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Vacuum valve

Application Technology

1. Definition

The ordinary dictionary definition of a valve is a device that can open and close the passage of fluid or air in order to control the amount or flow thereof installable through a pipe or other equipment.

The functions of a valve can be explained in engineering terms as a device used to control the flow of fluid or air. Here, control means to adjust physically expressed pressure, flow rate, or flux. The valve is to open or close the fluid transport pipe or to help adjust the amount of fluid energy (throttling) or the passage of fluid or air. It is an important control component operated for the physical condition and amount of the fluid required by each process system.

The main industrial features of the vacuum valve are maintaining and releasing vacuum during processing, maintaining and controlling the set vacuum pressure, separating the processing zone and managing the on-off function.

The first principle in distinguishing and selecting a vacuum valve is knowing what its key functions are. The second principle is checking the range applied based on the type of valve, selecting materials suitable for the use environment, and maintaining sealing for the vacuum level to be delivered.

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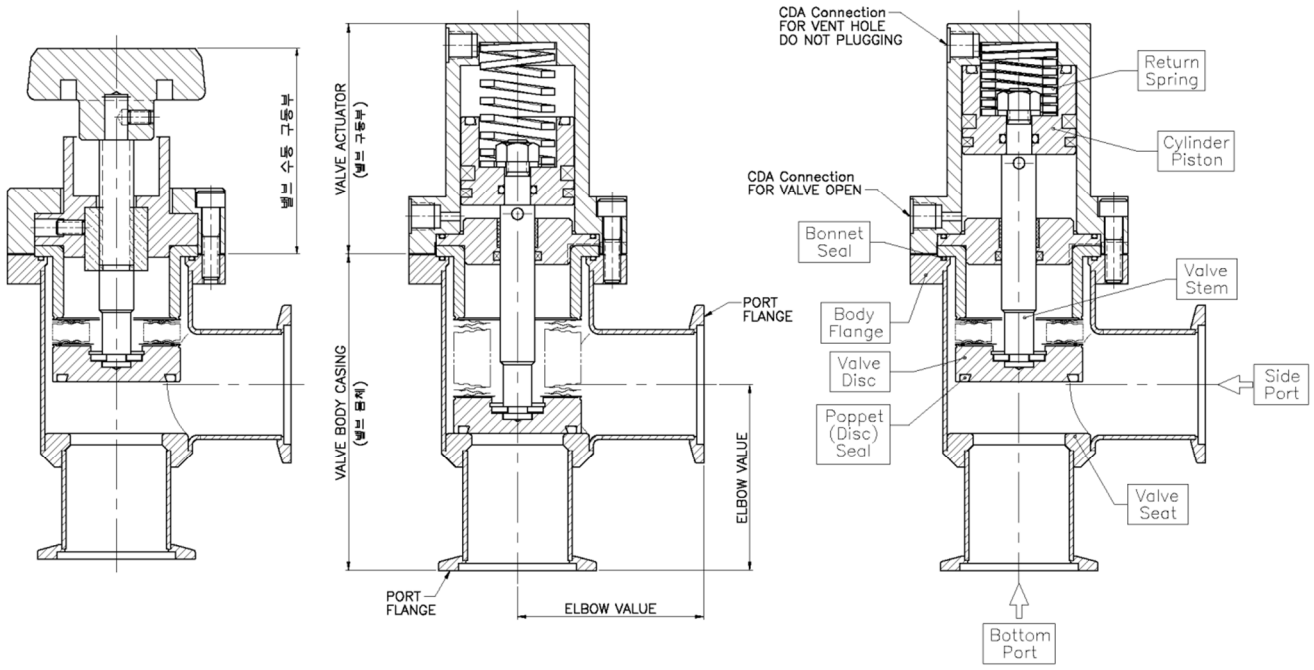

(Picture 1.) Inside structure of Vacuum angle valve

2. Structure

Key parts of the vacuum valve constitute the valve body, the valve seat, and disc. The opening and closing of the fluid/air passage by the valve is done by the rotation of the disc or its up-and-down motion.
Below, the structure of the simplest regular vacuum valve, the angle valve, describes the representative feature parts.

2-1. Typology

2-1-1. Valve Body Casing

→ The valve body constitutes the flange in regular intervals at the port that is connectable to the pipe. Connected to the seat, the opening and closing point, and the drive, the flange constitutes the casing body that can block external sealing.

2-1-2. Disc and stem
→ The O-ring is the part that looks like a disc. It serves as the gate in terms of opening and closing the valve. It is inserted in the gland that looks like a dovetail or the channel. The distance between the channel corners is smaller than the diameter of the elastic O-ring, which is inserted into the gland to avoid straying. Connected to the disc, the stem constitutes the axis inside the valve to deliver power to the actuator.

2-1-3. Actuator
→ The part that creates power to open/close the valve, the actuator can be selected to run manually or automatically. Manual operation means opening and closing the valve by using the lever and rotating the handle by the operator directly. Automatic operation means that the external kinetic energy is not delivered by the operator but the actuator applies power sources from dynamic pressure, electricity, or fluid pressure. Generally, operating the actuator is adopting the air cylinder which uses dynamic pressure. There are also parts that use single-acting, regular closed-type valves for safety in case of vacuum system emergencies.

2-1-4. Poppet seal (disc seal)
→ This refers to the packing used for vacuum opening and closing of the valve disc and the seat ring part of the valve casing.
Mostly elastic O-rings are used, inserted in the disc's O-ring groove.

2-1-5. Stem seal
→ In the form of packing to block vacuum leakage from the valve's drive, the stem seal uses O-rings or metal bellows. For sealing low vacuum areas, valves that adopt dynamic O-rings are used. Welded metal bellows or plastic bellows are used for the valve's stem seal used for high-vacuum areas.

2-1-6. Bonnet seal (packing)
→ The bonnet seal refers to the vacuum seal material in-between the flange connected to the valve's drive casing body, connected to the interior of the vacuum pipe.

2-1-7. Back pressure
Back pressure arises in an abnormal situation of a sealed vacuum valve when the internal pressure of the disc seal side is higher than that of the other side.

