Cryopump

Vacuum components

Cryopump POWER Series
Cryopump POWER^{ECO} Series

CANON ANELVA CORPORATION

High-Performance Cryopump Backed by Long-Standing Trust and Proven Performance

POWER/POWER^{ECO} Series Cryopump System

Intake diameter 8 to 22 inches

Summary

The POWER/POWERECO series cryogenic pump systems can be combined with a variety of units to accommodate a wide range of applications, from equipment for research and development to equipment for mass production.

The standard system is a simple and easy-to-use configuration with a temperature monitor. It can be used in combination with the CRYONAVI controller for automatic regeneration.

The Eco system has a unique control system that reduces maintenance costs through reduced power consumption and longer maintenance intervals, which contributes to the achievement of SDGs.

Applications

- Semiconductor manufacturing equipment (Sputtering equipment,Ion implanter)
- Electronic component manufacturing equipment
- Vacuum evaporation systems
- Vacuum furnace,space chambers
- Accelerators
- Various high vacuum equipment

About the POWER/POWER^{ECO} series cryopump model

An example is shown below for reference.

P — 080CL — AHN

Pump intake diameter
(08 ～ 22 inch)

Specification No.
0, 5：Standard
1, 6：Hydrogen high exhaust performance model
2, 3, 7：Argon gas large exhaust capacity model

C ：Cryopump (vertical)
CL：Cryopump (horizontal)

Intake flange specifications
J：Form JIS flange
A：ASA flange
S：ISO (new JIS) flange
U：ICF flange specification
X：All metal seal specification

N：Without heater
HN：With heater

■ Unit Configuration of POWER/POWER^{ECO} Series Cryopumps

There are two different types of POWER/POWER^{ECO} series cryopump systems.

The standard system uses a conventional cryopump (refrigerator) and compressor that operate at a constant speed.

With the Eco system, the operation speed of the cryopump and compressor are adjusted according to the output required at any given time.

Most of the power in a system is consumed by the compressor. However, while the compressor in the standard system operates at a constant power supply frequency (50/60 Hz), the compressor in the Eco system has a built-in inverter that adjusts the operating frequency to reduce power consumption.

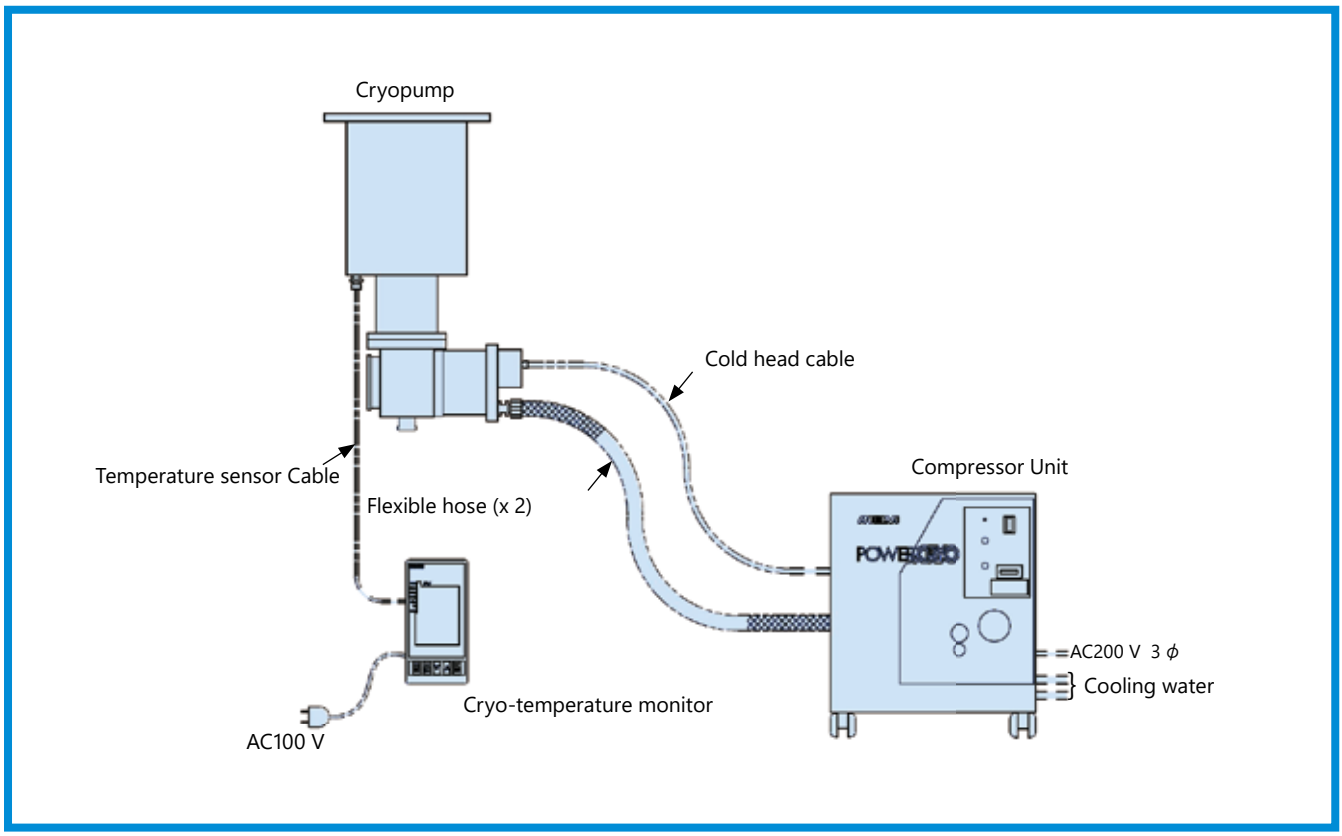
The unit configurations of the standard system and the Eco system are shown below.

<table>
<tr><th>Unit</th><th>Standard system</th><th>Eco system</th></tr>
<tr><td>Cryopump</td><td>POWER Series
POWER^{ECO} Series</td><td>POWER^{ECO} Series</td></tr>
<tr><td>Temperature monitor
Cold head driver
Controller</td><td>DB650 Temperature monitor
P-023CD-R Cold head driver
P-024CD Cold head driver
P-011CC-R CRYONAVI Controller</td><td>P-031CC Controller</td></tr>
<tr><td>Compressor</td><td>E-77NL Compressor</td><td>CSW-61CN2 Compressor</td></tr>
<tr><td rowspan="2">Features</td><td colspan="2">High-speed cooling operation
Heating operation (Self-heating function)
High exhaust performance (practical exhaust capacity)
Low vibration (Low vibration motor)</td></tr>
<tr><td>Temperature stability (multi-wave operation)
Supercooling prevention structure (POWER series)
Reduced power consumption (multi-unit effect)</td><td>Reduced power consumption (output control)
Multi-operation of different models (minimum configuration)
Temperature stability (temperature control)
Exhaust performance stability (optimal temperature)
Longer maintenance intervals (reduced wear)</td></tr>
</table>

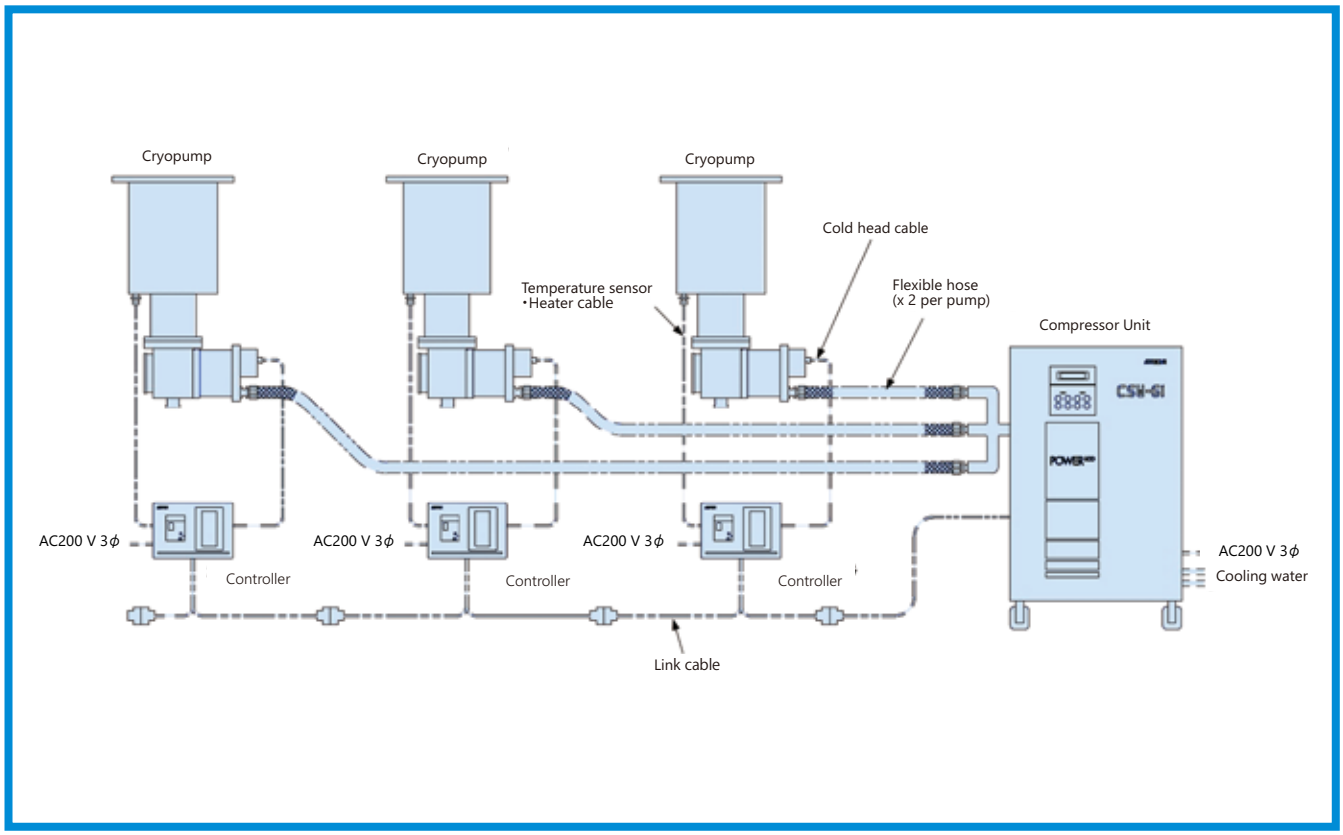
※ POWER^{ECO} series cryopumps are equipped with highly efficient refrigerators, so it is necessary to use the controller to adjust the temperature according to the application and system configuration.
The POWER/POWER^{ECO} series use the same cryotrap, but the controller must be used to adjust the temperature.

■ POWER/POWER^{ECO} series cryo pump system configration

Standard system configuration example. (Temperature monitor×1)



Eco system configuration example. (Multi-system)



High-Performance Cryopump that Contributes to the Operating Efficiency of Vacuum Equipment

POWER series cryopump

High performance cryopump

Intake diameter 8 to 12 inches (with small built-in refrigerator)

Summary

The high-performance, compact cryopumps in the POWER series, which prioritize practical performance, feature the world's first self-heating function, temperature stability during multi-operation, and our unique exhaust panel structure.

Features

1 .High-speed cooling operation

The refrigerator uses high-speed cooling operation for cooling (down to 20K).

2 .Heating operation

The refrigerator's self-heating function allows rapid heating operation.
The exhaust panel is heated directly, allowing efficient regeneration.

3 .High exhaust performance

Our unique panel structure provides a large practical exhaust capacity.
In addition to its high cooling capacity, it is also resistant to mixed gas exhaust.

