

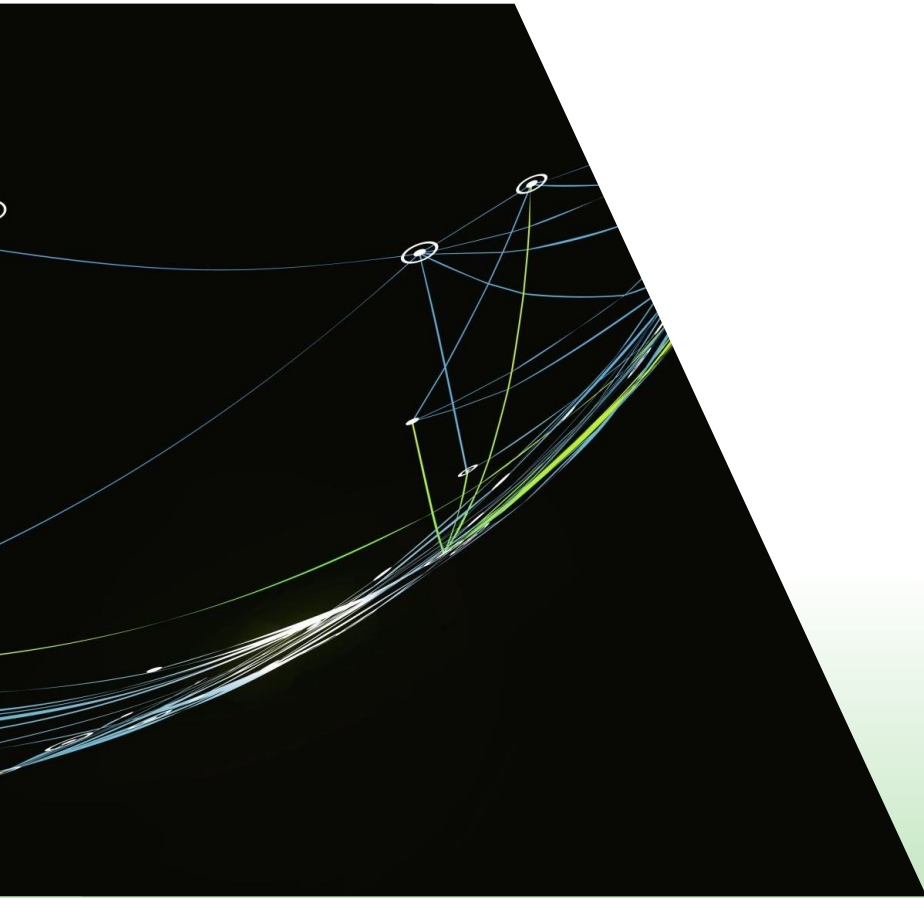


# SF6 Gas Recovery and Purification Device

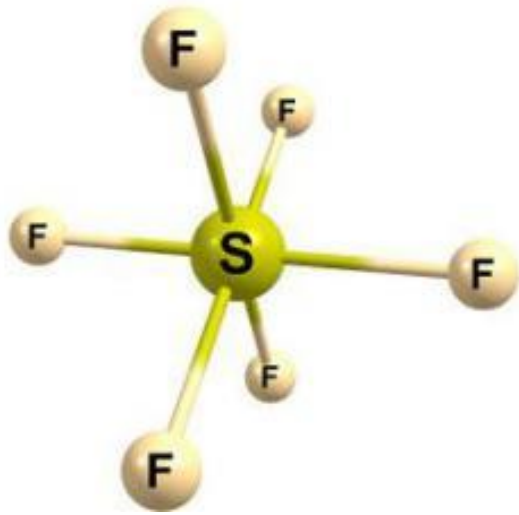


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# What is SF6 Gas?



**Molecular structure**

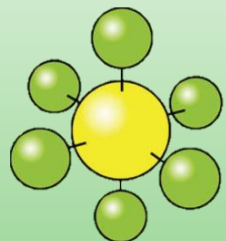
## SF6 Introduction

- International Union of Pure and Applied Chemistry (IUPAC): Sulfur Hexafluoride
- Molecular structure: The S atoms form bonds with  $sp^3d^2$  hybrid orbitals, and the molecule is a regular octahedron.
- Chemical Formula: SF<sub>6</sub>
- Molar Mass: 146.06 g/mol

# Physical Property and Global Warming Potential of SF6 Gas

SF6 is an extremely stable, non-flammable and highly electronegative gas with excellent dielectric properties. It is commonly used in medium and high-voltage electrical equipment as an electrical insulator, arc-quenching and cooling medium. However, SF6 is classified as a greenhouse gas and must be kept within a closed circuit to avoid any deliberate release into the atmosphere. Its global warming potential is 23,900 times of CO2. Its lifetime is 3200 years which is not easy to break down.