3. Typology

Based on exhaust of atmospheric pressure and of gas used during processing and for set pressure maintenance and other applicable conditions, different types of vacuum valves each have strengths and weaknesses. Designers of valves are to use the right type based on its characteristics by choosing the one suitable for the necessary condition.
Classifying valve types by method of open/closing, the chart below considers different valve types and characteristics. Generally, they are dividable by whether the valve type has an on/off isolation function or control function (throttling valves). Below shows different vacuum valves by size and shape for a variety of purposes.

□ Typology of Vacuum Valves

Vacuum valve type	On/Off isolation	Work transfer	Control	Positions Line Applications	Figure
Angle valve	Y	N	N	Roughing, gauge isolation, backing line, bypass line, venting	1
Inline valve	Y	N(Y)	N	Roughing line	2
Offset inline valve	Y	N	N	Backing line, bypass line	3
Circular gate valve	Y	Y/N	N	Main valve, isolation	4
Rectangular gate valve	Y	Y	N	Transfer, isolation	5
Throttle valve	Y/N	N	Y	Pressure control	6
Pendulum gate valve	Y	N(Y)	Y/N	Main valve, pressure control	7
Butterfly valve	Y/N	N	Y	Shut on, flow control	8
Diaphragm valve	Y	N	N	Gas line	9
Door gate valve	Y	Y	N	Transfer, isolation	10
All metal valve	Y	N	N	XHV, UHV, high temperature	

3-1. Angle Valve

Angle valves are shaped so that the flow direction of the fluid changes at a right angle. The centerline of the valve body's entrance and exit is at a right angle. It is recommended to use the angle valve as a substitute for the "elbow" in the pipe system. The angle valve is a valve type with high demand, typically for the vacuum roughing line.

3-2. Inline valve

The inline valve constitutes the casing body located on both sides of the valves' port center so as to install the inline valve inside a straight pipe.

3-3. Offset inline valve

The valve's drive is perpendicular to the pipe. The offset inline valve is designed so that the pipe can be installed in a straight line. The direction of the pipes is the same as the inline valve's, but the difference is that the offset inline valve is made of the casing body so that the pipe's center can be installed perpendicularly.

3-4. Circular gate valve

Located on both sides of the vacuum valve body in a straight direction, the flange has a circular disc inside at its center. The circular gate valve is a valve that opens and closes when this disc moves perpendicularly. The circular gate valve is essentially used in the form of a main valve between the processing chamber and the high-vacuum pump (such as oil diffusion pumps, turbo-molecular pumps, and cryo-pumps).

The circular gate valve is also a representative valve, with the strength of decreasing the path on the same axis for the fluid to flow. The circular gate valve is structured so that it can seal the vacuum due to the pressure from the disc seal, perpendicular to the straight line movement by the actuator, located where the gate disc is closed, by lifting up and down.

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3-5. Rectangular gate valve
The vacuum valve's port is rectangular in shape, not circular. Mainly installed in the processing and return chambers, the rectangular gate valve is used as a vacuum valve for the processing and withdrawal of products. Like the circular gate valves, the gate disc converts the actuator's direction of motion into L-motion or angle motion such that the structure seals by delivering contact surface pressure to the total circumference. It is also used as a product with decreased noise and vibration that has been patented overseas, with transformed seat structure and disc form.

3-6. Throttle valve
Throttle valves are for controlling the vacuum pressure, instead of opening and closing a valve (on/off). Shaped like a butterfly proportion valve, throttle valves' flapper at the valve body port center rotates 90 degrees, like the circular gate valves. The throttle valve is used to control pressure based on the setpoint signals in the vacuum pressure system. This is to adjust the vacuum pressure selected by the system aligned in front of the on/off vacuum valve.

3-7. Pendulum gate valve
The pendulum gate valve is a gate valve whose operating method has been changed from the circular gate valve. Regular circular valves open and close in a straight line due to the expanded displacement device of the link structure. Pendulum gate valves open and close as the drive axis of the valve rotates parallel from the center of the pipe in pendulum motion. Making more compact
In addition to the on/off function of the main valve, throttling offers as strengths lightweight installation and making more compact. One drawback is having to use more expensive vacuum valves exported from overseas manufacturers on their payment terms. This is because throttling control includes an additional control device to the communication controller that can connect the vacuum valve hardware with the vacuum control system.

3-8. Butterfly valve
Like the throttle valve, the on/off function of the butterfly valve is carried out by a circular disc rotating at 90 degrees. Butterfly valves have the strength of being able to rapidly open and close the valve by using elastic O-ring (packing) outside the circular disc. The valve completely opens when the manually operated lever is parallel to the pipe and completely closes when it is perpendicular. While opening/closing the valve is convenient, the simple structure is unsuitable spatially for complete vacuum sealing because the diameter of the circular disc places inside the pipe when the valve is fully open.

3-9. Diaphragm valve
The diaphragm valve opens and closes the air/fluid passage by up-and-down motion of the corrosion-resistant diaphragm. It requires neither packing nor gland. To the extent that the diaphragm remains undamaged, the fluid does not leak. For this reason, the diaphragm valve is suitable for transporting toxic, corrosive fluids.

3-10. Door gate valve
Door gate valves are used for opening and closing the gate, circular or rectangular, in the vacuum processing chamber. It is used only as internal vacuum at the atmospheric pressure in the processing chamber or the load lock chamber. Because there is no use by back pressure, the structure of the door gate valve is moderate without stem seal or bonnet seal.

