

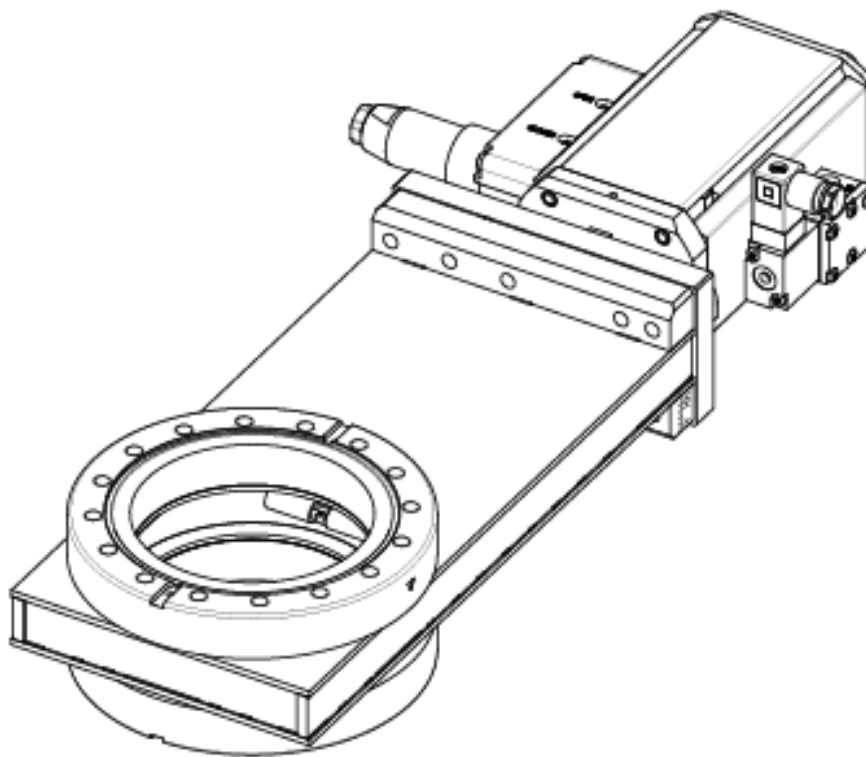
## HV gate valve with pneumatic actuator

**Series 111**  
**DN 250-320 mm (I. D. 10" - 12")**

This manual is valid for the following product ordering number/s:

**11148 -.E14/24/34/44 - . . . .**

**11150 -.E14/24/34/44 - . . . .**



Sample picture

## Imprint

Manufacturer VAT Vakuumventile AG, CH-9469 Haag, Switzerland

Website: [www.vatvalve.com](http://www.vatvalve.com)

Phone: +41 81 771 61 61

Fax: +41 81 771 48 30

Email: [CH@vatvalve.com](mailto:CH@vatvalve.com)

Publisher VAT Vakuumventile AG, CH-9469 Haag, Switzerland

Editor VAT Vakuumventile AG, CH-9469 Haag, Switzerland

Print VAT Vakuumventile AG, CH-9469 Haag, Switzerland

Copyright © VAT Vakuumventile AG 2021

No part of these instructions may be reproduced in any way (photocopies, microfilms or any other reproduction processes) nor may it be manipulated with electronic systems, duplicated or distributed without written permission from VAT. Offenders are liable to pay damages.

The original VAT firmware and updated state of the art versions of the VAT firmware are intended for use with VAT products. The VAT firmware contains a limited, time unlimited user license. The VAT firmware may not be used for purposes other than those intended nor is it permitted to make copies of the VAT firmware. In particular, it is strictly forbidden to give copies of the VAT firmware to other people.

The use of trade names, brand names, trademarks, etc. in these Instructions does not entitle third parties to consider these names to be unprotected and to use them freely. This is in accordance with the meaning of the laws and acts covering brand names and trademarks.