4 .Low vibration

A low-vibration motor is used.
In addition, vibration-proof structures are also available.

5 .Temperature stability

The temperature is stable during multi-operation. (multi-wave operation)

6 .Supercooling prevention structure

The 1st stage has a supercooling prevention structure to prevent Argon hang-up.

■ POWER series cryopump performance specifications (with small built-in refrigerator)

Pump Type		P-080C	P-081C	P-081CL	P-082C	P-083C	P-100C	P-100CL	Remarks
Diameter		8 inch	8 inch	8 inch	8 inch	8 inch	10 inch	10 inch	
Shape		Vertical	Vertical	Horizontal	Vertical	Vertical	Vertical	Horizontal	
Pumping speed (L/s)	Nitrogen	1,500	1,500	1,500	1,500	1,500	2,400	2,400	
	Argon	1,300	1,300	1,300	1,300	1,300	2,000	2,000	
	Hydrogen	1,000	2,500	2,200	1,000	1,000	3,000	3,000	
	Water	4,500	4,500	4,500	4,500	4,500	7,100	7,100	
Maximum pumping flow ($Pa \cdot m^3/s$)		1.5	1.2	1.2	1.5	1.5	1.0	1.0	Argon
Maximum gas instantaneous tolerance ($Pa \cdot m^3$)		18.0	18.0	18.0	18.0	18.0	18.0	18.0	
Cool-down time (min)		45	50	65	45	50	70	80	＊1
Heat-up time (min)		30	30	30	30	35	35	40	＊1
Regeneration time (min)		75 + α	80 + α	95 + α	75 + α	85 + α	105 + α	120 + α	＊1
Pumping capacity ($Pa \cdot m^3$)	Argon	80,000	80,000	80,000	150,000	190,000	160,000	140,000	＊2
	Hydrogen	1,300	1,800	1,600	1,300	1,300	1,600	1,300	
Ultimate temperature (K)		15 or less							
Ultimate pressure (Pa)		Approx. 10^{-7}							
Maximum heating temperature (°C)		70							
Ambient temperature range (°C)		10 ～ 35							
Recommended maintenance hour (h)		Within 16,000							
Weight (kg)		20	21	22	23	24	25	27	
Operating units	E-77NL	3	3	3	3	3	3	3	＊3

Pump Type		P-101C	P-101CL	P-120C	P-120CL	P-121C	P-121CL	P-122C	Remarks
Diameter		10 inch	10 inch	12 inch	12 inch	12 inch	12 inch	12 inch	
Shape		Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
Pumping speed (L/s)	Nitrogen	2,400	2,400	4,000	4,000	4,000	4,000	4,000	
	Argon	2,000	2,000	3,200	3,200	3,200	3,200	3,200	
	Hydrogen	3,800	3,700	3,600	3,000	6,000	5,000	3,000	
	Water	7,100	7,100	9,800	9,800	9,800	9,800	9,800	
Maximum pumping flow ($Pa \cdot m^3/s$)		1.0	1.0	1.0	1.0	1.0	1.0	1.0	Argon
Maximum gas instantaneous tolerance ($Pa \cdot m^3$)		18.0	18.0	18.0	18.0	18.0	18.0	18.0	
Cool-down time (min)		70	80	60	90	70	100	60	＊1
Heat-up time (min)		35	45	35	40	40	50	35	＊1
Regeneration time (min)		105 + α	125 + α	95 + α	130 + α	110 + α	150 + α	95 + α	＊1
Pumping capacity ($Pa \cdot m^3$)	Argon	160,000	140,000	260,000	200,000	260,000	200,000	400,000	＊2
	Hydrogen	2,000	1,800	1,600	1,400	2,400	2,200	1,600	
Ultimate temperature (K)		15 or less							
Ultimate pressure (Pa)		Approx. 10^{-7}							
Maximum heating temperature (°C)		70							
Ambient temperature range (°C)		10 ～ 35							
Recommended maintenance hour (h)		Within 16,000							
Weight (kg)		25	27	29	30	29	30	30	
Operating units	E-77NL	3	3	3	3	3	3	3	＊3

＊ 1) Cool-down time (to 20K) is achieved by high-speed cooling operation, and heat-up time is the value when purge gas is introduced without storage gas during self-heating.
The "+α" for regeneration time indicates the time required for roughing, etc.

＊ 2) Exhaust capacity is based on our own evaluation method. It is a practical value equivalent to when the unit is actually used.

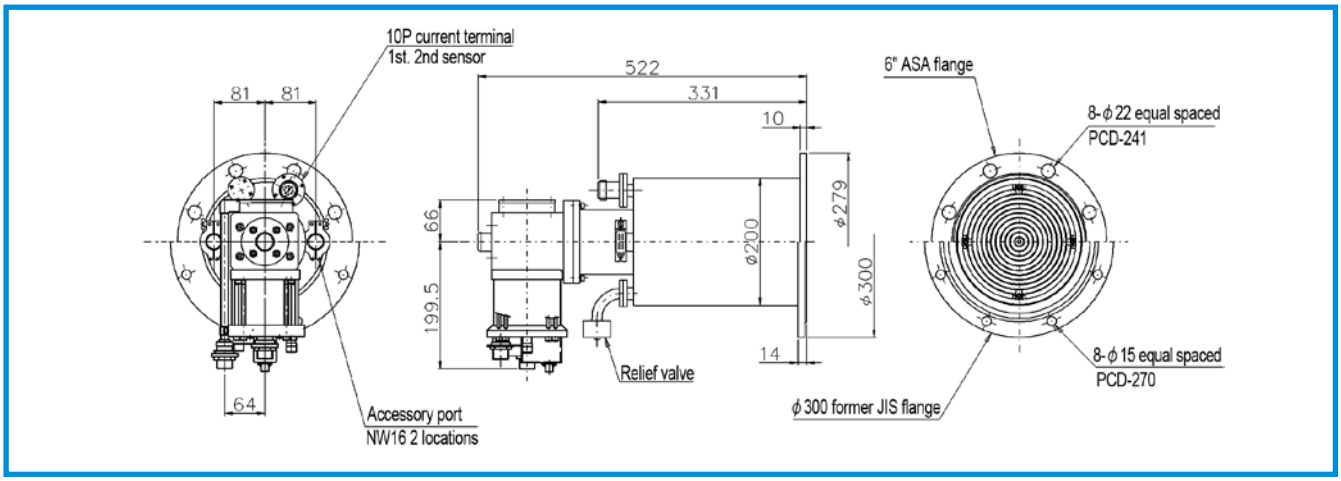
＊ 3) This depends on the heat load on the pump.

※ These specifications are for the pump alone.
The values when vacuum equipment is installed are affected by factors such as gas emissions and heat load in the installation environment.

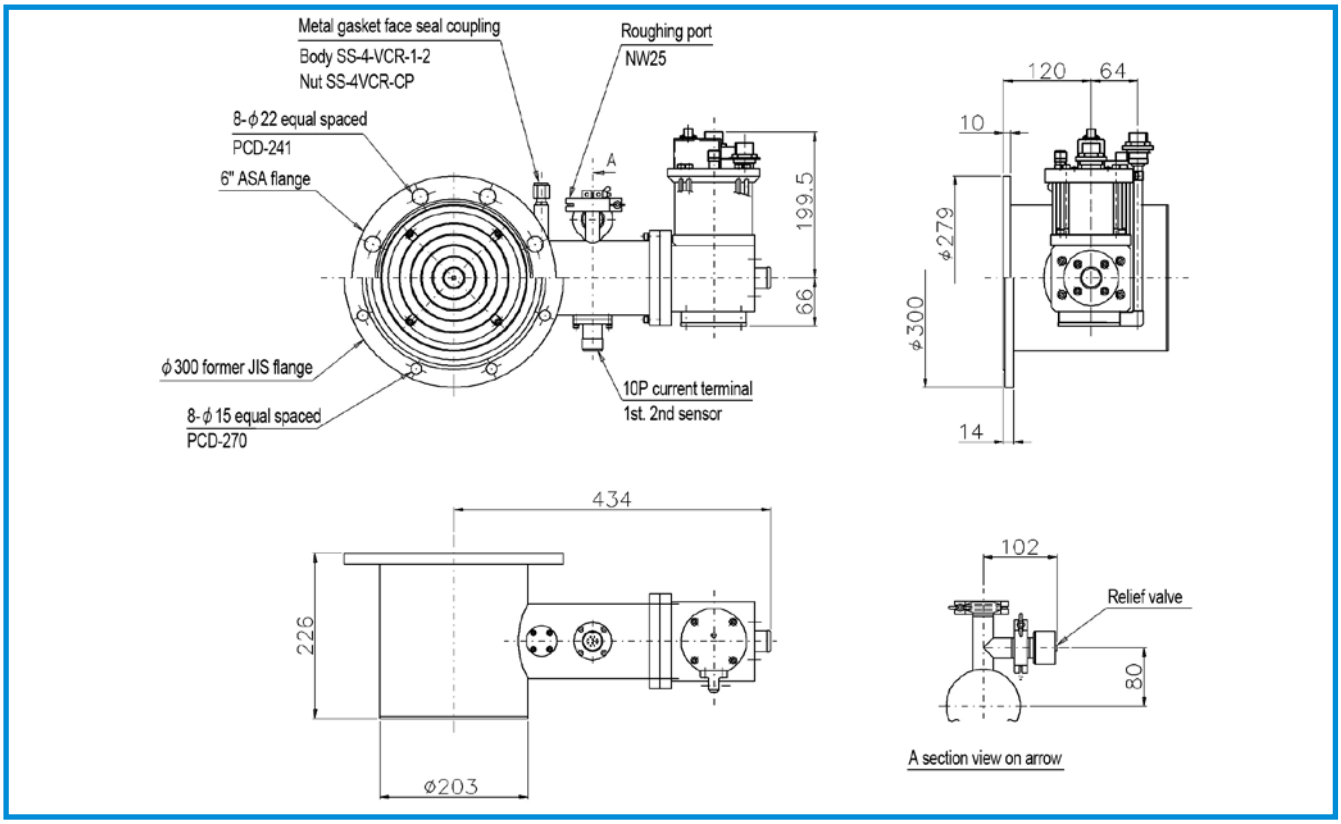
These specifications are subject to change without notice for product improvement or other reasons.