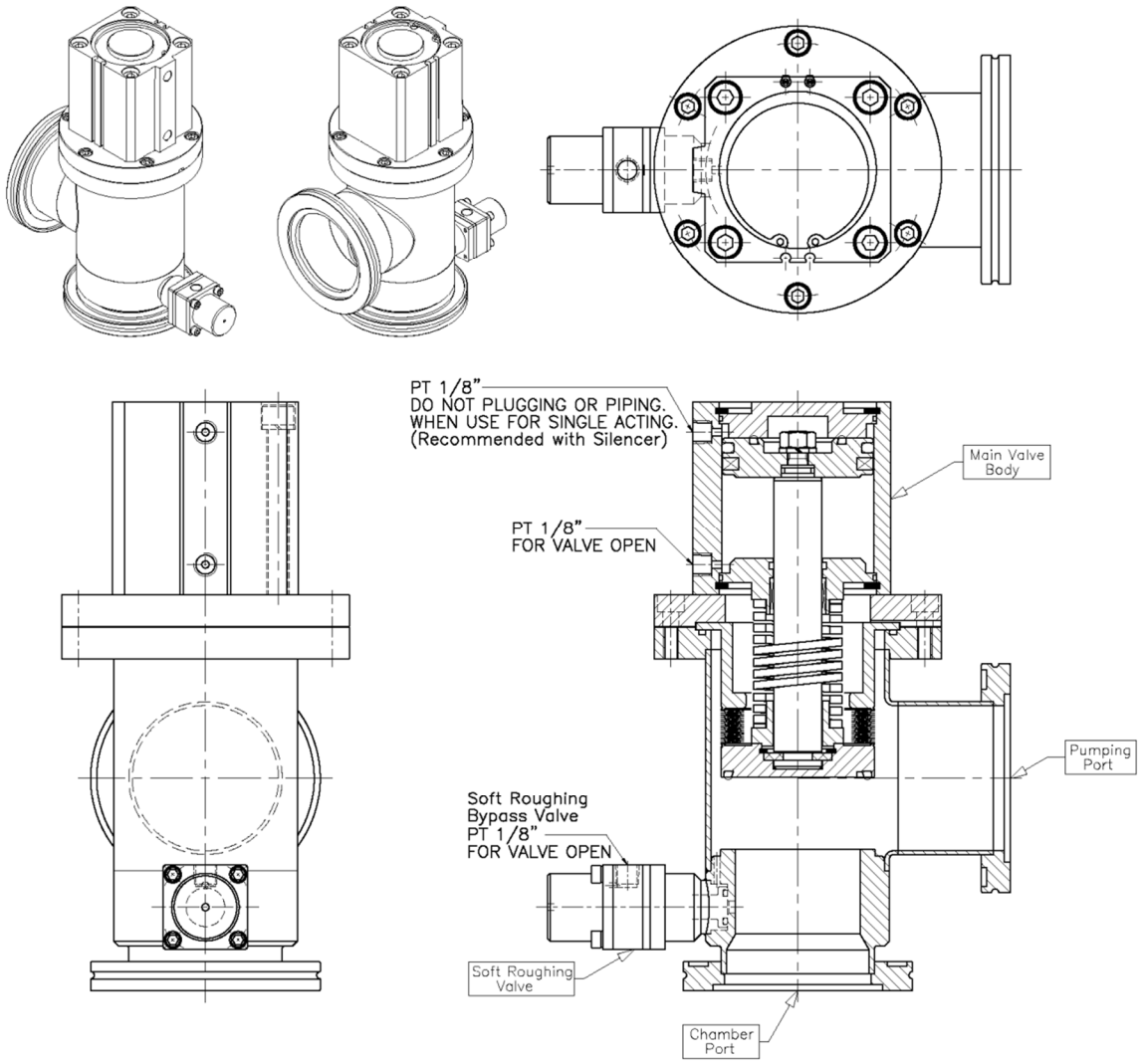
3-11. All metal valve
All metal valves are especially designed and manufactured for vacuum valves that require high-temperature bake-out processing used in ultra high vacuum environments, or for those that require constant heating during processing where elastic seals cannot be used. The packing material, used for the driving part of the vacuum valve at high-temperature heating, is made of heat-resistant alloy that retains its material properties in high-temperature environments.

4-1. Vacuum angle valve
Composed of the valve casing body substitutable for elbow-shaped pipes, the vacuum angle valve is variously applied as the bypass valve of the roughing line, the backing line valve of high-vacuum pumps, vacuum venting, and gauge sensor isolation. In addition, with added parts and improved structure, the vacuum angle valve contributes to increasing the MTBF (Mean Time Between Failures), which can be used effectively long-term not only for regular vacuum but also advanced processing.

Another example of the vacuum angle valve's features is expanding the valve's lifespan. This is possible by having added a heater and T.C. sensor to the valve disc for constant heating so as to prevent sedimentation from processed chemicals. Over all, the source of particle contamination from opening and closing the valve is eliminated.

There is more to the valve's features, the use quality of which has been proven by patents from valve manufacturers overseas. The angle valve itself has the feature of vacuum pressure throttling by the straight line actuator. Coupling manual operation of fully opening and closing the valve with controlling the controller's set pressure, the vacuum angle valve is used in advanced processing fab lines.