## Contents

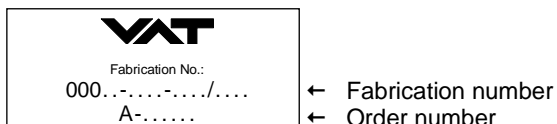
<b>1</b>	<b>Description of product.....</b>	<b>5</b>
1.1	Identification of product .....	5
1.2	Use of product .....	5
1.3	Related documents.....	5
1.4	Important information.....	5
1.5	Technical data .....	5
<b>2</b>	<b>Safety .....</b>	<b>6</b>
2.1	Compulsory reading material.....	6
2.2	Danger levels .....	6
2.3	Personnel qualifications.....	7
2.4	Safety labels.....	7
<b>3</b>	<b>Design and Function.....</b>	<b>8</b>
3.1	Design .....	8
3.2	Function.....	8
<b>4</b>	<b>Installation .....</b>	<b>9</b>
4.1	Unpacking .....	9
4.2	Installation into the system .....	10
4.2.1	Admissible forces and bending moments .....	12
4.3	Compressed air connection.....	13
4.4	Electrical connection.....	13
<b>5</b>	<b>Operation .....</b>	<b>14</b>
5.1	Normal operation.....	14
5.2	Operation under increased temperature.....	14
5.3	Behavior in case of air pressure drop.....	14
5.4	Behavior in case of power failure .....	15
5.4.1	Manual emergency operation .....	15
<b>6</b>	<b>Trouble shooting.....</b>	<b>16</b>
<b>7</b>	<b>Maintenance .....</b>	<b>17</b>
7.1	Maintenance intervals.....	17
7.2	Required tools .....	17
7.3	Replacement of valve gate / mechanism unit .....	18
7.4	Replacement of gate seal.....	21
<b>8</b>	<b>Repairs.....</b>	<b>22</b>
<b>9</b>	<b>Dismounting and Storage.....</b>	<b>23</b>
9.1	Dismounting .....	24
9.2	Storage.....	24
<b>10</b>	<b>Packaging and Transport .....</b>	<b>25</b>
10.1	Packaging.....	26
10.2	Transport.....	26
<b>11</b>	<b>Disposal .....</b>	<b>27</b>
<b>12</b>	<b>Spare parts .....</b>	<b>28</b>

**13 Appendix ..... 29**

# 1 Description of product

## 1.1 Identification of product

The fabrication number and order number are fixed on the product directly or by means of an identification plate.



## 1.2 Use of product

Use product for clean and dry vacuum applications only. Other applications are only allowed with the written permission of VAT.

## 1.3 Related documents

- Product data sheet
- Dimensional drawing

## 1.4 Important information



This symbol points to a very important statement that requires particular attention.

Example:



VAT disclaims any liability for damages resulting from inappropriate packaging.

## 1.5 Technical data


See product data sheet and dimensional drawing.

- DN 250 approx. 48 kg
- DN 320 approx. 92 kg

## 2 Safety

### 2.1 Compulsory reading material

Read this chapter prior to performing any work with or on the product. It contains important information that is significant for your own personal safety. This chapter must have been read and understood by all persons who perform any kind of work with or on the product during any stage of its serviceable life.


	NOTICE
	<p><b>Lack of knowledge</b> Failing to read this manual may result in property damage. Firstly, read manual.</p>





These Installation, Operating & Maintenance Instructions are an integral part of a comprehensive documentation belonging to a complete technical system. They must be stored together with the other documentation and accessible for anybody who is authorized to work with the system at any time.

### 2.2 Danger levels

	⚠ DANGER
	<p><b>High risk</b> Indicates a hazardous situation which, if not avoided, will result in death or serious injury.</p>

	⚠ WARNING
	<p><b>Medium risk</b> Indicates a hazardous situation which, if not avoided, could result in death or serious injury.</p>

	⚠ CAUTION
	<p><b>Low risk</b> Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.</p>

	NOTICE
	<p><b>Command</b> Indicates a hazardous situation which, if not avoided, may result in property damage.</p>

### 2.3 Personnel qualifications

	<b>WARNING</b>
	<p><b>Unqualified personnel</b>                  Inappropriate handling may cause serious injury or property damage.                  Only qualified personnel are allowed to carry out the described work.</p>