Dimensions diagram

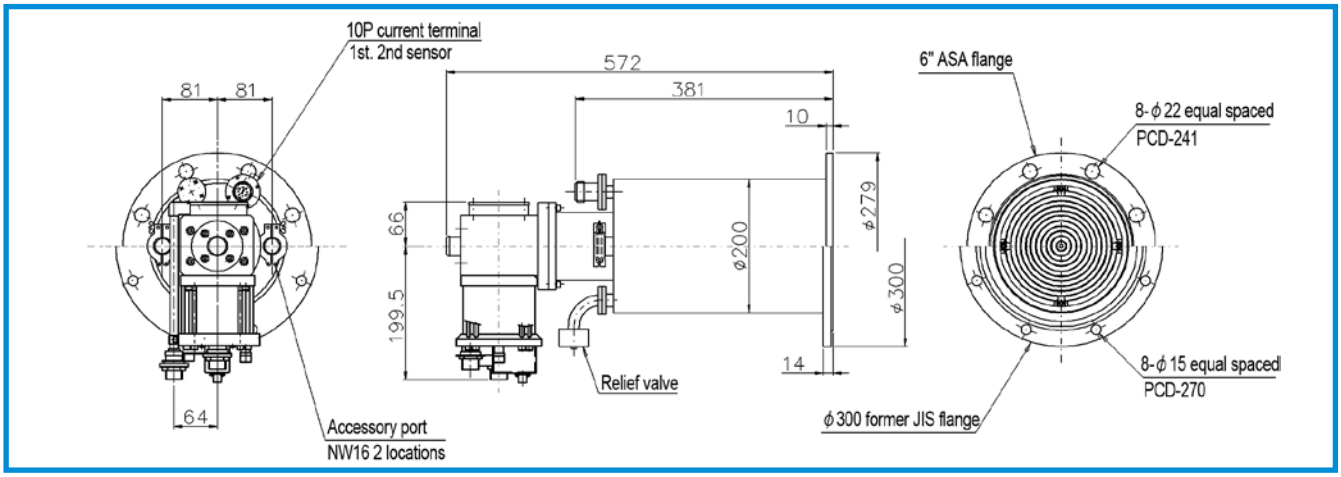
P-080C/P-081C



P-081CL

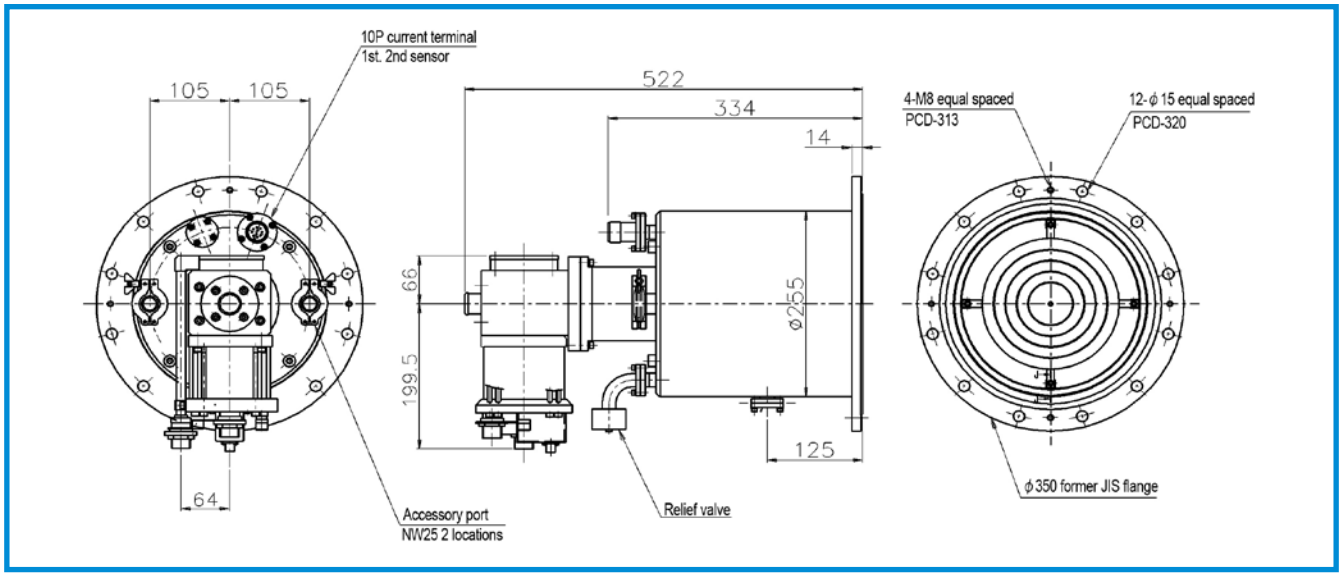


P-082C

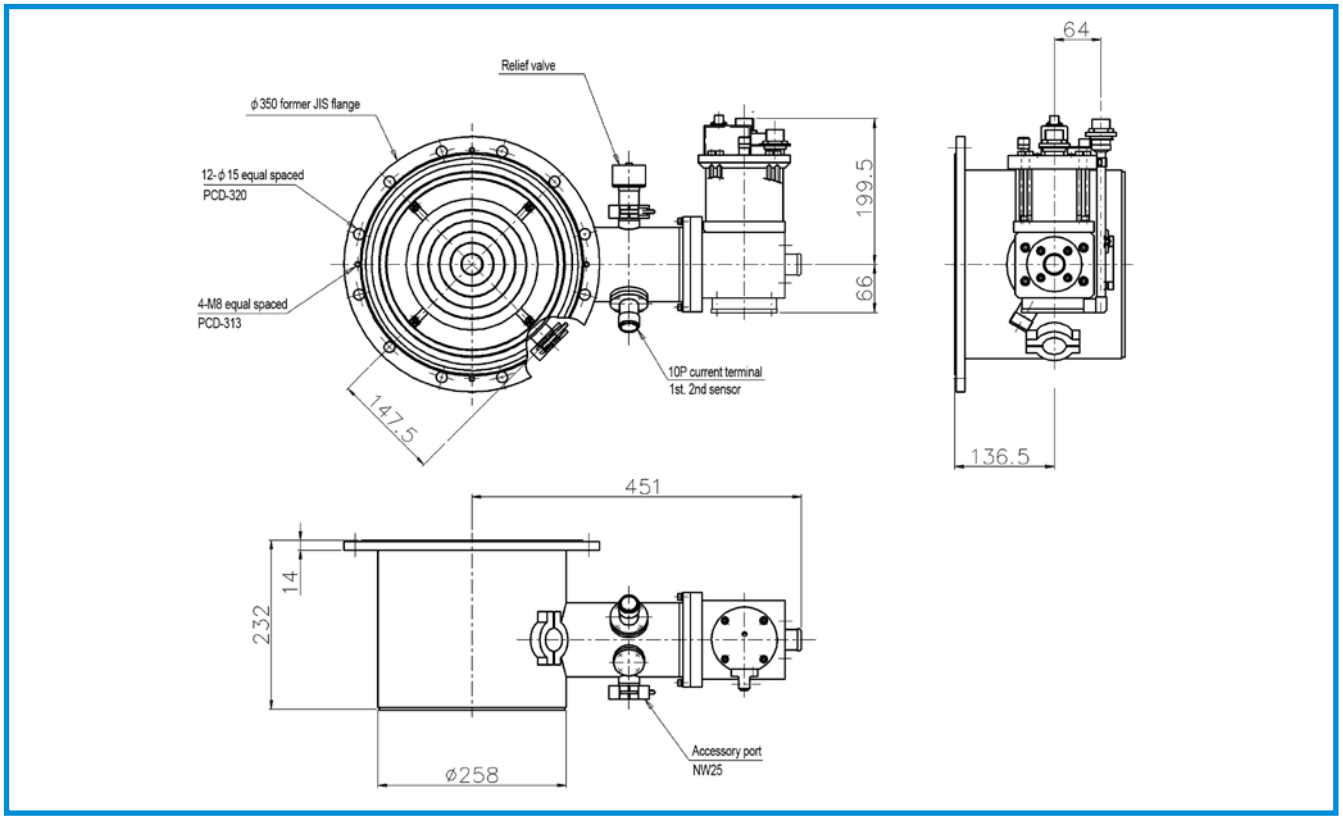


Dimensions diagram

P-101C

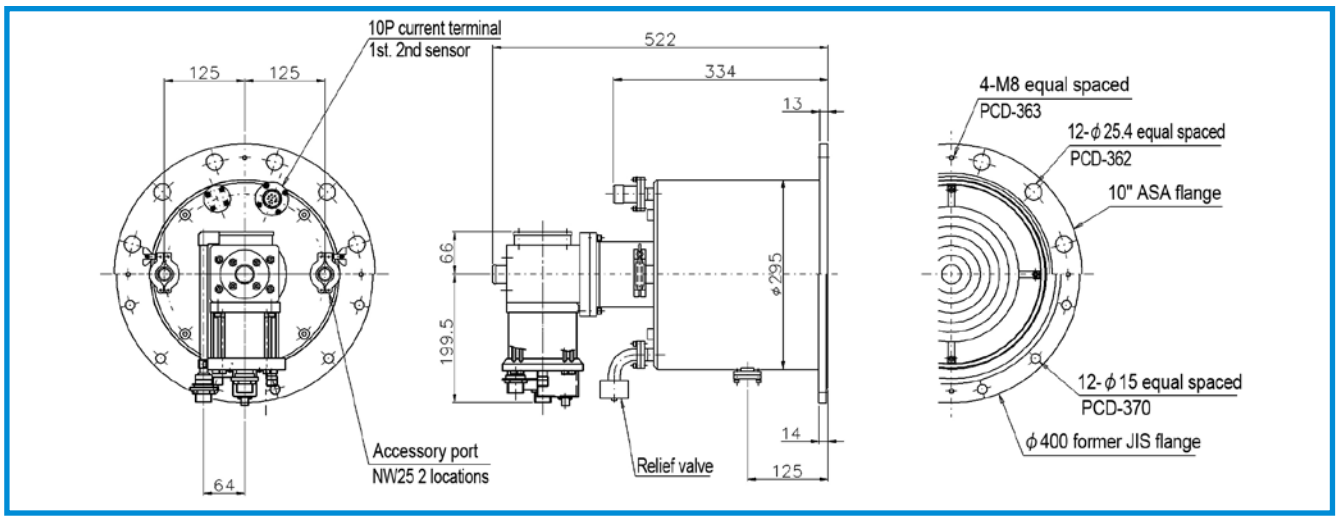


P-100CL/P-101CL

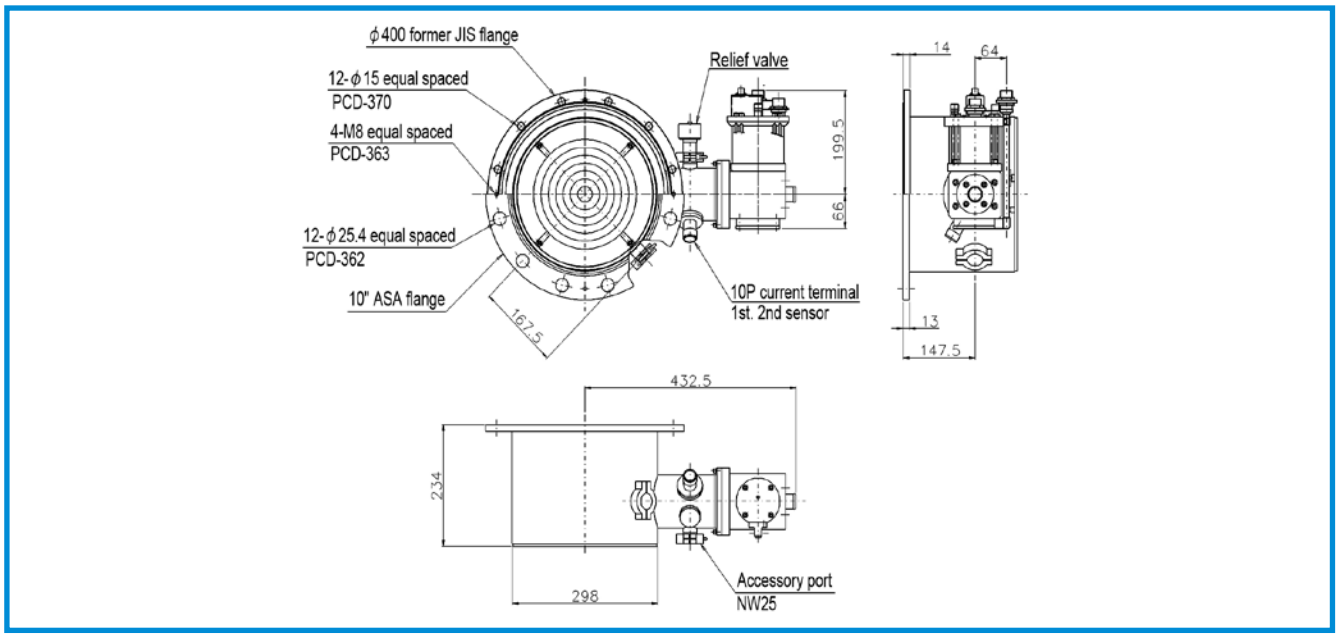


Dimensions diagram

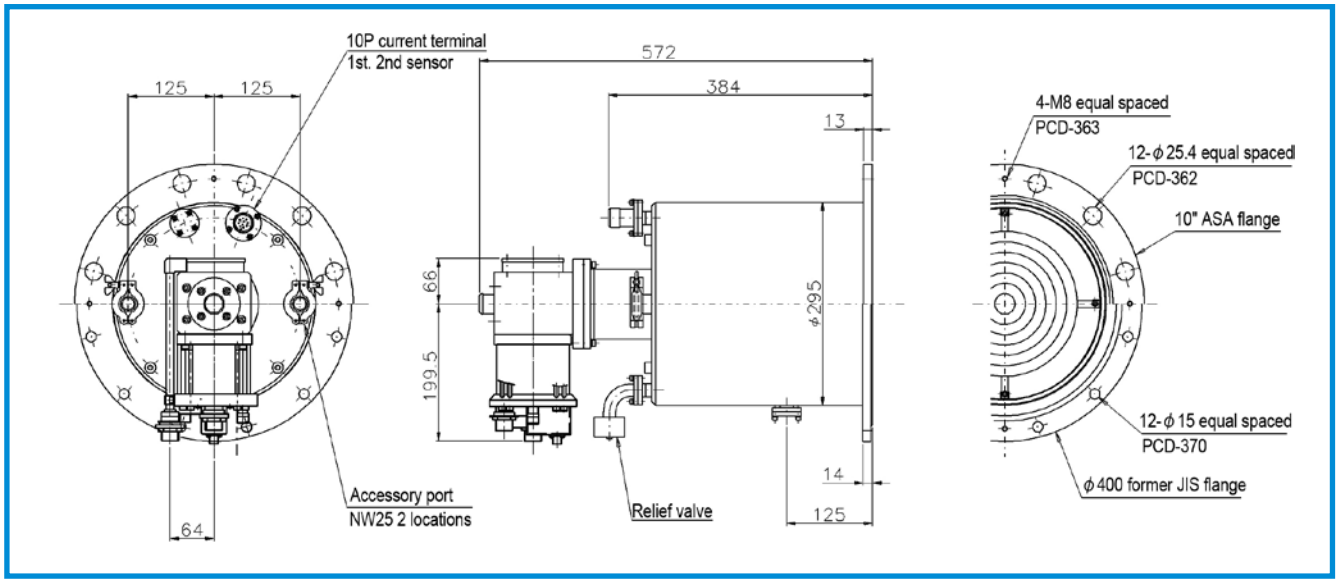
P-120C/P-121C



P-120CL/P-121CL



P-122C



Cryopump System that Contributes to Running Cost and the Operating Efficiency of Vacuum Equipment

POWER^{ECO} series cryopump

High-performance, high-efficiency cryopump
Intake diameter 8 to 22 inches
(with small/medium/large built-in refrigerator)

Summary

POWER^{ECO} series cryopumps achieve high efficiency while retaining the features of the POWER series.

The standard system can operate five 8-inch cryopumps.

The combination of a dedicated controller and compressor in the Eco system provides stable temperature and exhaust performance. Output is kept to a minimum according to the number of cryopump units in operation and the amount of heat input to the cryopumps, thereby reducing power consumption.

Power consumption can also be reduced by stopping cryopumps that are not in use or closing the main valve to reduce the amount of heat entering the cryopumps. By optimizing the operation of the vacuum system in this way, you can achieve further improvements in efficiency.

In addition, since the operating speed of the refrigerator is kept to a minimum, wear on internal parts is reduced, which extends the time until maintenance is required.

In addition to reduced power consumption, you can expect an overall reduction in running cost.

Features (in addition to the features of the POWER series)

1. Reduced power consumption (standard system)

Capable of multi-unit operation with up to five 8-inch cryopumps and four 10-inch cryopumps. Through the use of multiple units, power consumption is reduced per cryopump.

2. Reduced power consumption (Eco system)

Output is suppressed to the minimum necessary within the range of 50 to 100%, reducing power consumption.

3. Multi-operation of different models (Eco system)

Small/medium cryopumps and cryotraps can be operated with the same compressor.
Vacuum equipment can be configured with the minimum number of compressors required.

4. Temperature stability (Eco system)

Our unique control system maintains a constant temperature.

5. Exhaust performance stability (Eco system)

An optimal temperature is maintained for stable exhaust performance.

6. Longer maintenance intervals (Eco system)

Wear on the internal parts of the refrigerator is suppressed, which extends the time until maintenance is required.
This is effective in reducing running costs.

■ POWER^{ECO} series cryopump performance specifications (with small built-in refrigerator)

Pump Type		P-085C	P-086C	P-086CL	P-087C	P-105C	P-105CL	P-106C	P-106CL	P-107C	Remarks
Diameter		8 inch	8 inch	8 inch	8 inch	10 inch	10 inch	10 inch	10 inch	10 inch	
Shape		Vertical	Vertical	Horizontal	Vertical	Vertical	Horizontal	Vertical	Horizontal	Vertical	
Pumping speed (L/s)	Nitrogen	1,500	1,500	1,500	1,500	2,400	2,400	2,400	2,400	2,200	
	Argon	1,300	1,300	1,300	1,300	2,000	2,000	2,000	2,000	1,600	
	Hydrogen	1,000	2,500	2,200	1,000	3,000	3,000	3,800	3,700	2,600	
	Water	4,500	4,500	4,500	4,500	7,100	7,100	7,100	7,100	7,100	
Maximum pumping flow ($Pa \cdot m^3/s$)		1.2	1.2	1.1	1.2	1.0	1.0	1.0	1.0	1.0	Argon
Maximum gas instantaneous tolerance ($Pa \cdot m^3$)		18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	
Cool-down time (min)		60	65	80	60	75	90	85	100	120	＊1
Heat-up time (min)		40	40	45	40	45	50	45	50	50	
Regeneration time (min)		100 ＋ α	105 ＋ α	125 ＋ α	100 ＋ α	120 ＋ α	140 ＋ α	130 ＋ α	150 ＋ α	170 ＋ α	