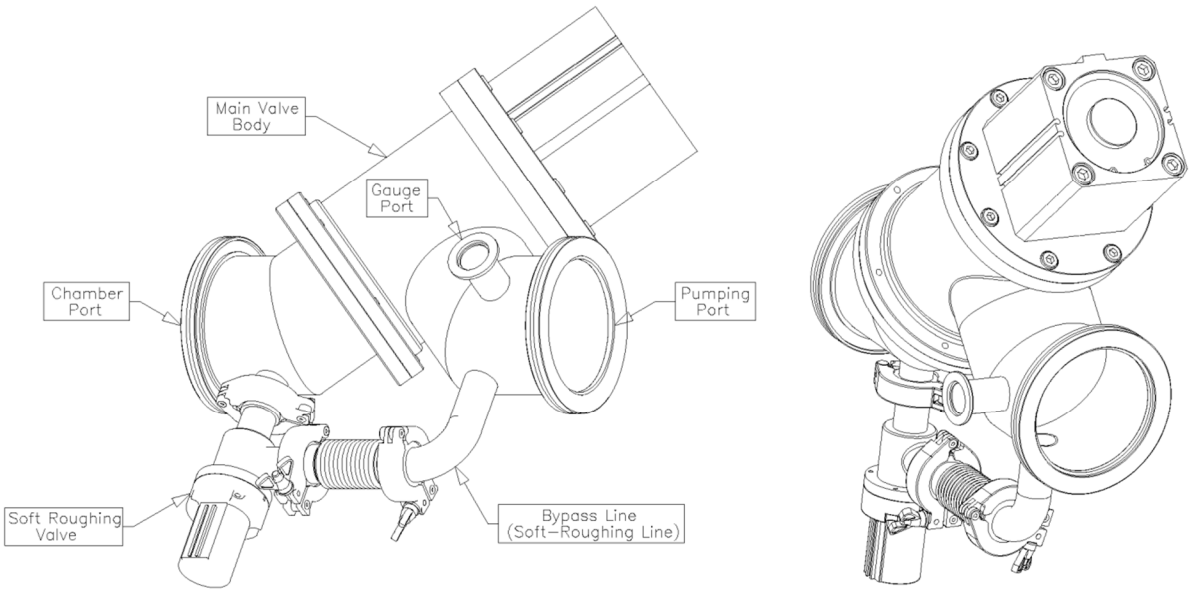
In addition, installation is simplified and cost-friendly. Adding another bypass valve to the vacuum angle valve as the main valve takes away the need for a separate soft roughing line pipe in order to constitute a vacuum pumping system. Demand for such applied valve products is increasing.



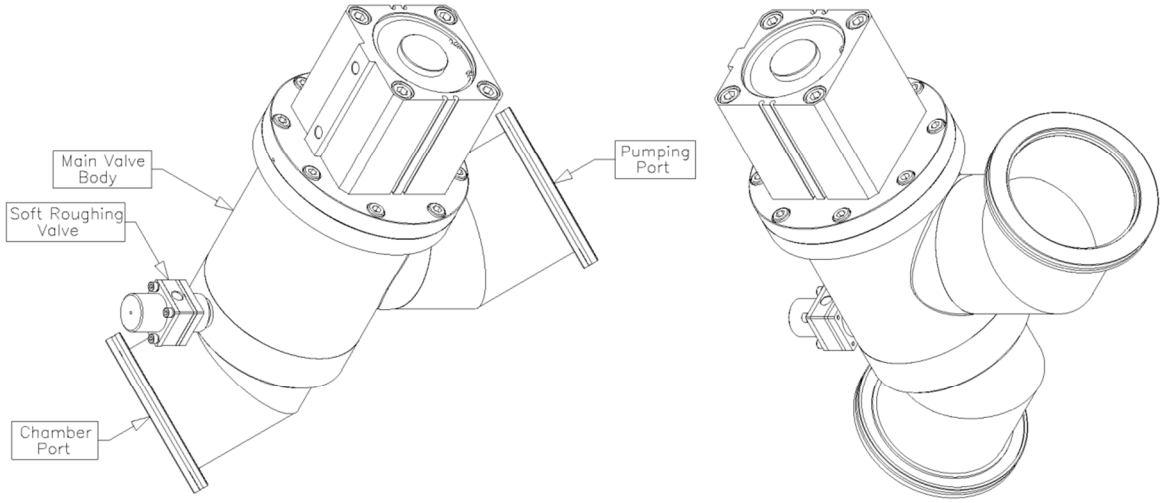
(Picture 2.) vacuum angle valve with bypass valve(soft start)

Above (figure 2) regards the vacuum control valve. It combines the soft bypass vacuum control valve, previously composed separately, and the fast line vacuum control valve into one.

The fast line rapidly discharges air in large quantities from inside the chamber when the difference between the chamber pressure and the vacuum pump pressure has decreased. To the fast line and soft bypass line is each installed with its own vacuum control valve that controls air input and output.



(Picture 3.) vacuum Inline valve with bypass valve (soft Roughing Line)



(Picture 4.) vacuum Inline valve with bypass Block valve (soft start)

4-2. Rectangualr Gate Valve

Generally, the semi-conductor manufacturing equipment includes multiple adjoining chambers besides independently sealable chambers. It is made of single wafer type process chambers and one or more load-lock chambers near the center robot transfer chambers. The transfer chamber and nearby chambers, the combination of which and the staging area are referred as the cluster tool

The long, narrow slits form walls between the chambers, through which the semi-conductor wafer travels. It physically enters and exits between two vacuum chambers through these slits, which can be opened or closed by the slit valve.

The vacuum valve called the slit valve in processing semi-conductor wafers is the rectangular gate valve. This slit valve additionally includes the door and in case this door is in the closed position compressible sealing material (O-ring, elastic). The compressible sealing material is responsible for sealing the processing chamber interior in order to prevent leakage from or within the chamber and to maintain non-atmospheric condition inside the chamber.

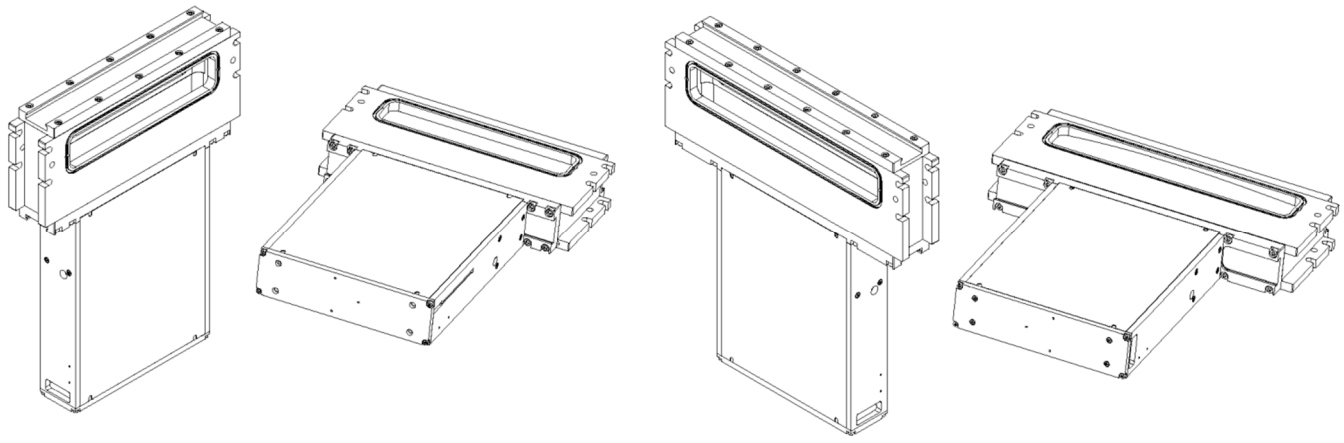
Slit valves must be sealed so that no gas leaks through the slit valve due to the pressure difference between the chambers.