### 2.4 Safety labels

Label	Part No.	Location on valve
	T-9001-156	Protective cover

Table 2-1

### 3 Design and Function

#### 3.1 Design

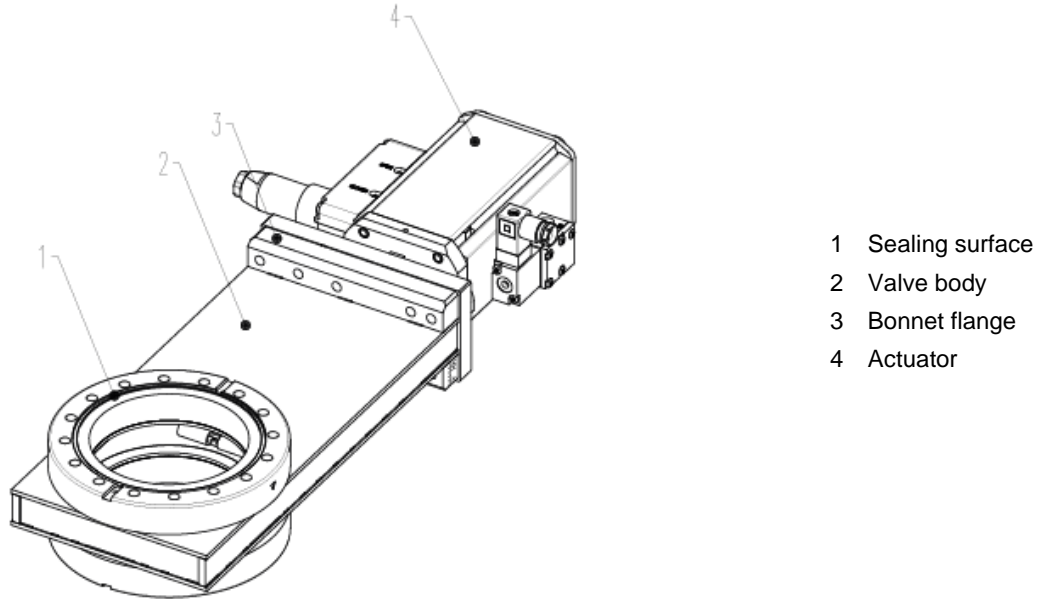


Figure 3-1

#### 3.2 Function

The valve features the VATLOCK sealing technology. This means, the valve is mechanically locked in the closed position. In the open position, the mechanism is not locked. Leaf springs hold gate and counter-plate against the carriage with the ball retainers. The ball pairs are in the detents. For closing, the mechanism is moved forward into the closing position. The locking starts after the leaf spring stop touches the body. The ball retainers move the ball pairs out of the detents. Gate and counter-plate are spread apart. The gate seal is pressed against the sealing surface without scuffing. The arrangement of the ball pairs ensures an increase of the sealing force with vacuum on either side of the gate. During opening the movements proceed in the reverse order. See «Figure 3-2».

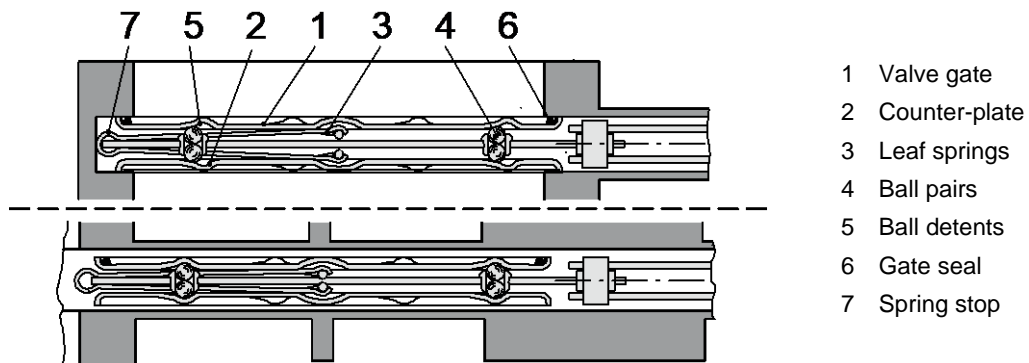




Figure 3-2



## 4 Installation

	<b>! WARNING</b>
	<p><b>Unqualified personnel</b> Inappropriate handling may cause serious injury or property damage. Only qualified personnel are allowed to carry out the described work.</p>

	<b>! WARNING</b>
	<p><b>Heavy weight</b> Physical overstraining. Use a crane to lift the product.</p>

### 4.1 Unpacking



- Make sure that the supplied products are in accordance with your order.
- Inspect the quality of the supplied products visually. If it does not meet your requirements, please contact VAT immediately.
- Store the original packaging material. It may be useful if products must be returned to VAT.

1. Screw eyebolts into two of the threads (1) and fasten lifting ropes to the eyebolts; see «Figure 4-1».



Threads for eyebolts: **M8, depth 14 mm**  
Weight to carry: See Product data sheet

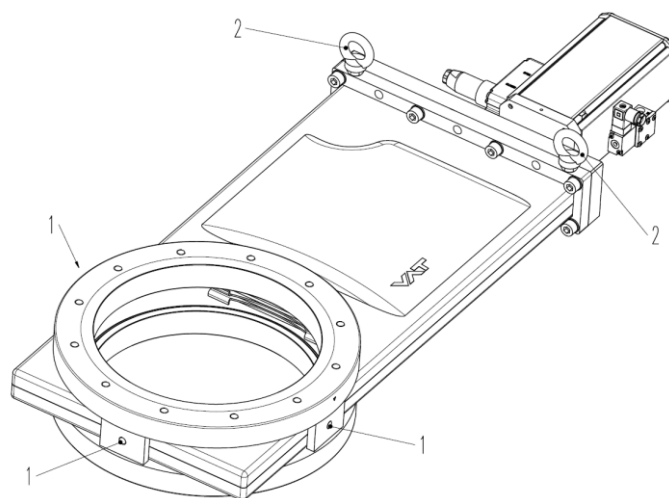


Figure 4-1

- 1 Threads for eyebolts
- 2 Eyebolts

	NOTICE
	<p><b>Sensitive product</b>                  Product will get damaged if not handled carefully.                  Handle product with care: Do not touch solid objects when lifting the product.</p>