Pumping capacity ($Pa \cdot m^3$)	Argon	80,000	80,000	80,000	150,000	160,000	140,000	160,000	140,000	300,000	＊2
	Hydrogen	1,300	1,800	1,600	1,300	1,600	1,300	2,000	1,800	1,600	
Ultimate temperature (K)		15 or less									
Ultimate pressure (Pa)		Approx. 10^{-7}									
Maximum heating temperature (°C)		70									
Ambient temperature range (°C)		10 ～ 35									
Recommended maintenance hour (h)		Within 16,000									
Weight (kg)		22	22	22	23	25	27	24	25	29	
Number of operating units	E-77NL	5	5	5	5	4	4	4	4	4	＊3
	CSW-61CN2	6	6	6	6	4	4	4	4	4	

＊1) Cool-down time (to 20K) is achieved by high-speed cooling operation, and heat-up time is the value when purge gas is introduced without storage gas during self-heating.
The "+α" for regeneration time indicates the time required for roughing, etc.

＊2) Exhaust capacity is based on our own evaluation method. It is a practical value equivalent to when the unit is actually used.

＊3) This depends on the heat load on the pump.

※ These specifications are for the pump alone.

The values when vacuum equipment is installed are affected by factors such as gas emissions and heat load in the installation environment.
These specifications are subject to change without notice for product improvement or other reasons.

■ Medium/Large POWER^{ECO} series cryopump performance specifications
(with medium/large built-in refrigerator)

Pump Type		P-128C	P-128CL	P-160C	P-160CL	P-161C	P-161CL	P-206C	P-226C	Remarks
Diameter		12inch	12inch	16inch	16inch	16inch	16inch	20inch	22 inch	
Shape		Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Vertical	
Pumping speed (L/s)	Nitrogen	4,000	4,000	7,500	6,800	7,500	6,800	13,000	17,000	
	Argon	3,200	3,200	6,300	5,700	6,300	5,700	9,000	11,000	
	Hydrogen	6,000	5,000	5,500	5,000	11,000	10,000	17,000	23,000	
	Water	9,800	9,800	19,000	19,000	19,000	19,000	30,000	39,000	
Maximum pumping flow ($Pa \cdot m^3/s$)		2.2	2.2	2.2	2,2	2.0	2.2	3.0	2.7	Argon
Maximum gas instantaneous tolerance ($Pa \cdot m^3$)		40	40	50	50	50	50	80	133	
Cool-down time (min)		110	115	70	95	90	120	100	120	＊1
Heat-up time (min)		70	70	40	60	60	60	80	80	
Regeneration time (min)		180 ＋ α	185 ＋ α	110 ＋ α	155 ＋ α	150 ＋ α	180 ＋ α	180 ＋ α	200 ＋ α	
Pumping capacity ($Pa \cdot m^3$)	Argon	270,000	200,000	400,000	200,000	400,000	200,000	650,000	1,000,000	＊2
	Hydrogen	4,000	3,500	1,600	1,400	3,400	3,000	7,500	7,500	
Ultimate temperature (K)		15 or less							15 or less	
Ultimate pressure (Pa)		Approx. 10^{-7}								
Maximum heating temperature (°C)		70								
Ambient temperature range (°C)		10 ～ 35								
Recommended maintenance hour (h)		Within 16,000 (longer with the Eco system)								
Weight (kg)		37	39	50	62	50	62	67	87	
Number of operating units	E-77NL	2	2	2	2	2	2	1	1	＊3
	CSW-61CN2	2	2	2	2	2	2	1	1	

＊1) Cool-down time (to 20K) is achieved by high-speed cooling operation, and heat-up time is the value when purge gas is introduced without storage gas during self-heating.
The "+α" for regeneration time indicates the time required for roughing, etc.

＊2) Exhaust capacity is based on our own evaluation method. It is a practical value equivalent to when the unit is actually used.

＊3) This depends on the heat load on the pump.

※ These specifications are for the pump alone.
The values when vacuum equipment is installed are affected by factors such as gas emissions and heat load in the installation environment.
These specifications are subject to change without notice for product improvement or other reasons.

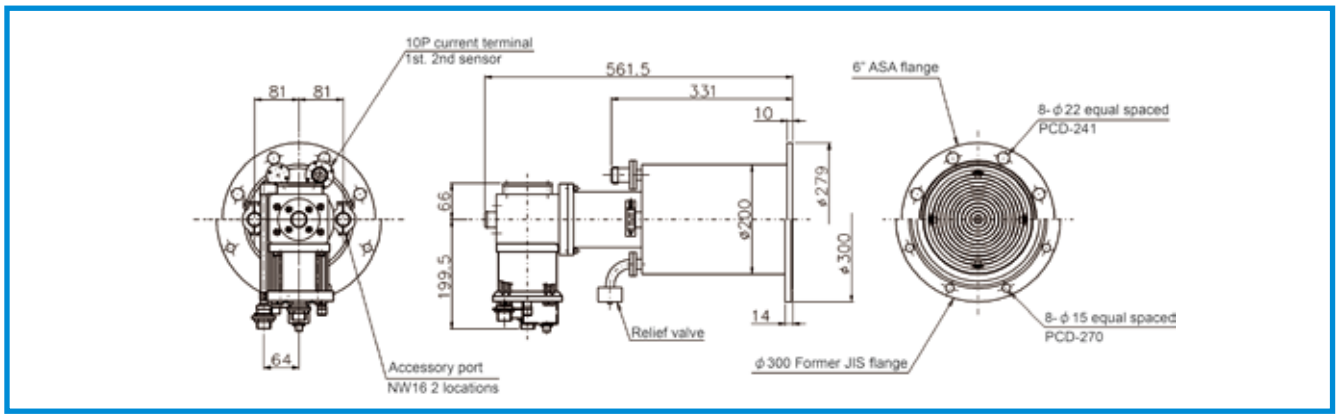
Notes regarding export, transfer, and disposal

When exporting large-diameter cryopumps outside Japan, it might be necessary to conduct classification in accordance with the Foreign Exchange and Foreign Trade Act. Please contact our sales department for more information.