In the process chamber for manufacturing equipment of semi-conductors or chemicals, breaking chemical compounds by plasma is used often, as gases with high chemical reactivity are supplied for layering, etching, and cleaning. When chemical compounds are broken down by plasma, radicals (nuclei with unpaired electrons) are produced. Reactivity to heat is so high that even if radicals collide multiple times against the vacuum chamber walls, they tend not to lose the heat energy. So, polymerization of packing or other sealing materials is broken down to heat up.

For this reason, process chamber's vacuum exhaust system must safely and efficiently exhaust these gases with high reactivity.

For the static sealed portion of the vacuum chamber among vacuum seal types, the O-ring is inside the groove of the seal (metal). In order for plasma or radical to arrive at the O-ring, it needs to progress the wall surface, in tens of nanometer intervals, by some millimeters. In the meantime, plasma or radical loses its energy, decreasing the heat of the sealing material.

However, the O-ring, which is the disc seal of the gate valve in the exhaust system, is located just near the exhaust gas passage. Because the O-ring is exposed to highly reactive radicals and energy-retaining plasma, its life span markedly decreases. For the gate valve that used plasma as the disc seal O-ring sealing material, FKM was used one generation ago. Today, it has become common sense to use Chemraz E-38, 513 and 520 materials and similarly elastic polymerized materials (perfluoroelastomer: FFKM) because plasma and radicals have been made high-energy. These materials share the quality of gate valves' disc seal O-ring, with improved plasma- and radical-resistance. When using perluoroelastomers, they need to be exchanged once every two to three months depending on the circumstances due to heating by plasma or radicals.



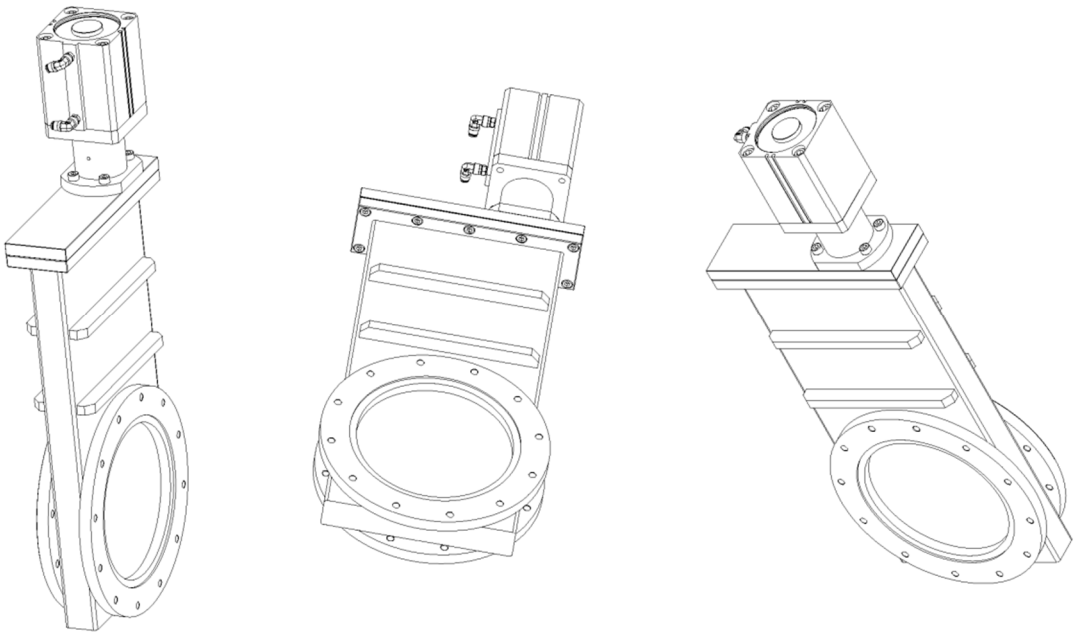
(Picture 5.) Rectangular Gate valves for Wafer Fab Process

4-3. Circular gate valve

The circular gate valve requires long operational lifespan from particle-sensitive processing and multiple applications at high vacuum between opened and closed positions repeatedly as well as minimal particle production. Semi-conductor wafers increasingly become sensitive to particle contaminants as the size of the semiconductor elements geometrically decrease and the density of the circuit increases. The vacuum interior components in the processing chamber, like the gate valves, are potential particle contaminants. Furthermore, if the gate valve fails to function, working the semi-conductor manufacturing line must pause completely or partially. This could adversely affect the throughput. Accordingly, the long operational lifespan and minimal particle production are important attributes of the gate valves.

Relatedly, other potential problems include shock and vibration, which can arise during opening or closing of the valve. The shock rapidly damages sensitive constituent parts and could release particles into the system. Additionally, there could be friction when the seal table of the O-ring, which is the disc seal, retreats from the valve seat. Such scuffing or rubbing wears out the O-ring (disc seal) and may cut short the operational life span of the gate valve. Moreover, shock and vibration may disrupt or confuse the operation of the equipment, near the sensitive gate valves. So far, the gate valve manufacturing technology has observed that charcoal-absorbed gas from inside the ultra low-temperature vacuum pump could leak from the shock and vibration that operating the gate valves generates. As such, it is proper to limit the shock and vibration caused by the gate valve.