1. Lift valve carefully and put it down on a clean surface or mount it to a clean system.

## 4.2 Installation into the system

	⚠ WARNING
	<p><b>Movable parts</b>                  Human body parts may get jammed and severely injured.                  Do not connect or supply electrical power and compressed air before the product is completely mounted in the system.</p>

	NOTICE
	<p><b>Contamination</b>                  Product may get contaminated.                  Always wear cleanroom gloves when handling the product.</p>

	NOTICE
	<p><b>Inappropriate tools</b>                  Sealing surfaces may get damaged.                  Do not use sharp-edged tools.</p>

	NOTICE
	<p><b>Wrong tightening torque</b>                  Valve body and screws may get damaged.                  Use tightening torque according the size of the screws.</p>

	NOTICE
	<p><b>Too long screws</b>                  Valve body may get deformed and / or malfunctions may occur.                  Make sure the length of the flange screws is suitable.</p>

1. Identify flange type according the fabrication number on the identification plate; see chapter «1.1 Identification of product».

Example: 110..-P.../... = Flange type ISO-F

Valve		Maximum screw-in depth «X» in mm	Flange types				
Nom. I.D. mm	inch		C	U	P	J	T
250	10	X =	13	13	15	15	19
320	12	X =	13	13	18	18	19
			C = CF-F, metric thread U = CF-F, UNF thread		P = ISO-F J = JIS		T = ASA-LP

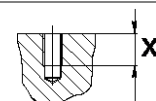


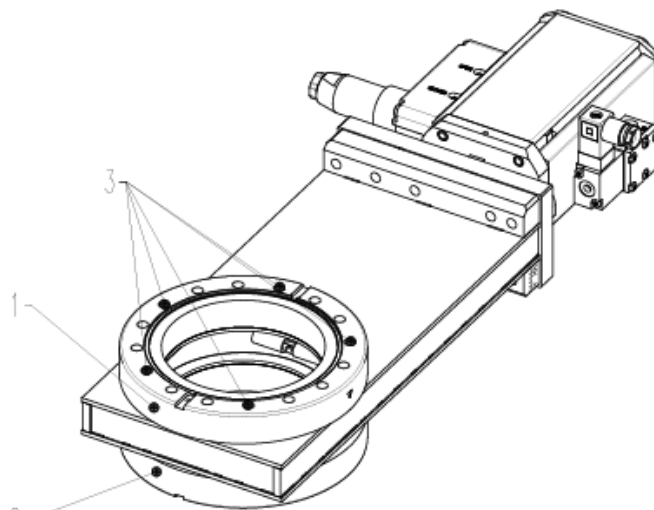
Table 4-1

2. Remove protective covers from body flanges.
3. Clean sealing surfaces and seals of both flanges; see (1) and (2) according to «Figure 4-2» on page 11 .



The valve seat side is marked with the symbol «∇» on flange «A».

4. Put valve to the mounting position.
5. Mount the four screws (3) according to «Figure 4-2» on page 11 evenly in crosswise order until the seal touches the sealing surface.
6. Tighten all screws with the torques appropriate for their property classes.



- 1 Flange A
- 2 Flange B
- 3 Screws

Figure 4-2

**4.2.1 Admissible forces and bending moments**



Forces from evacuating the system, from the weight of other components or from baking can lead to deformation of the valve body and to malfunction of the valve. The stress has to be relieved by suitable means, e.g. bellows sections.


The following forces or moments are admissible:

DN (nom. I.D.)		Axial tensile or compressive force «FA»		Bending moment «M»	
mm	inch	N	lbf	Nm	lbf · ft
250	10	3430	770	196	140
320	12	4000	900	300	220
If a combination of both forces («FA» and «M») occurs, the values mentioned above are invalid. Please contact VAT for more information.					

The diagram shows a vertical cross-section of a valve stem. A solid arrow labeled 'FA' points to the left, representing axial force. A dashed curved arrow labeled 'M' indicates a bending moment applied to the stem.

Table 4-2

### 4.3 Compressed air connection

	<b>⚠ WARNING</b>
	<p><b>Valve in open position</b> Risk of injury when compressed air is connected to the valve. Connect compressed air only when:</p> <ul style="list-style-type: none"><li>– valve is installed in the vacuum system</li><li>– moving parts cannot be touched</li></ul>




Use clean, dry or slightly oiled air only.



Admissible air pressure range, see product data sheet.