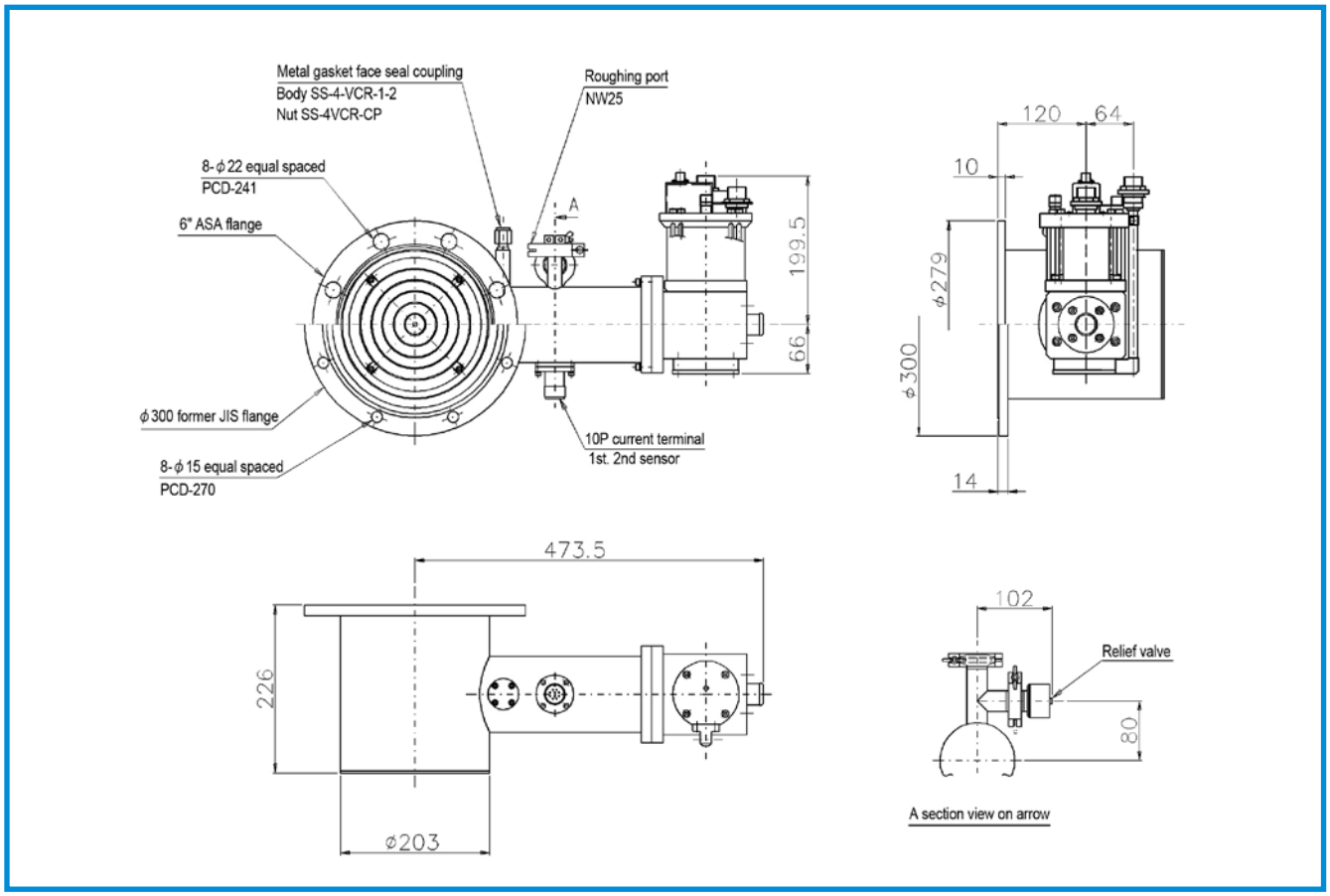
In addition, the same classification is required when transferring or disposing of units within Japan. Please notify the transfer or disposal destination of the results of the classification process.