The international Kyoto agreement protocol has mandated reductions to harmful emissions amongst its member states. For the power transmission and distribution network, SF6 technology remains essential. When come in the twentieth century, all of the countries are forces on the work of SF6 gas recycling and reusing, which is one of the link of Clean Development Mechanism(CDM), the power companies have already put SF6 gas recycling and reusing details into important project of energy saving and emissions reduction.



SF6



# Global Warming Potential (GWP) Measures

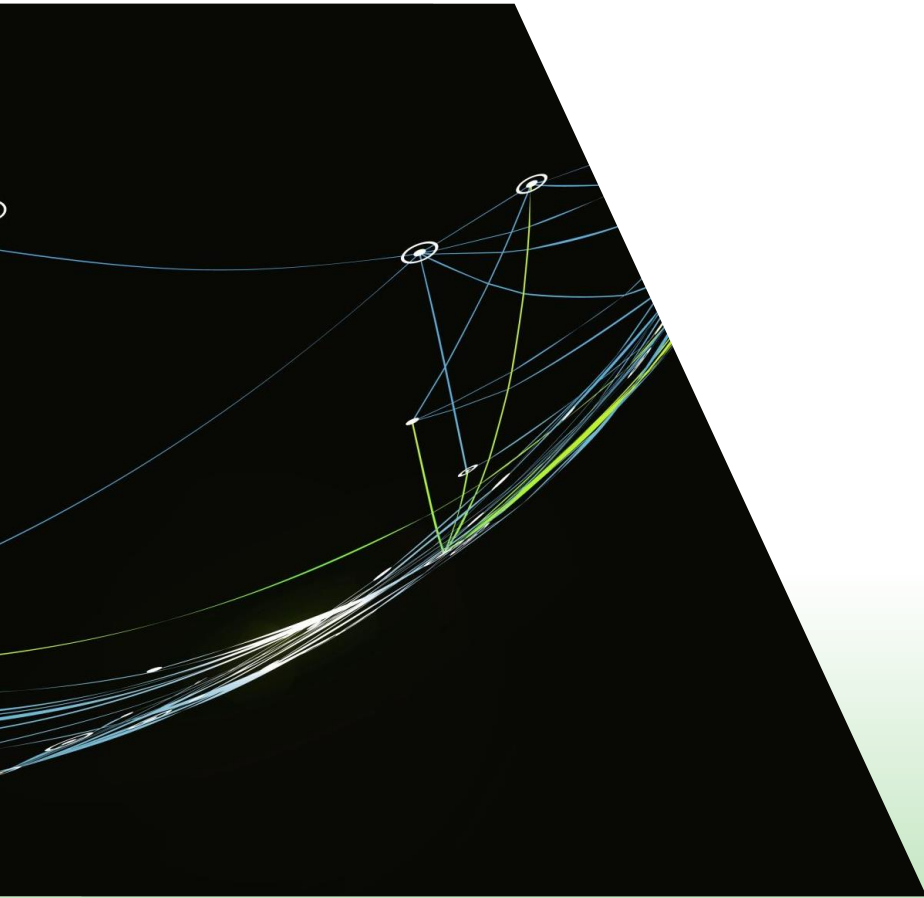
According America EPA in 2001, SF6 gas shares the most percentage in global warming effect which aren't only used in power industry but also, smelting and semiconductor industry.