1. Druckluft gemäss Produktdatenblatt und Massbild anschliessen.


### 4.4 Electrical connection

	<b>NOTICE</b>
	<p><b>Wrong voltage</b> Electrical components may get damaged. Supply electrical components with the correct voltage.</p>

1. Connect solenoid valve according to the product data sheet and dimensional drawing.
2. Connect position indicator according to the product data sheet and dimensional drawing.

## 5 Operation

	<b>⚠ WARNING</b>
	<b>Unqualified personnel</b> Inappropriate handling may cause serious injury or property damage. Only qualified personnel are allowed to carry out the described work.

	<b>⚠ WARNING</b>
	<b>Movable parts</b> Human body parts may get jammed and severely injured. Do not operate before product is installed completely into the vacuum system.

### 5.1 Normal operation

Valve is opened and closed pneumatically.

### 5.2 Operation under increased temperature

Maximum allowed temperature, see product data sheet.



After bake-out check and re-torque the bonnet screws.

### 5.3 Behavior in case of air pressure drop

Valve closed: Valve remains closed.

Valve open: Valve position is undefined – depending on mounting position.

Valve in motion: Valve position is undefined – depending on mounting position.

## 5.4 Behavior in case of power failure

Standard solenoid valve:	Valve closes.
Solenoid valve for impulse actuation:	Valve position remains unchanged, but a started movement will be terminated.

### 5.4.1 Manual emergency operation

⚠ **WARNING**

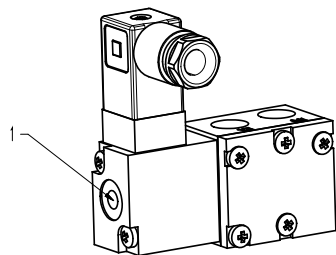
**Movable parts**

Human body parts may get jammed and severely injured.  
Keep human body parts away from movable parts.

Only valid for the ordering number 108...34/44 (with solenoid valve)

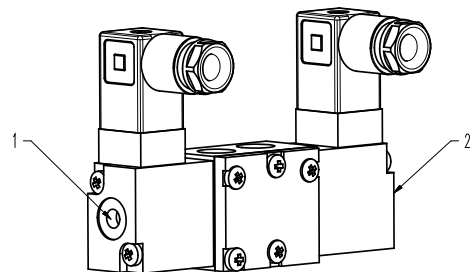
In case of a power failure, the valve can be actuated manually if compressed air is available.

Standard solenoid valve



Press push-button (1): valve opens  
Release push-button (1): valve closes  
Figure 5-1

Solenoid valve for impulse actuation (option)



Press push-button (1): valve opens  
Press push-button (2): valve closes

## 6 Trouble shooting

Failure	Check	Action	See
Valve does not close / open	Air pressure	Connect compressed air	«4.3 Compressed air connection»
	Operating pressure	Adjust operating pressure	Product data sheet
	Voltage at solenoid valve	Connect voltage	«4.4 Electrical connection»
Leak at gate	Gate seal all right?	Replace Gate seal	«7.3 Replacement of valve gate / mechanism unit
	Gate damaged or contaminated?	Replace valve gate	«7.3 Replacement of valve gate / mechanism unit
	Operating pressure	Adjust operating pressure	Product data sheet
Leak at body	Bonnet seal and sealing surface all right?	Clean sealing surface – if necessary, replace bonnet seal	«7.3 Replacement of valve gate / mechanism unit steps 1 to 6
	Bellows all right?	Contact VAT	<a href="http://www.vatvalve.com">www.vatvalve.com</a>

Table 6-1

If you need any further information, please contact one of our service centers. You will find the addresses on our website [www.vatvalve.com](http://www.vatvalve.com).



## 7 Maintenance

	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Unqualified personnel</b> Inappropriate handling may cause serious injury or property damage. Only qualified personnel are allowed to carry out the described work.</p>
	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Heavy weight</b> Physical overstraining. Use a crane to lift the valve.</p>
	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Hazardous components</b> Human body parts may get jammed and severely injured. Before starting maintenance: – disconnect compressed air supply – disconnect electrical power supply</p>
	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Movable parts</b> Human body parts may get jammed and severely injured. Keep human body parts away from movable parts.</p>

### 7.1 Maintenance intervals

Under clean operating conditions the valve does not require any maintenance during 200'000 cycles. After 200'000 cycles, VAT recommends replacing the mechanism unit; see chapter «7.3 Replacement of valve gate / mechanism unit».

For more information or a general overhaul please contact one of our service centers. You will find the addresses on our website [www.vatvalve.com](http://www.vatvalve.com).

### 7.2 Required tools

- Torque wrench 40 Nm
- Cleanroom wiper soaked with alcohol (2% methyl ethyl ketone)
- O-Ring removal tool; see «Table 12-1» on page 28.