Dimensions diagram

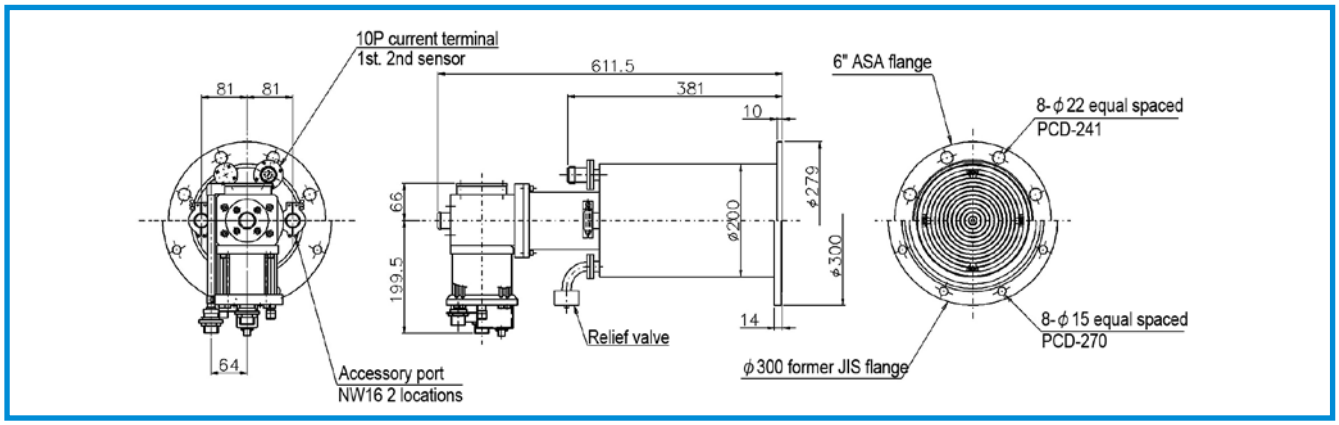
P-085C/P-086C



P-086CL

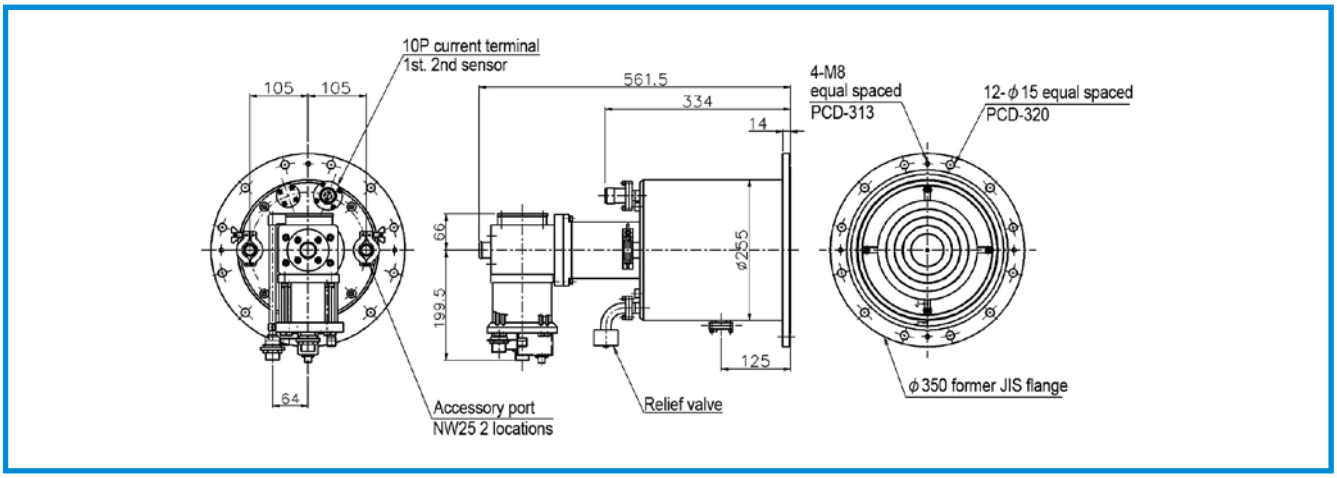


P-087C

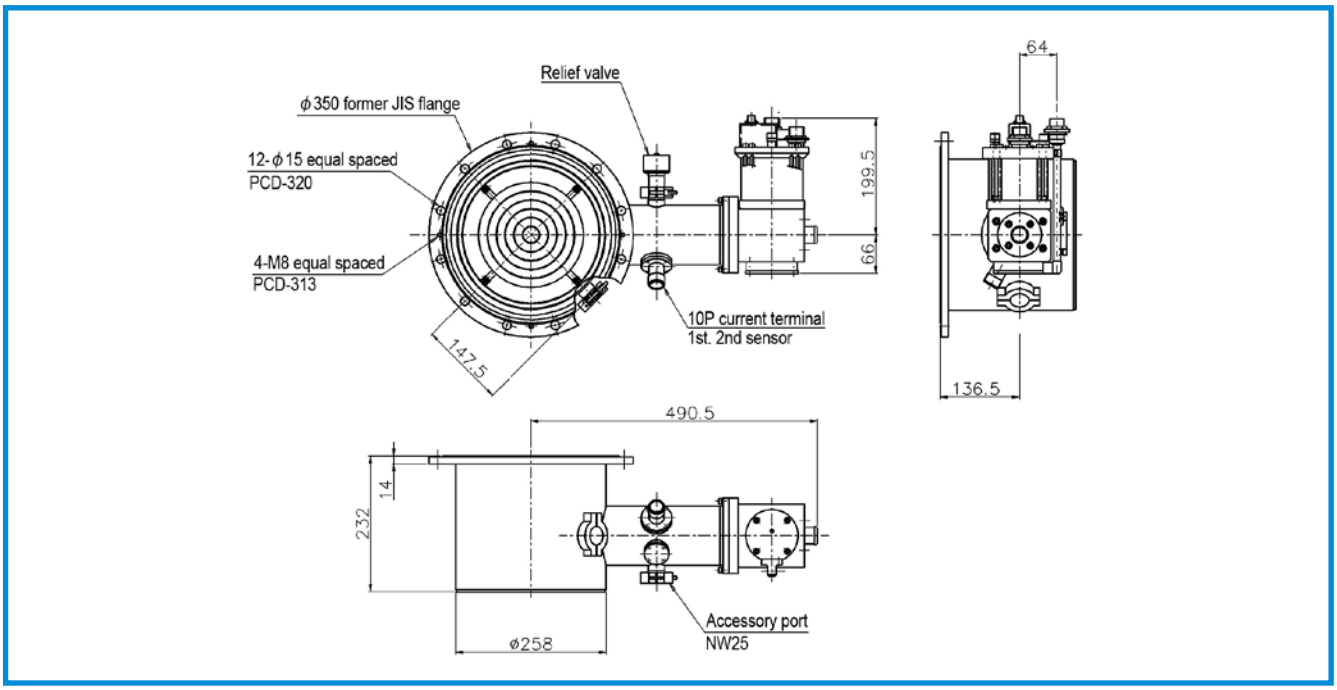


■ Dimensions diagram

P-105C/P-106C

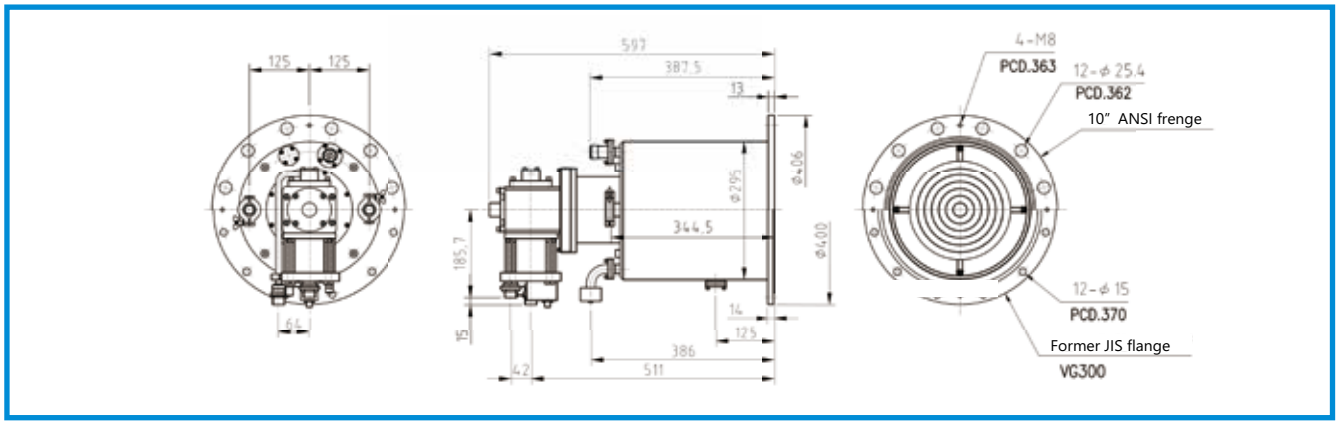


P-105CL/P-106CL

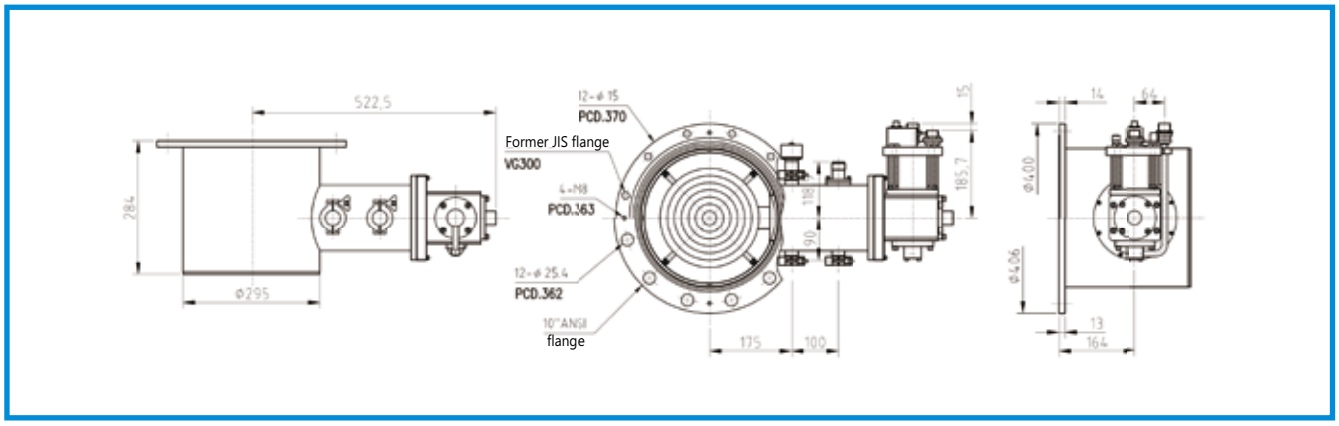


■Dimensions diagram

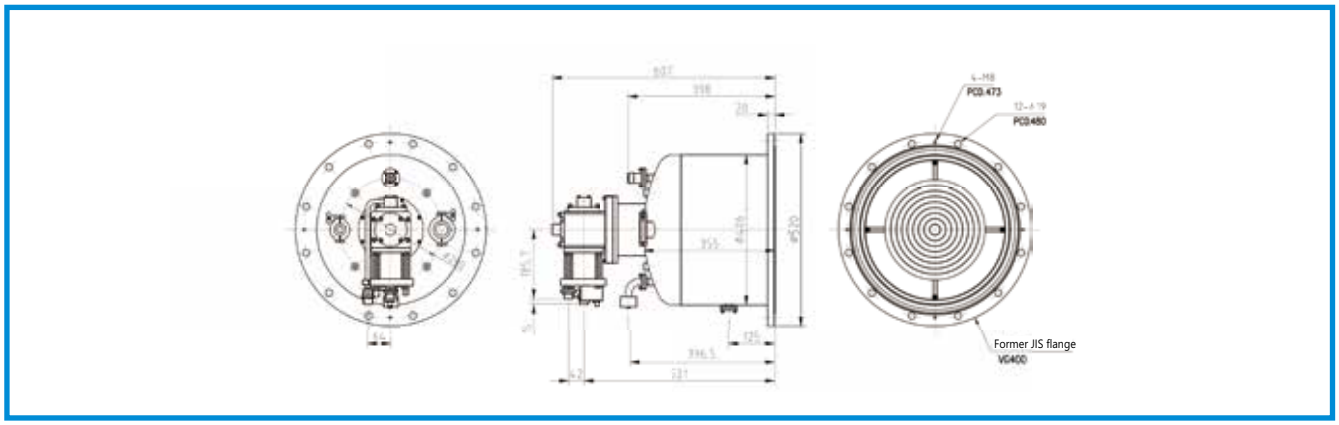
P-128C



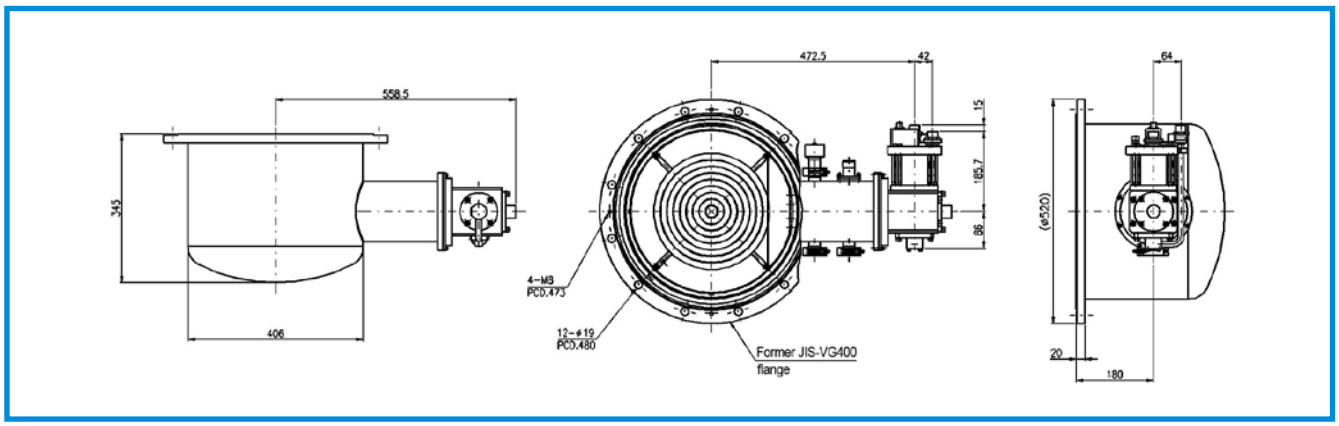
P-128CL



P-161C

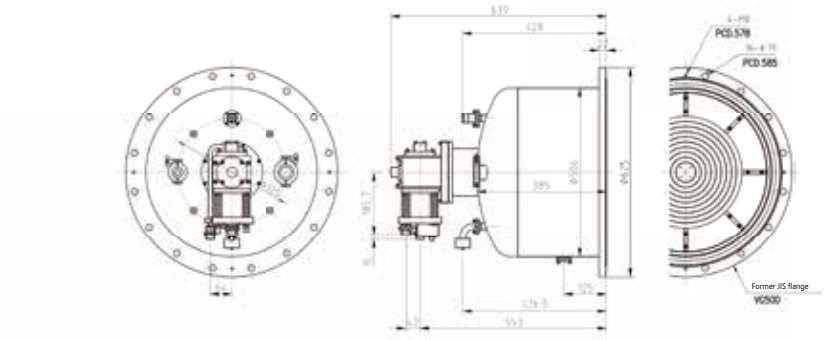


P-161CL

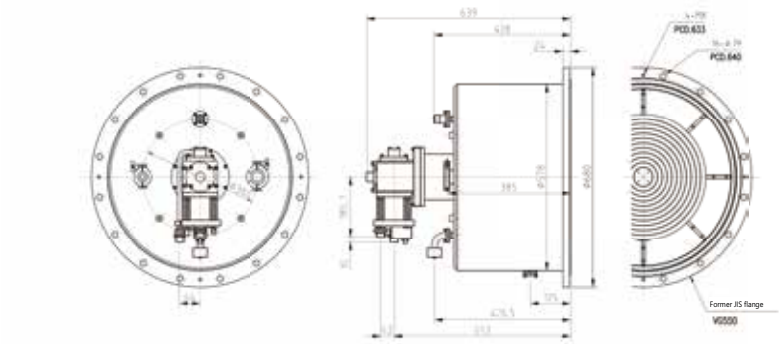


Dimensions diagram

P-206C



P-226C



E-77NL Compressor unit

■ Summary

This is a large compressor unit for standard systems.
(Manufactured by Sumitomo Heavy Industries, Ltd.)

A separate cold head driver is required.

An external inline relief valve is provided for cryopumps/traps.

■ Specifications

Type		E-77NL
Helium gas pressure (Mpa)	Not operating	1.60 ～ 1.65
Compressor cooling water	Flow Rate (L/min)	4 ～ 10
	Maximum water pressure (Mpa)	0.69
	Input temperature (℃)	4 ～ 28
Input power supply /voltage	50 Hz	3 ϕ 200 VAC
	60 Hz	3 ϕ 200/230 VAC
Power consumption (kw)	Steady-state (50Hz)	5.2
	Steady-state (60Hz)	6.5
Ambient temperature range (℃)		5 ～ 35
Maintenance interval (h) (adsorber replacement)		Every 30,000
Dimensions (mm) W×D× H		450×485×591
Weight (kg)		120

CSW-61CN2 Compressor unit (for Eco system)

Summary

UL CE

This is a large compressor unit for Eco systems.

It has a built-in pressure sensor and inverter to regulate the compression flow of helium gas to the minimum necessary.