**Exhibit 1.1: Major High GWP Gases in the United States (100-year GWPs)<sup>a</sup>**

Gas	GWP	Atmospheric Lifetime (yrs)	Source of Emissions
HFC-23	11,700	264	HCFC-22 Production, Fire Extinguishing Equipment, Aerosols, Semiconductor Manufacture
HFC-43-10mee	1,300	17.1	Solvents
HFC-125	2,800	32.6	Refrigeration/Air-Conditioning
HFC-134a	1,300	14.6	Refrigeration/Air-Conditioning, Aerosols, Foams
HFC-143a	3,800	48.3	Refrigeration/Air-Conditioning
HFC-152a	140	1.5	Refrigeration/Air-Conditioning, Aerosols, Foams
HFC-227ea	2,900	36.5	Aerosols, Fire Extinguishing Equipment
HFC-236fa	6,300	209	Refrigeration/Air-Conditioning, Fire Extinguishing
SF <sub>6</sub>	23,900	3,200	Electric Utilities; Magnesium Production; Semiconductor Manufacture
PFCs (primarily CF <sub>4</sub> and C <sub>2</sub> F <sub>6</sub> )	6,500 – 9,200	2,600-50,000	Aluminum Smelting, Semiconductor Manufacture, Fire Extinguishing
PFC/PFPEs <sup>b</sup>	7,400	3,200	Solvents

<sup>a</sup> Note that this table lists major commercial gases and sources; other minor gases and uses such as lab applications are not listed here. The GWP and atmospheric lifetimes are taken from Climate Change 1995, the IPCC Second Assessment Report (Schimel *et al.*, 1995).

<sup>b</sup> PFC/PFPEs are a diverse collection of PFCs and perfluoropolyethers (PFPEs) used as solvents.



# Implementation Standards



# Standard Comparison

Standard Item	China	IEC	ASTM
Purity	≥99.9%	≥99.8%	≥99.8%
CF <sub>4</sub>	≤0.04%	≤0.05%	≤0.05%
Air (N <sub>2</sub> +O <sub>2</sub> )	≤0.04%	≤0.05%	≤0.05%
H <sub>2</sub> O	≤5×10 <sup>-6</sup>	≤15×10 <sup>-6</sup>	≤8.9×10 <sup>-6</sup>
Acidity (in HF)	≤0.2×10 <sup>-6</sup>	≤0.3×10 <sup>-6</sup>	≤0.3×10 <sup>-6</sup>
Hydrolyzable fluoride (in HF)	≤1.0×10 <sup>-6</sup>	≤1.0×10 <sup>-6</sup>	—
Mineral oil	≤4×10 <sup>-6</sup>	≤10×10 <sup>-6</sup>	—
Biological toxicity	nontoxic	nontoxic	nontoxic

## Note:

China national standard: GB/T 12022-2006 《Industrial SF6 Gas》

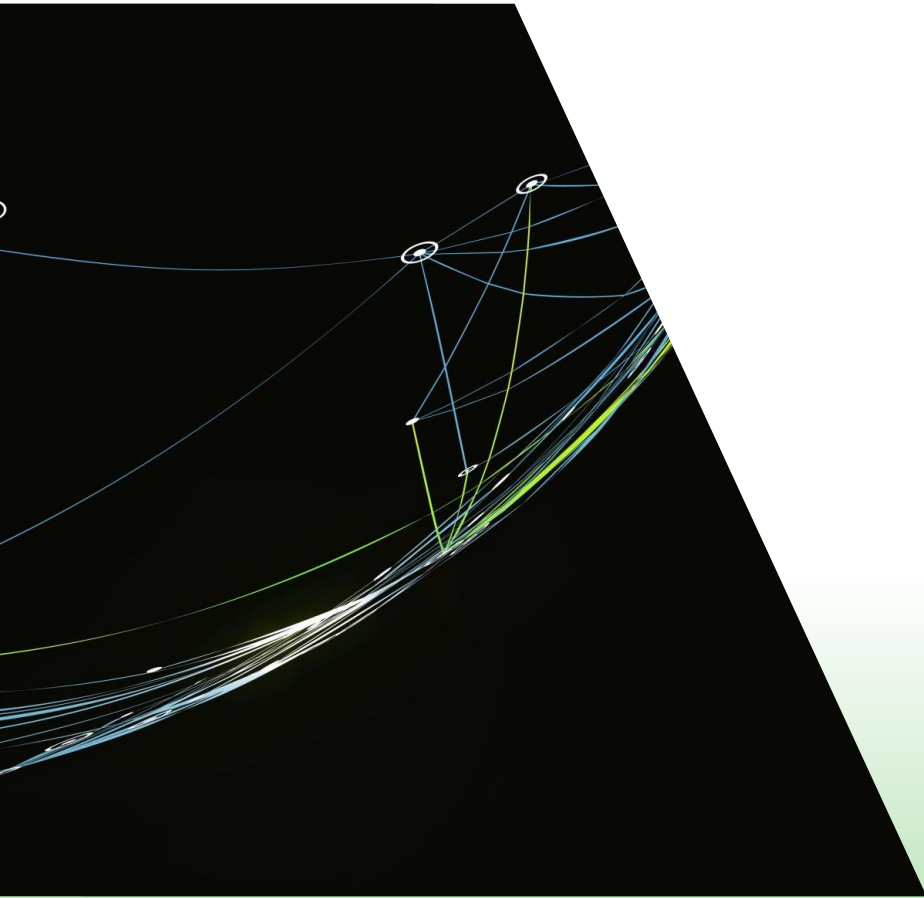
International Committee for Standardization Standards: IEC60376-2005 《New Specification and Acceptance of SF6 Gas》