To limit shock and vibration, we can expect alleviating the impact of vibration by decreasing the speed of opening and closing the gate valve. To decrease the processing time interval of mass production line equipments, designing structures that minimizes shock and noise during valve opening and closing as well as optimizing the quantity of functional constituent parts.



(Picture 6.) Circular Gate valves

4-3. General vacuum valve applications

Of importance when it comes to designing the vacuum process is optimizing the system processing time, and as a result, careful review of the selection and periodic maintenance of the constituent parts is necessary.

Additional considerations are selecting vacuum valves, essential in the vacuum pipe system, for their effective use, necessity of auxiliary devices suitable for pipe standards and safety of the vacuum system.

As the flow of fluid or air relates to its pressure and internal diameter of the passage, the flow areas are classified into viscous and molecular. Viscous flow area is required for efficient exhaust. For this, the internal diameter of the passage (D) should be greater than or equal to the mean free path of the gas molecules (L): $L \leq D$.

Also, the relationship between L and pressure (P) is defined as $L = 4.98 \times 10^{-3}/P$. This is used to find the relationship between the pressure for viscous flow area of the pipe interior and the internal diameter of the passage. By increasing the pressure (P) the mean free path is decreased, and as a result, the internal diameter (D) can be decreased in order to secure the viscous flow area.

For example, when the pressure of the chamber side (inlet port side) is 10^{-3} Torr, the pressure of the outlet port side is at a low pressure of approximately 10^{-2} Torr. In order to better secure the viscous flow area, it is necessary to have a pipe whose internal diameter is more than 2". Because such pipes with large internal diameters are needed when it comes to the vacuum pipe system, there have been problems of oversized equipment.

Both the volume inside the pipes and the vacuum exhaust time increase as well.

In order to exhaust efficiently, the vacuum pipe system requires vacuum pumps with high compression ratios and fast exhaust rates. As pumps with high compression rates developed, pressure conditions of the process chambers and vacuum pipe systems became optimized. As a result, the internal diameter of the pipes decreased, securing viscous flow areas.

However, when the pressure is high like this, moisture or gas condenses, sticking inside the pipes.
Even when condensed moisture or gas does not stick, gas within the pipe decomposes upon pausing the vacuum pump. The decomposed gas products deposit and corrode the material of the part or cause blockage of the valve or internal leaks between the valve seat side and the disc seal.

It is thus required to maintain the moisture or gas inside the pipe system below saturated vapor pressure. Generally, there is heating (baking) in the vacuum exhaust system. (For water, the saturated vapor pressure at 20 degrees Celsius is 1753 Torr.) When the temperature rises due to heat, the saturated vapor pressure also rises, making difficult the sticking of condensed gas and thus decreasing risks such as of corrosion.

Thus, it is proper to increase the temperature to approximately 150 degrees Celsius, considering the types of gas components inside the vacuum exhaust system. However, when the temperature inside the pipes increases, gas decomposes (dissociation), creating a new problem of corrosion by the decomposed gas products as they deposit and stick.

This phenomenon of gas dissociation is caused by the catalysis of the metal components on the pipe interior wall. Solutions include improving the pipe interior surface by coating it.

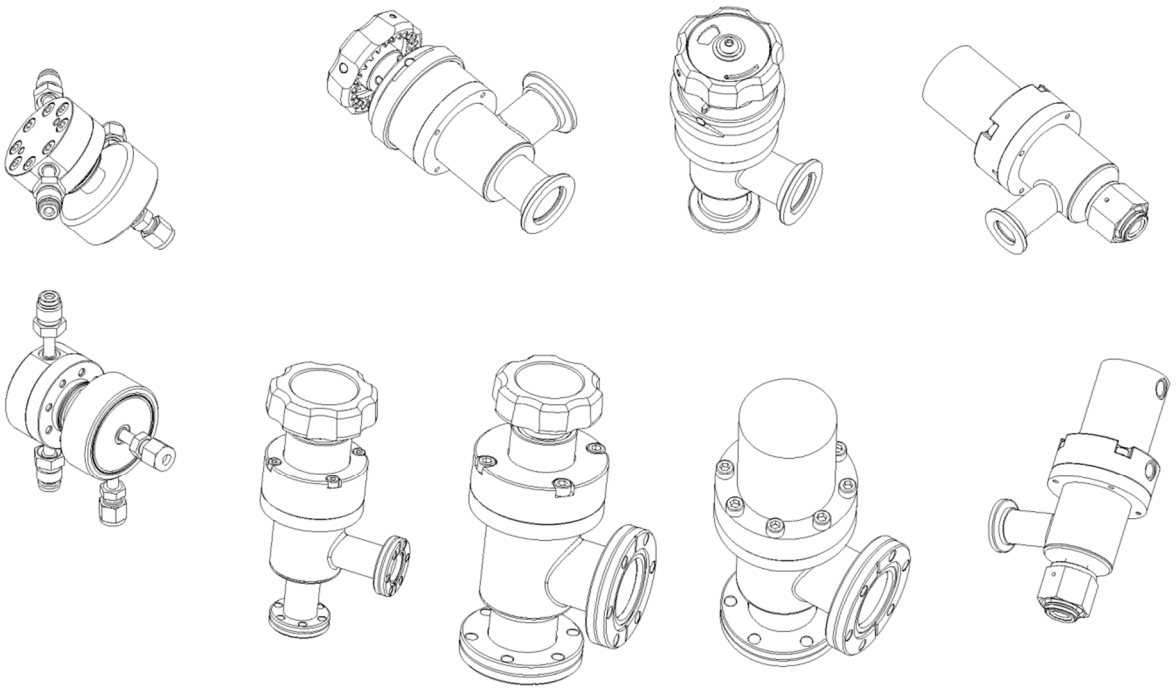
When it comes to selecting valves, review and additional response options are needed to address all problems and possibilities that could arise during processing.

This requires general examination and identification of the operation type (automatic, manual), pipe specification and coupling type, vacuum opening/closing and the control function.