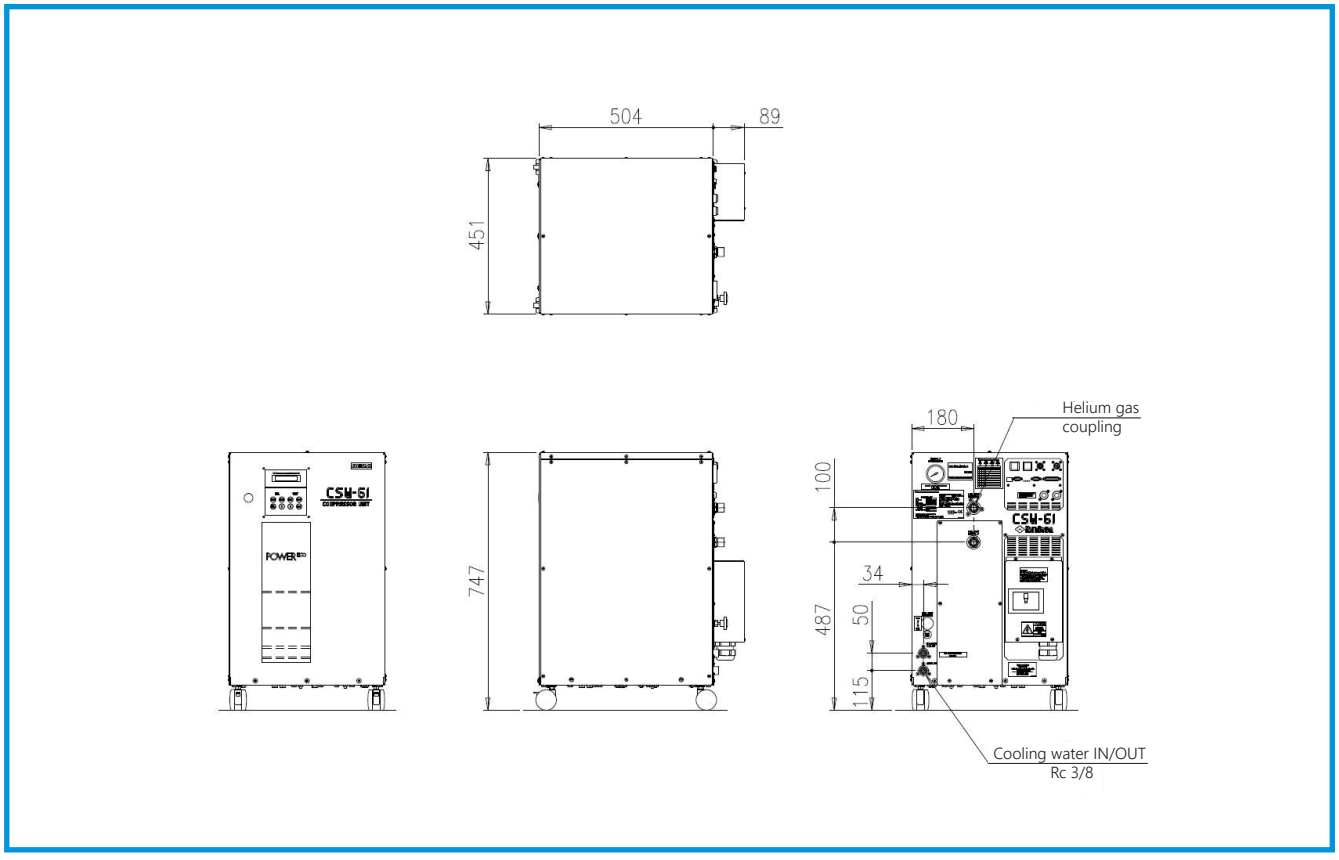
A separate controller is required for the Eco system.

Specifications

Type		CSW-61CN2
Helium gas pressure (MPa)	Not operating	1.65 ～ 1.70
	Operating (High Side)	2.2 ～ 2.5
Compressor cooling water	Flow Rate (L/min) ※ Depends on cooling water temperature	4 ～ 10
	Maximum water pressure (MPa)	0.7
	Input temperature (°C)	4 ～ 28
Input power supply/voltage (50/60Hz)		3 ϕ AC200 ～ 240 V±10%
Power consumption (kW)		3.5 ～ 9.2
Ambient temperature range for installation (°C)		5 ～ 40
Maintenance interval (h) (adsorber replacement)		Every 30,000h
Dimensions (mm) W×D×H		451×594×747
Weight (kg)		130

Dimensions diagram

CSW-61CN2



■ System selection guide

◎：Optimum　○：Applicable

Selection criteria	Pump body	Power series (Intake diameter 8 to 12 inches)			Power ECO series (Intake diameter 8 to 22 inches)			
	System	Standard system			Standard system			Eco system
		Temperature monitor ×1	Temperature monitor ×2	CRYONAVI Contoroller	Temperature monitor ×1	Temperature monitor ×2	CRYONAVI Contoroller	
① High-speed cooling operation		◎	◎	◎	◎	◎	◎	◎
② Heating operation		-	◎	◎	-	◎	◎	◎
③ Auto regeneration (heating → roughing → cooling)		-	-	◎	-	-	◎	-
④ Multi-operation of small pumps (diameter in inches)	1 - 3 pumps	◎	◎	◎	-	-	-	◎
	4 pumps (8 to 12)	-	-	-	◎	◎	◎	◎
	5 pumps (8)	-	-	-	◎	◎	◎	◎
	6 pumps (8)	-	-	-	-	-	-	◎
⑤ Multi-operation of different models	Including medium-sized	-	-	-	-	-	-	◎
	Including traps	-	-	○	-	-	○	◎
⑥ 1st stage temperature control	Heat-up adjustment with heater	-	-	◎	-	-	◎	-
	Cooling output adjustment	-	-	-	-	-	-	◎
⑦ Power consumption reduction	Multi-unit effect	-	-	-	○	○	○	-
	Output adjustment effect	-	-	-	-	-	-	◎
⑧ Maintenance cost		-	-	-	-	-	-	◎

[Standard system]　System in which a cryopump, trap, and compressor operate at a constant speed

[Eco system]　System in which output is adjusted according to the heat load on the cryopump/trap, resulting in minimum power consumption

① Cool-down time is reduced by high-speed cooling operation of the refrigerator.

② Heat-up time is reduced by the self-heating operation of the refrigerator.Two temperature monitors or a dedicated controller are required.

③ Regeneration is performed automatically.(Heating and cooling operation, roughing pressure measurement, purge valve and roughing valve open/close control

④ Multi-operation (multiple operation with the same compressor) of small pumps of the same diameter is possible. Up to four 10-inch diameter pumps and up to six 8-inch diameter pumps can be operated.

⑤ Multi-operation is possible by combining cryopumps and cryotraps with different diameters and refrigerator sizes as desired.
Vacuum equipment can be configured with the minimum number of compressors required. Please contact us for more information about combinations, the number of units that can be operated, etc.

⑥ The 1st stage temperature control is effective for the stable exhaust of Kr (krypton) and Xe (xenon) and for preventing Ar (argon) hang-up.
There are two types of temperature control: adjusting the heating amount of the heater and adjusting the cooling output. However, in the case of cryopumps, both methods require a heater to be installed in the 1st stage.
In the Eco system, the 1st stage temperature is controlled by adjusting the cooling output for all cryopumps/traps.

⑦ In the standard system, the more cryopump/trap units that are operating with the same compressor, the lower the power consumption per unit. (Multi-unit effect)
In the Eco system, the compressor's compression flow rate is also adjusted according to the heat load on the cryopump/trap, resulting in minimum power consumption.(Compressor output is adjustable within a range of 50 to 100%.)

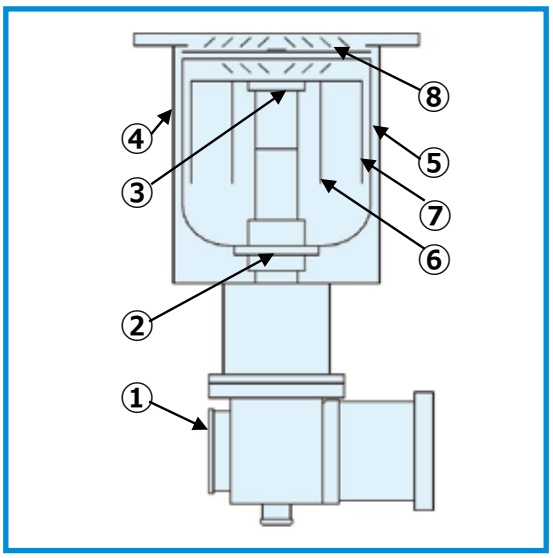
⑧ The Eco system suppresses the operation speed of cryopumps/traps, which reduces wear on the refrigerator and extends the time until maintenance is required.

■ What is a cryopump?

The gas molecules in a vacuum cool and solidify when they collide with an extremely cold surface.This is called sublimation, and it occurs when the temperature and pressure are below the triple point.Cryopumps utilize this phenomenon. The vacuum pump uses the refrigerator to cool the exhaust panel inside the vacuum chamber to extremely low temperatures, causing gas molecules to sublimate and be evacuated under vacuum.However, H_2 (hydrogen), Ne (neon), and He (helium) do not sublimate even at extremely low temperatures, so they are adsorbed by activated carbon on the exhaust panel and then evacuated under vacuum.
Cryopumps have excellent features such as a high exhaust speed and the ability to achieve a clean vacuum.However, since the gas evacuated under vacuum is stored inside, exhaust performance declines when a certain volume of gas molecules is evacuated, and it is necessary to restore the exhaust performance.The exhaust panel, which was at an extremely low temperature, is first heated to room temperature to vaporize the sublimated gas, which is then discharged outside the cryopump. This operation is called regeneration.
Since it is not possible to evacuate gas under vacuum during regeneration, the productivity and operating rate of vacuum equipment are greatly affected by how quickly regeneration can be performed or how much gas can be accumulated to reduce the frequency of regeneration.

■ Cryopump parts and exhaust principle

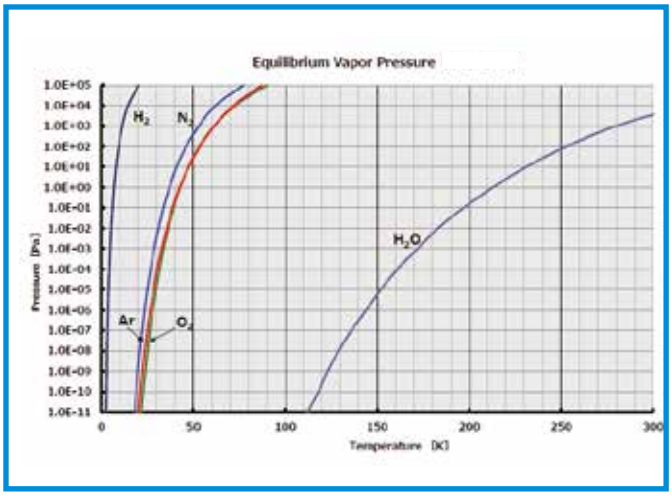
① Refrigerator ② Refrigerator first thermal load stage
③ Refrigerator second thermal load stage
④ Pump container ⑤ Radiation shield
⑥ Cryosorption panel ⑦ Cryo-condensation panel
⑧ Louver



There are two cooling sections in the refrigerator.The 1st cooling stage is cooled to 80K to 100K, and a radiation shield and louvers are installed to block heat from outside and sublimate H_2O.The second cooling stage is cooled to below 20K and consists of a cryogenic panel where N_2 (nitrogen), O_2 (oxygen), Ar (argon) etc. sublimate, and a charcoal panel with activated carbon that adsorbs H_2, Ne, and He, which do not sublimate even at temperatures below 20K.
Cryopumps use sublimation and adsorption at extremely low temperatures to evacuate gas under vacuum, and if the 2nd cooling stage is below 20K, a pressure of 10^{-7} Pa can be achieved with the pump alone.