American Society of Testing and Materials Standards: ASTM D2472-00(2006) 《Standard Specification for SF6 Gas》



# China vs IEC Standard Comparison

SF6 Standard Comparison		
Standard number	GB/T12022-2014	IEC60376-2005
SF6 Purity	$\geq 99.9\%$	$\geq 99.7\%$
CF4 content	$\leq 300\text{ppm}$	$2400\text{mg/kg}=2400\text{ppm}$
Air content	$\leq 100\text{ppm}$	$2\text{g/kg}=2000\text{ppm}$
Dew Point	$\leq 5 \times 10^{-6} = -49.7 \text{ deg C}$	$25\text{mg/kg}=25\text{ppm} = -36 \text{ deg C}$
Acidity expressed as HF	$\leq 0.2\text{ppm}$	$1\text{mg/kg}=1\text{ppm}$
Hydrolysable fluorides	$\leq 1\text{ppm}$	
Oil content	$\leq 4\text{ppm}$	$10\text{mg/kg}=10\text{ppm}$



# SF6 Gas Recovery and Purification Device RF300J

# Application Introduction



## Application

- SF6 gas electrical equipment, transformer, GIS, GIL, etc.
- Low and medium voltage gas insulated switchgear(10-40.5KV);

High voltage circuit breaker、GIS(72.5KV、110KV、220KV、330KV、500KV、750KV );

Recovery, purification and refilling of SF6 gas in 500KV circuit breaker.

# Patent for Invention of SF6 Gas Recovery and Purification Method



# Technical Specifications

Dimension	2400×1400×2150 (mm)	Yearly leakage rate	≤1%
Power supply	380V±10% 50Hz	Noise	< 75dB (A)
Power	20kw (Max)	Purifying capacity	Moisture ≤40ppmv
Weight	1800kg		Acid value≤40ppm/wt
Storage tank	300L		CF4 ≤0.04%
Vacuum pumping speed	100m³/h (Max)		Air ≤0.04%
			Purity ≥99.9%
			Dust filtration accuracy: < 1μm dust
			Gas quality after purification: conforming to new gas standard of GB12022-2014.

# Functional Units Introduction



Units:

- 1) Molecular sieve
- 2) Oil-free compressor designed for SF6 gas
- 3) Refrigerating unit
- 4) Vacuum compressor (negative pressure recovery pump)
- 5) Vacuum pump
- 6) Compressor for refilling
- 7) Operation interface
- 8) Solenoid valves
- 9) Purification unit

# Molecular Sieve (Adsorbent)

This unique unit component is crucial as its purpose is to remove impurities such as dust, flocs, moisture, toxic subfluoride, and decomposition products in SF6 gas. This selection of molecular sieve offers good adsorption, strong adsorption capacity and good regeneration ability.



Visible filter for  
floc and dust

## Main features:

- Adsorption of impurities such as dust, flocs, moisture, toxic subfluoride, decomposition products in SF6 gas
- Technical parameters: filtration accuracy  $\leq 1$  micron
- Renewable rate: 3000Kg (4-5 times) ; Automatic notification of regeneration status



# Oil-Free Compressor



According to the physical characteristics of SF6 gas and the difference of ambient temperature in each area of China, oil-free compressor is selected, and supplemented with refrigerant; Even when working in high temperature environment, SF6 gas recovery device can recover SF6 gas in SF6 electrical equipment quickly and efficiently (maximum recovery rate is 200Kg/h); It can satisfy the “failure found, timely fix” requirement of power utilities.

## Main features:

- SF6 gas recovery in SF6 electrical equipment; The recovery process is supplemented with refrigerant
- Technical parameters: Inlet pressure < 0.6MPa; Recovery rate: 38m<sup>3</sup>/h; Outlet pressure ≤3.3MPa.