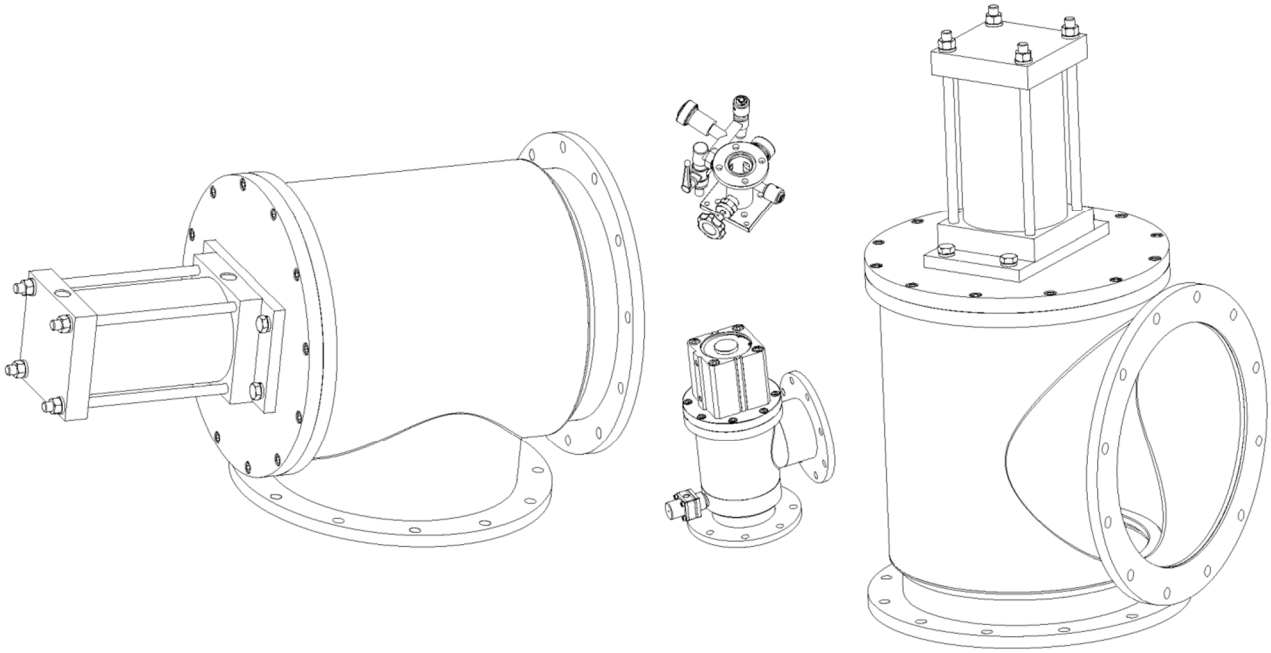
Using additional auxiliary devices is also required in order to prevent reduction in the use cycle from reactive products due to applied temperatures and reactive gases.

There is a disparity in technology in the valve designs by the domestic vacuum industry and overseas.

Considering our experience and technological environment for important control valves used for processing and high-value valves for certain special processing, our company believes that we can contribute to the vacuum industry by improving performance and domestic development through active consultations in equipment and processing technology with our clients.



(Picture 7.) Various vacuum valves according to customer`s environments-1



(Picture 8.) Various vacuum valves according to customer`s environments-2

5. Flange (of vacuum valve ports) standards, review items, diagnosis of emergency responses related to use

5-1. Standards for vacuum flanges

Flanges can be largely divided into: flanges that use O-Ring (elastic; rubber) as air-tightening material and flanges that use metal gasket as sealant. Flanges must be designed by selecting suitable purposes to use for the general vacuum area at ultra-high vacuum, such as the use temperature and minimizing degassing.

When it comes to the vacuum pipes constituting the vacuum system, ranging from the vacuum generator to the vacuum container, the flange that is used among pipes, valves and sensor ports can also be used for the vacuum sealing parts that are designed for special purposes besides the standardized ones.
Among vacuum flanges that use the O-Ring, ISO-KF, ISO-K, ISO-F flanges are mainly used for quick release coupling. Their strengths are considered below.

5-1-1. ISO-KF type (NW16~ NW50)

Developed in Germany, ISO-KF, or the small ISO flange, refers to “small flange” in German (“klein” means “small”). The standard for ISO vacuum flange uses the standardized Kwik Flange by the global vacuum part maker MDC from the U.S. The standard for this flange is in the form of the Tapered Flange by the Swiss company EVAC.

The flange maintains sealing by pressing the sealant (centering ring), affixing two flanges together, by using the C-Clamp type wing nut clamp at 15 degree slant from the flange’s external diameter to the internal.

Generally, hinge bolts and butterfly nuts affix the NW16 ~ NW 50 standardized 2-piece C-Clamps. Here, NW refers to the internal diameter of the vacuum pipe, from the German “Nenn-Weite” which means “nominal diameter.”

In countries that use the metric system, “DN” is used widely, for “diametre nominal” in French.
“NW25KF” refers to flanges that use the bulk head flange or the nail clamp to clamp the tapered small flange to the vacuum pipe’s nominal diameter 25 mm (1.0’’ tubing).

5-1-2. ISO-K type (ISO63 ~ ISO 320)

Designed to clamp the vacuum flange to the equipment body, the ISO-K can clamp with the single claw clamp or the double claw clamp. These vacuum flanges are not clamped at the bolt hole but because rotation between flanges is convenient, the organization or assembly of the vacuum pipe is easy. The position of the double claw clamp can be freely chosen, making possible working in a confined space.

The NW ISO-K type flange connects with the chain clamp at a 20 degree slant from the external diameter to the internal. It has the strength of rapid assembly and disassembly like the wingnut clamp. However, for large-scale designs this must be applied considering the weight worked on by the pipe and of the pipe components.

5-1-3. ISO-F type (ISO63 ~ ISO320)

ISO-K type flanges standardized P.C.D. of the bolt tap hole, which can clamp with the single claw clamp. (The ISO320 is an exception.) The bolt hole or bolt tap can be used optionally as well as for rotational flanges. Generally, for flanges standardized to the circular gate valve port flanges, specifications of the bolt tap are applied.