■ Equilibrium vapor pressure

The equilibrium vapor pressure in a cryopump refers to the relationship between temperature and pressure at which the gas around the exhaust panel, which is cooled to an extremely low temperature, reaches phase equilibrium (the point at which the rate of phase change between gas and solid is equal) in a vacuum.
If the equilibrium vapor pressure corresponding to the temperature of the exhaust panel is sufficiently lower than the pressure in the chamber, the gas flowing in from the chamber side will be sublimated to the equilibrium vapor pressure and evacuated under vacuum.



The graph on the right shows the equilibrium vapor pressure of typical gases in a vacuum. If the temperature of the exhaust panel is lower than 20K, the equilibrium vapor pressure of gases other than H_2, Ne, and He will be 1×10^{-9} Pa or less, enabling sufficient vacuum exhaust performance.

Therefore, normally, the cryopump temperature (2nd cooling stage) is maintained at 20K or below as a guideline.

H_2, Ne, and He can be adsorbed by activated carbon cooled to 20K or less, enabling sufficient vacuum exhaust performance for all gases.

■ Operation of cryopump refrigerators

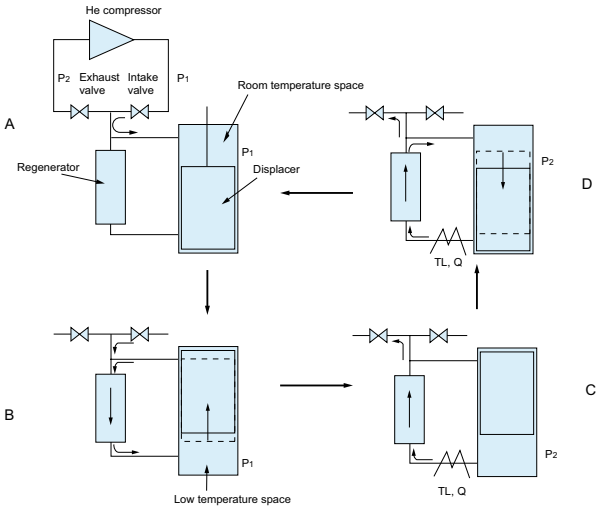
Refrigerators operate using a cooling cycle called the G-M cycle.

A: The intake valve opens and high-pressure helium gas fills the room temperature space at the top of the cylinder.(Gas remaining in the space generates heat due to adiabatic compression.)

B: When the displacer moves upward, the high-pressure gas in the room temperature space is cooled in the cold accumulator and transferred to the low-temperature space at the bottom of the cylinder. Cooling causes a reduction in volume, so more air is supplied from the intake valve.

C: When the intake valve closes and the exhaust valve opens, high-pressure gas in the low-temperature space undergoes adiabatic expansion, causing cooling.This low-temperature, low-pressure gas cools the low-temperature space (cooling stage) and the cold storage unit, and then returns to the compressor.

D: When the displacer moves downward, the low-temperature, low-pressure gas in the low-temperature space further cools the cold storage unit and returns to the room temperature space and compressor.



■ What is a self-heating function?

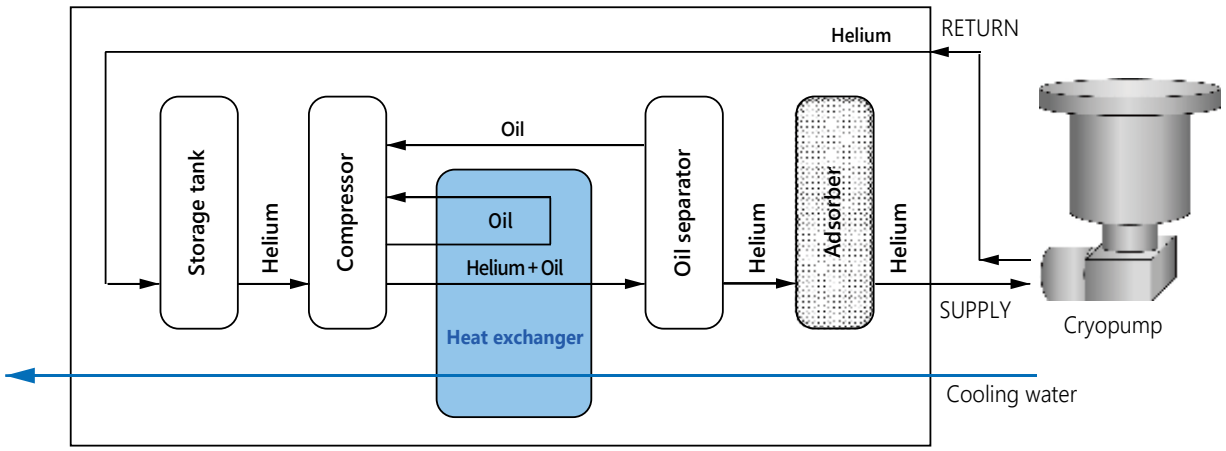
In refrigerators, cold is generated by insulating and expanding low-temperature, high-pressure helium gas in the low-temperature space inside the cooling stage.However, in the cooling cycle performed by the refrigerator, there is a process in which compression heat is generated when low-pressure gas remaining in the room temperature space is compressed into high-pressure gas (Fig. A above).The self-heating function utilizes this compression heat for heating by switching the operation timing of the displacer in response to the gas intake and exhaust timing. This generates compression heat in the low-temperature space and heats the cooling stage.
During self-heating operation, it is necessary to monitor the temperatures of the 1st and 2nd cooling stages, which are the heat-generating areas, and control them to stop at 310K.
Unlike indirect methods that heat cryopump containers with band heaters, this method directly heats the exhaust panel, allowing efficient heating in a short time.

■ Features of multi-operation (standard system)

In vacuum equipment with multiple vacuum chambers, it is common to operate multiple cryopumps with a single compressor in a multi-operation configuration. However, there are features that are unique to a multi-operation configuration.
For example, if all cryopumps in the system are cooled simultaneously, the cool-down time will be as specified in the catalog. However, if only one pump is regenerated during operation, the cool-down time will be longer than the value shown in the catalog (cooling lag).This is because the cryopump being cooled consumes insufficient helium gas due to the consumption of large volumes of helium gas by other cryopumps that are maintaining low temperatures. To minimize this effect in POWER series and POWER^{ECO} series cryopumps, the consumption of helium gas is increased by operating at high speed until 20K during cooling, thereby achieving a cool-down time that is almost the same as when all units are cooled simultaneously.
In addition, multi-systems tend to have large temperature differences between cryopumps.One reason for this is that the timing of helium gas intake and exhaust in refrigerators is arbitrary.During intake, the helium gas supply pressure drops momentarily. However, if there is a pump that intakes at that moment, the supply pressure drops slightly, causing the temperature to gradually rise if operated at that interval for a long time.
On the other hand, since more helium gas fills refrigerators with lower temperatures and thereby decreases the temperature further, the temperature difference between cryopumps tends to increase.
POWER series and POWER^{ECO} series cryopumps operate with a slight difference in operating speed between each cryopump (multi-wave operation).This ensures that the helium gas intake and exhaust times between each cryopump are switched at regular intervals, minimizing any temperature differences between cryopumps due to intake and exhaust timing.
Thanks to the above technologies, POWER series and POWER^{ECO} series cryopumps offer a greater number of cryopumps/traps compared to conventional multi-systems, resulting in a stable system with a smaller temperature difference.

■ Compressors

Helium compressor units for cryopumps have the basic configuration shown in the figure below.
Low-pressure helium gas recovered from the cryopump/trap side via the RETURN line passes through the storage tank and enters the compressor.In the case of large compressors, the compressor unit is a scroll compressor filled with oil.The oil has sealing and compression heat absorption functions. The compressed helium gas and oil are cooled in a heat exchanger before entering the oil separator.The oil circulation line is also cooled, cooling the compressor itself.The oil separator separates oil from the helium gas, returns the oil to the compressor, and sends only the helium gas to the adsorber.The adsorber is filled with adsorbents such as activated carbon, which adsorb and remove minute amounts of oil mist that cannot be removed by the oil separator, in order to supply pure high-pressure helium gas to the cryopump/trap.
Any impurities will freeze in the cryogenic section of the refrigerator, causing problems such as increased temperature and malfunctions. Therefore, the adsorbent must be replaced every 30,000 operating hours to maintain its adsorption capacity.



Basic configuration of a compressor

■ Eco system

Most of the power consumed by cryopump systems is used to compress helium gas in the compressor.
The Eco system minimizes the consumption of helium gas in the cryopump/trap and compresses only the volume of helium gas consumed in the compressor, thereby reducing power consumption.(See the figure below.)
The conventional system is designed to operate at 100% output (constant speed) at all times, assuming maximum load.
On the other hand, the Eco system suppresses output in accordance with the heat load at any given time. So, when replacing conventional systems, a reduction in power consumption of approximately 20 to 40% can typically be expected.
In addition, in conventional systems, medium-sized cryopumps and small cryopumps/traps are operated by separate compressors. However, by replacing them with an Eco system that allows cryopumps/traps to be operated by the same compressor, it is possible to reduce power consumption by approximately 50% in some cases.

In addition, the Eco system offers the following benefits.

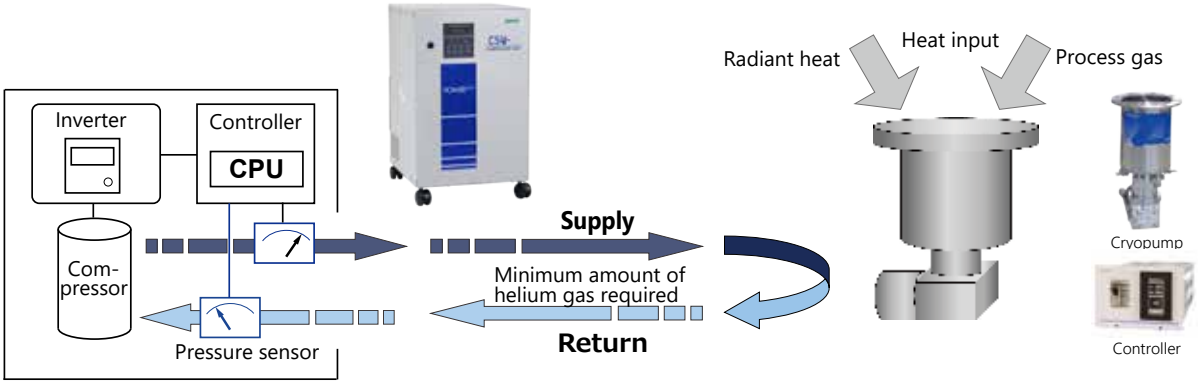
[Temperature and exhaust performance stability]　Temperature is controlled by adjusting the operation speed of the refrigerator in response to fluctuations in heat input, which also achieves stable exhaust performance.

[System stability]　The helium supply pressure is kept constant at all times and is not affected by the regeneration or shutdown of other pumps.

[Extended maintenance intervals]　The operating speed of the refrigerator is reduced, which slows down wear on seal parts and bearings, extending their service life.

[Mixed operation is possible]　Small/medium cryopumps and cryotraps can be operated with the same compressor.

[Reduced power consumption during operation]　Power consumption can be further reduced by shutting down pumps and closing main valves during operation.



Compressor

Controls the rotation speed of the compressor so that the pressure difference between the supply and return sides remains constant.
Only the helium gas consumed by the cryopump is compressed and supplied.

Cryopump

Operates the refrigerator by adjusting its output (operating speed) so that the temperature of the cryopump remains constant.
Consumes helium gas equivalent to the heat load on the cryopump.

Eco system

January 2026

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115-07-2601-0007KK