# Refrigerating Unit

In order allow SF6 gas to efficiently recover at ambient temperature, environment friendly refrigeration unit from France DANFOSS(R410A) is selected to assist the oil-free compressor unit for quick and efficient recovery as well as refilling.



**R410A:** It is a new type of environment friendly refrigerant that does not destroy the ozone layer. It is mainly composed of hydrogen, fluorine and carbon elements (represented as HFC), with the characteristics of stability, non-toxicity and superior performance. At the same time, because it does not contain chlorine, it will not react with ozone and destroy the ozone layer. Therefore, its ozone depletion potential (ODP) is 0, and the global warming potential (GWP) is less than 0.2.

## **Main features:**

- **Assists the oil-free compressor for quick and efficient recovery and refilling**
- **Technical parameters: Refrigerating capacity is 7.5kW**

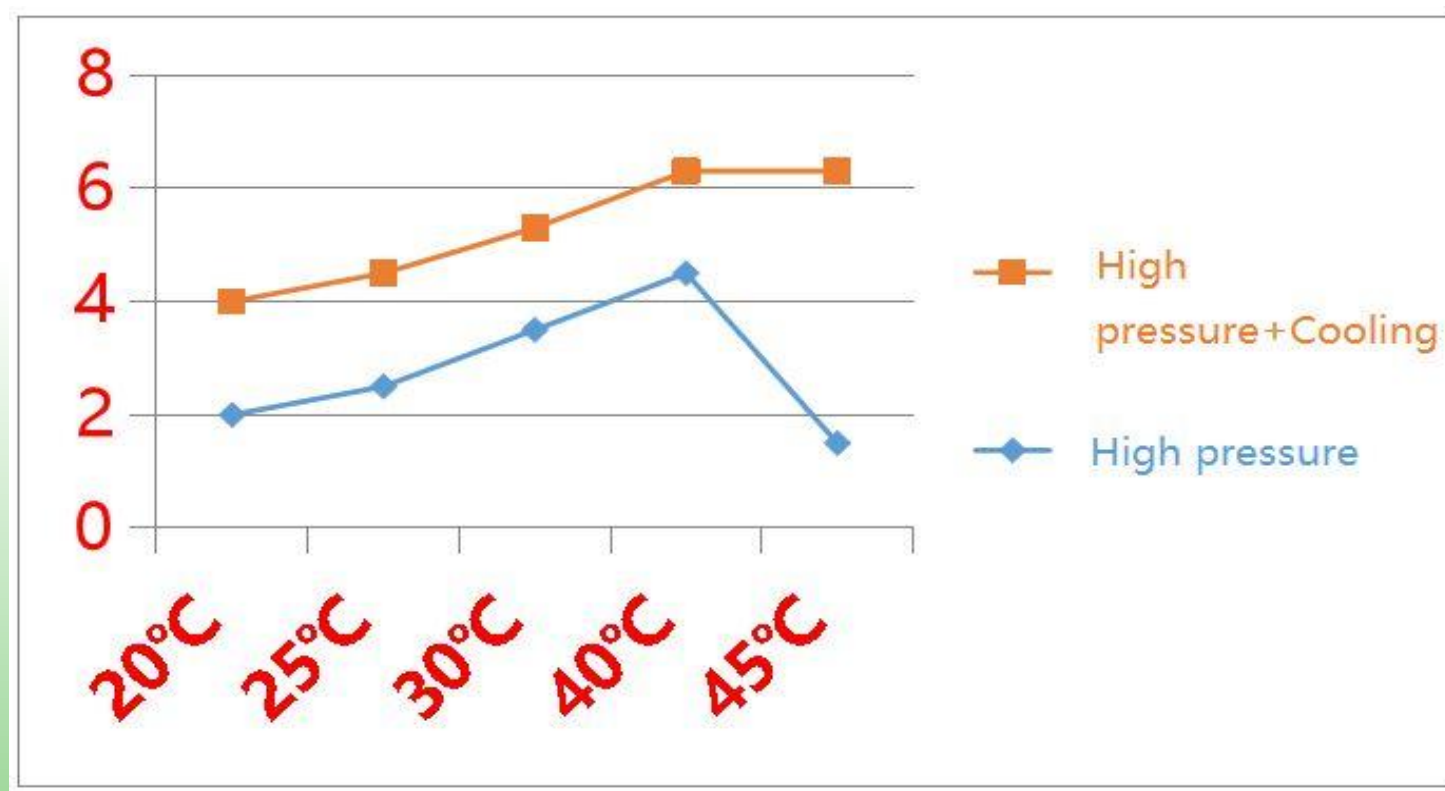
# Refrigerating Unit

There are two methods to recover SF6 Gas:

- High pressure compression
- High pressure + low temperature refrigerant refrigeration

These two methods are compared in the graph below.