5-1-4. JIS Vacuum Flange (VF, VG)

This is the vacuum flange standards by the Japanese industrial standards that meet the industrial pipe standards.

JIS vacuum flanges have been used domestically in the vacuum industry at the outset. They continue to be applied as standards for large-scale high-vacuum pumps and vacuum valves' flange standards.

Vacuum Industry Standards Reference

ISO (International Organization for Standardization)	ISO 3529 1, Vacuum Technology Vocabulary Part 1: General Terms ISO 3753, Vacuum Technology Vocabulary – Graphical Symbols ISO 1609, Vacuum Technology Flange Dimensions ISO 2861 1, Vacuum Technology Quick Release Couplings Dimension Part 1: Clamped Type ISO 2861 2, Vacuum Technology Quick Release Couplings Dimension Part 2: Screwed Type ISO 3669, Vacuum Technology Back-able Flanges Dimensions Part 1: Clamped Type
KS (Korean Standards)	KS A 3014, Vacuum Terms KS A 2015, Graphical Symbols for Vacuum Devices KS B ISO 3529 1, Vacuum Technology Vocabulary: General Terms KS B 6832 (ISO 2861 1:1974), Dimensions of Quick Release Couplings of the Clamped Type in Vacuum Technology KS B ISO 1609, Vacuum Technology Flange Dimensions KS B ISO 2861 1, Vacuum Technology Quick Release Couplings Dimension Part 1: Clamped Type KS B ISO 2861 2, Vacuum Technology Quick Release Couplings Dimension Part II: Screwed Type

5-2. Main items for review of vacuum valves

Vacuum valves, like vacuum pipes, must completely block internal leakage even when the valve is closed, as well as seal the vacuum externally. For this reason, parts that are made by welding and vacuum valves assembled by using packing materials undergo multiple reviews.

Below outlines the standard for leak tests, which is an essential review item, and the exterior, measurements, and operational tests.

Essential Review Items and Criteria for Vacuum Valves

Name		RG 2" x 12"	Valve	ISVV-12-0001
Type		Rectangular gate valve 50 x 336 (Standards)	Sheet Number	
No.	Item	Criteria		Check
1	Appearance	1) Product surface has no marks, chips, or scratches (by the naked eye) Seal case and actuator case 2) Finished surface of sealing has no flaws (by the naked eye) Connecting flange sealing surface, etc. 3) Surface state of contamination by debris, etc. (cleansing and surface treatment) (by the naked eye) All parts		(Assembly, test manuals)
2	Measurements	Within main dimensions and permitted limits of the measurement recording sheet		Drawing sheet, measurement recording sheet
3	Motion	1) Smoothness of operation No vibration or shock during opening and closing of valve 2) Operation pressure setting minimum 4.0 kgf/cm^{2}G, maximum 5.0 kgf/cm^{2}G 3) Actuator Micro-Switch Setting (Normal contact output) (Measure tester resistance) 4) Controller sequence working time Valve open: Disc release → disc full open position within 3 seconds Valve close: Disc lift up close position → disc push and close within 3 seconds 5) Test controller motion more than 50 times		(Assembly, test manuals)
4	Leak test	1) Welded part of the valve body case (Helium leak detector) 2) Bonnet seal (Helium leak detector) 3) Actuator stem seal (Helium leak detector) 4) Pumping side back-pressure seal check (Helium leak detector) Detection must be below 1.3 x 10^{-8} Pa•m^2/sec 5) Re-do items 2–4 after 50 times of motion test 6) air pressure connection of fitting – no leak of air pressure (bubble test) 7) No conversion to hunting or middle leak check mode from helium leak test – fine leak check mode during motion test		Helium gas flow rate For leak detection: < 40 sccm To find leak point: < 20 sccm
5	Heating	1) Heater resistance measurements (or heat up test) 2) insulation check		Optional

5-3. Trouble shooting and emergency response

Below troubleshoots problems that arise from the vacuum valve's function and predicts breakdown scenarios that could offer emergency responses.
If the cause of the vacuum valve problem cannot be determined from above, it is proper to contact that manufacturer. Vacuum valves whose predicted life span has expired may be reused through exchanging parts, cleaning and leak testing at the manufacturer or companies specializing in repair/maintenance.

Issue		Cause	Solution
Valve does not operate	No signal and supply of pressurized air	Air is the cause; air pressure device is broken	Check air pressure device. Check power supply of air pressure solenoid valve
		Air pressure tube leak	Check tube fitting, tube lines
	No supply of pressurized air	Air pressure tube is clogged or leaking	Check air pressure tube
		Speed control valve is broken	Check and repair speed control valve
	Actuating power cutoff	Supply of actuating power is cut off	Check power supply
		Drive system error	Repair or replace drive system
	Unknown open/close position	Position sensor, valve is broken	Examine position sensor, check and replace valve
		Actuator leak	Dissemble and check actuator
	Actuator valve is not working (but the working pressure is)	Valve stem, guide are stuck	Disassemble disc and replace parts. Apply vacuum grease
		Valve stem error or damage	Repair and replace valve stem
Vibration/noise from valve	Noise from certain part(s)	Large difference between guide bush and stem	Check if stem or guide bush is worn out
		Lack of lubrication	Apply vacuum grease
		Loosened coupling	Identify and tighten coupling
Slow valve operation	Change in supply of air pressure	Insufficient volume or pressure of air pressure supply	Check air pressure supplier and regulator's setting for air pressure supply
	Unstable rate	Large friction of valve stem	Check eccentric stem guide. Adjust guide balance.
		Irregular opening/closing rate	Adjust speed control valve
Valve does not move past certain stroke		Insufficient air pressure	Check air pressure supplier
		Disc does not seal with seat	Check and replace valve stem and piston
Leakage	Valve completely closed	Disc, braid leak	Repair or replace
		Sealing damage, corrosion	Replace sealing part
	Valve not completely closed	Interior valve contamination	Disassemble and clean
		Contaminant condensed and stuck in actuator	Disassemble and clean, replace

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