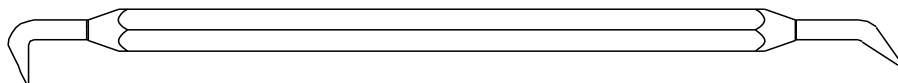





Figure 7-1

### 7.3 Replacement of valve gate / mechanism unit

	<p style="text-align: center;"><b>WARNING</b></p> <p><b>Loaded spring steel sheet</b> Human body parts may get jammed and severely injured. Do not put human body parts between valve gate and spring steel sheet.</p>
	<p style="text-align: center;"><b>NOTICE</b></p> <p><b>Contamination</b> Product may get contaminated. Always wear cleanroom gloves when handling the product.</p>
	<p style="text-align: center;"><b>NOTICE</b></p> <p><b>Inappropriate tools</b> Sealing surfaces may get damaged. Do not use sharp-edged tools.</p>

3. Vent chambers on either side to atmospheric pressure.
4. Open the valve.
5. Disconnect compressed air supply.
6. Disconnect electrical power supply.
7. Remove screws (1) according to «Figure 7-2» on page 19.
8. Lift actuator / mechanism unit carefully from body without touching the body wall; see «Figure 7-2» on page 19. Use only the eyebolt threats; see dimensional drawing.
9. Remove locking ring (5) according to «Figure 7-3» on page 19.
10. Withdraw bolt (4) by pulling it downwards according to «Figure 7-3» on page 19.
11. Put mechanism to the horizontal position.
12. Insert new mechanism in reverse order.
13. Mount bolt (4) according to «Figure 7-3» on page 19.
14. Mount locking ring (5) according to «Figure 7-3» on page 19.
15. Clean sealing surface of bonnet flange and valve seat, use cleanroom wiper.
16. Replace bonnet seal.

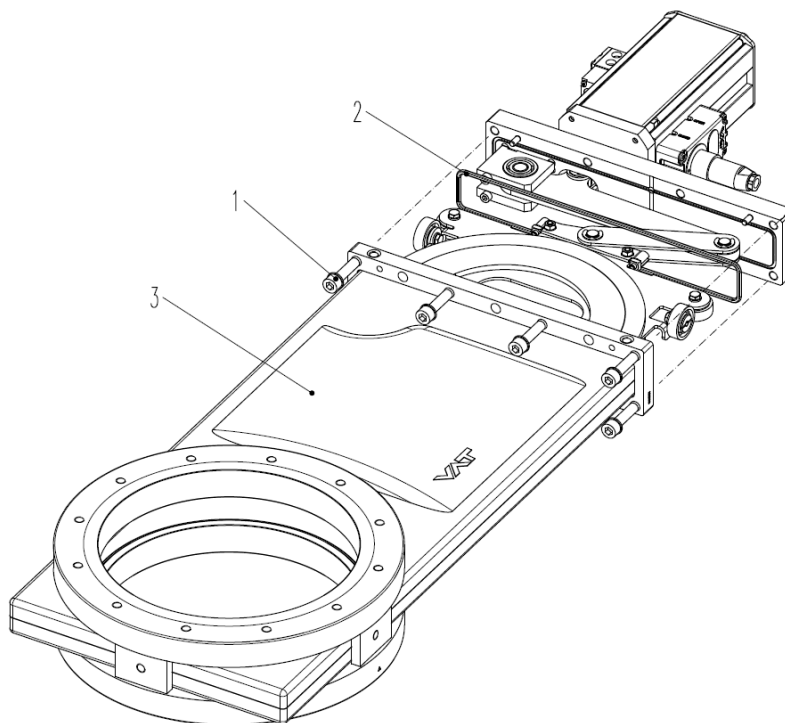


Figure 7-2

- 1 Screw
- 2 Bonnet seal
- 3 Valve body

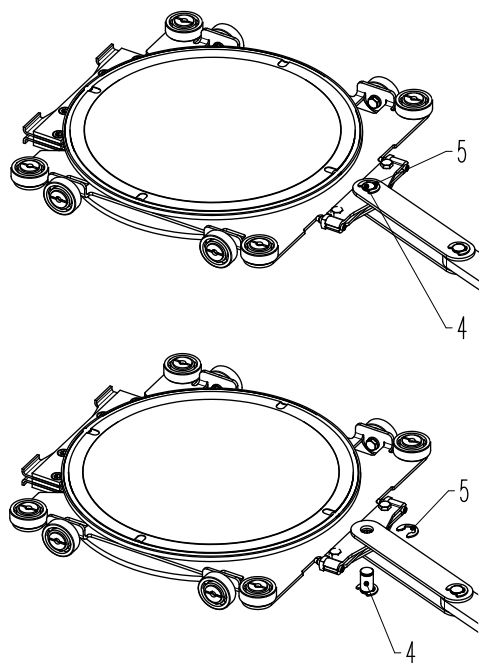


Figure 7-3

- 4 Bolt
- 5 Locking ring

17. Lift actuator / mechanism unit into body without touching the body wall.
18. Mount screws (1) according to «Figure 7-2» on page 19.



