DIN EN ISO 15848-1:2017 [3]		**Certification**
—	—	—	FCI 91-1 (ANSI)		
—	—	—	TA Luft 2002 (VDI 2440)		**Requirements** (met)
—	—	•	TA Luft 2021 [4]		
•	•	•	NACE version possible		
All valve models within the SMS Series	All valve models within the SMS Series	All valve models within the SMS Series			**Suitable for valves**

1) Materials that are interdependent as well as being dependent on other factors, such as valve body material, temperature ranges, medium properties etc.
2) Medium temperature at the valve inlet (applies to versions without insulating section or bellows seal)
3) Tightness class, test medium, endurance class, temperature class and pressure rating on request
4) Pressure rating and temperature class on request