Tighten screws in crosswise order with the following torques:  
 DN 250 / 320                      40 Nm / 30 lbf·ft

19. Connect electrical power supply.
20. Connect compressed air supply.

Valve is ready for use.

## 7.4 Replacement of gate seal

21. Remove actuator / mechanism unit as described in «**Error! Reference source not found. Error! Reference source not found.**».
22. Remove gate seal (1) from groove; see «Figure 7-5», use O-ring removal tool.

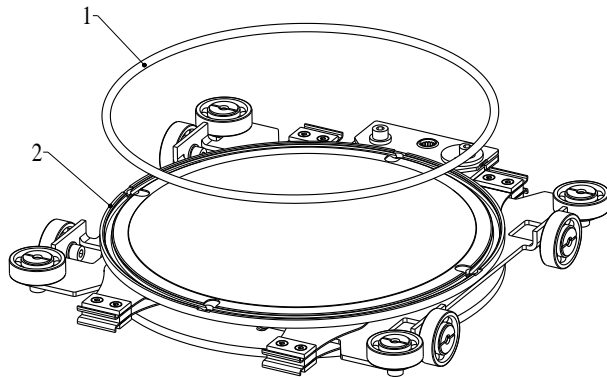


Figure 7-4

- 1 Gate seal
- 2 Valve gate

23. Check and clean sealing surface of valve seat.
24. Install new gate seal (1).



Press O-ring uniformly in crosswise order (diagonal) into groove.

25. Lift actuator / mechanism unit as described in section «**Error! Reference source not found. Error! Reference source not found.**».

Valve is ready for use

## 7.5 Replacement of gate seal

1. Remove actuator / mechanism unit as described in «7.3 Replacement of valve gate / mechanism unit ».
2. Remove gate seal (1) from groove; see «Figure 7-5», use O-ring removal tool.

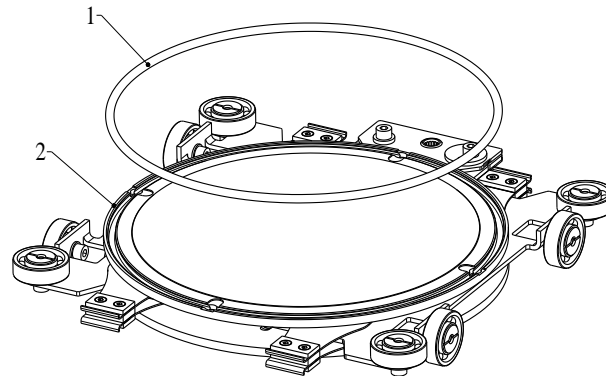


Figure 7-5

- 1 Gate seal
- 2 Valve gate

3. Check and clean sealing surface of valve seat.
4. Install new gate seal (1).



Press O-ring uniformly in crosswise order (diagonal) into groove.

5. Lift actuator / mechanism unit as described in section «7.3 Replacement of valve gate / mechanism unit».

Valve is ready for use.

## 8 Repairs


Repairs may only be carried out by the VAT service staff. In exceptional cases, the customer is allowed to carry out the repairs, but only with the prior consent of VAT.

Please contact one of our service centers. You will find the addresses on our website [www.vatvalve.com](http://www.vatvalve.com).

## 9 Dismounting and Storage


	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Unqualified personnel</b> Inappropriate handling may cause serious injury or property damage. Only qualified personnel are allowed to carry out the described work.</p>
	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Heavy weight</b> Physical overstraining. Use a crane to lift the product.</p>
	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Hazardous components</b> Human body parts may get jammed and severely injured. Before dismantling the product</p> <ul style="list-style-type: none"><li>– disconnect compressed air supply</li><li>– disconnect electrical power supply</li></ul>
	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Movable parts</b> Human body parts may get jammed and severely injured. Keep human body parts away from movable parts.</p>
	<p style="text-align: center;"><b>NOTICE</b></p> <p><b>Contamination</b> Product may get contaminated. Always wear cleanroom gloves when handling the product.</p>


## 9.1 Dismounting

	<b>NOTICE</b>
	<p><b>Valve in open position</b> Valve mechanism may get damaged if valve is in open position. Close valve before dismantling the valve from the system.</p>

1. Close valve.
2. Carry out the steps according to chapter «4 Installation» in reverse order.  
Pay attention to the safety instructions!

## 9.2 Storage





	<b>NOTICE</b>
	<p><b>Wrong storage</b> Inappropriate temperatures and humidity may cause damage to the product. Valve must be stored at: – relative humidity between 10% and 70% – temperature between +10 °C and +50 °C – non-condensing environment</p>

	<b>NOTICE</b>
	<p><b>Inappropriate packaging</b> Product may get damaged if inappropriate packaging material is used. Always use the original packaging material and handle product with care.</p>

1. Clean / decontaminate valve.
2. Cover all valve openings with a protective foil.
3. Pack valve appropriately by using the original packaging material.




## 10 Packaging and Transport

	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Unqualified personnel</b> Inappropriate handling may cause serious injury or property damage. Only qualified personnel are allowed to carry out the described work.</p>
	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Heavy weight</b> Physical overstraining. Use a crane to lift the product.</p>
	<p style="text-align: center;"><b>⚠ WARNING</b></p> <p><b>Harmful substances</b> Risk of injury in case of contact with harmful substances. Remove harmful substances (e. g. toxic, caustic or microbiological ones) from valve before you return the valve to VAT.</p>
	<p style="text-align: center;"><b>NOTICE</b></p> <p><b>Inappropriate packaging</b> Product may get damaged if inappropriate packaging material is used. Always use the original packaging material and handle product with care.</p>



- When returning products to VAT, please fill out the VAT form «Declaration of Chemical Contamination» and send it to VAT in advance. The form can be downloaded from our website [www.vatvalve.com](http://www.vatvalve.com).
- If products are radioactively contaminated, the VAT form «Contamination and Radiation Report» must be filled out. Please contact VAT in advance.
- If products are sent to VAT in contaminated condition, VAT will carry out the decontamination procedure at the customer's expense.

## 10.1 Packaging


	<b>NOTICE</b>
	<p><b>Valve in open position</b> Valve mechanism may get damaged if valve is in open position. Make sure that the valve is closed.</p>

1. Cover all valve openings with a protective foil.
2. Pack valve appropriately, by using the original packaging material.



VAT disclaims any liability for damages resulting from inappropriate packaging.

## 10.2 Transport


	<b>NOTICE</b>
	<p><b>Inappropriate packaging</b> Product may get damaged if inappropriate packaging material is used. Always use the original packaging material and handle product with care.</p>





VAT disclaims any liability for damages resulting from inappropriate packaging.


# 11 Disposal

Observe the local regulations for disposal

	<b>⚠ WARNING</b>
	<p><b>Harmful substances</b> Environmental pollution. Discard products and parts according to the local regulations.</p>

	<b>⚠ WARNING</b>
	<p><b>Unqualified personnel</b> Inappropriate handling may cause serious injury or property damage. Only qualified personnel are allowed to carry out the disposal.</p>

	<b>⚠ CAUTION</b>
	<p><b>Risk of damage</b> Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury. A large number of diverse materials are used in the product. Some of them could cause human and machine damage in the case of improper handling.</p> <ul style="list-style-type: none"> <li>• Observe local regulations in regard to waste disposal without fail.</li> <li>• Commission an authorized waste disposal company for the professional disposal of your waste.</li> </ul>

	<b>NOTICE</b>
	<p><b>Improper disposal</b> Some built-in materials can cause damage, if improperly handled. - When disposing, take into account all the different materials used</p>



- Hire an authorised waste disposal company to dispose of the waste in a professional manner.

The following list should help you to dismantle your product without making serious errors and to properly separate out the product scrap.

Material groups	Hazard level
non-ferrous metals	high
stainless steel	low
aluminium	low
plastics	medium
lubricants	high
electronic scrap	high
batteries	very high
cables and wires	medium
motors	medium
seals and rubber parts	high

## 12 Spare parts

	NOTICE
	<p><b>Non-original spare parts</b></p> <p>Non-original spare parts may cause damage to the product. Use original spare parts from VAT only.</p>



- Please specify the fabrication number of the product when you place an order for spare parts; see chapter «1.1 Identification of product». This is to ensure that the appropriate spare parts are supplied.
- VAT makes a difference between spare parts that may be replaced by the customer and those that need to be replaced by the VAT service staff.
- «Table 12-1» only contains spare parts that may be replaced by the customer. If you need any other spare parts, please contact one of our service centers. You will find the addresses on our website [www.vatvalve.com](http://www.vatvalve.com).

Description	Part No.	Quantity per valve	Maintenance procedure see chapter
Bonnet seal (Item 2 as per «Figure 7-2», page 19)	On request	1	«7.3 Replacement of valve gate / mechanism unit
Gate seal (Item 1 as per «Figure 7-5», page 21)	On request	1	«7.3 Replacement of valve gate / mechanism unit
Mechanism completely	On request	1	«7.3 Replacement of valve gate / mechanism unit
O-ring removal tool	234859	1	«7.5 Replacement of gate seal»

Table 12-1



---

## 13 Appendix