The oil-free compressor is used with inlet pressure of 0.6MPa and outlet pressure of 5.0MPa with a recovery rate of 20m<sup>3</sup>/hr

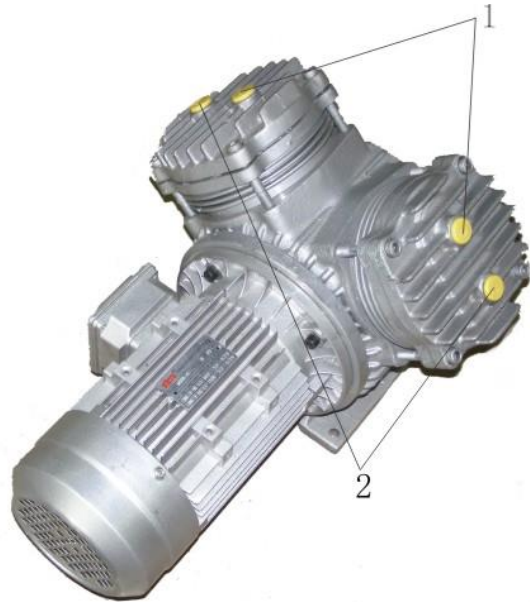


## Vacuum Compressor (Negative Pressure Recovery Pump)

To allow the SF6 gas to be fully recovered from the electrical equipment (to point of vacuumed state), HR configured the negative pressure recovery pump with a powerful vacuum compressor to meet the needs of end users.

**Note:**

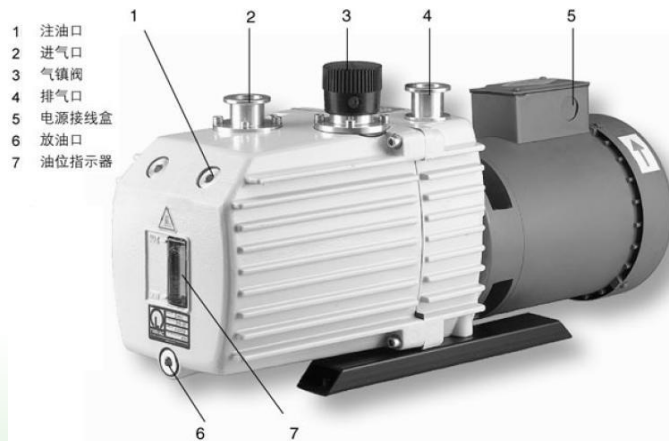
- Outlet – ZG1/2
- Inlet – ZG1/2



### **Main features:**

- Works hand-in-hand with the oil-free compressor to completely recover all SF6 from the electrical equipment until vacuum state
- Technical specification:
  - Power: 380V, 1.1kW
  - Recovery rate: 20m<sup>3</sup>/Hr
  - Vacuum: 100mbar-10mbar

After multiple case studies, German Leybold vacuum pump with high efficiency vacuuming with built-in oil feature was selected. The vacuum pump can be configured according to the end user's requirements (17m<sup>3</sup>/Hr – 253m<sup>3</sup>/Hr)



## Main features:

- Systematic evacuation to the SF<sub>6</sub> gas recovery device and vacuum treatment of external cylinders
- Technical specification:
  - Vacuum rate: 17m<sup>3</sup>/Hr – 253m<sup>3</sup>/Hr
  - Vacuum:  $\leq 0.1-4 \times 10^{-3}$  mbar

## Compressor for Refilling

To prevent cross-contamination of SF<sub>6</sub> gas before and after purification treatment, the oil-free compressor is used for refilling of the SF<sub>6</sub>. The outlet pressure can reach up to 50bars. With the help of the refrigerant refrigeration unit, a bottle of standard (T40) 50KG of SF<sub>6</sub> gas can be refilled in 5-8 minutes.

**Note:**

- Liquid outlet
- Liquid inlet

**Main features:**

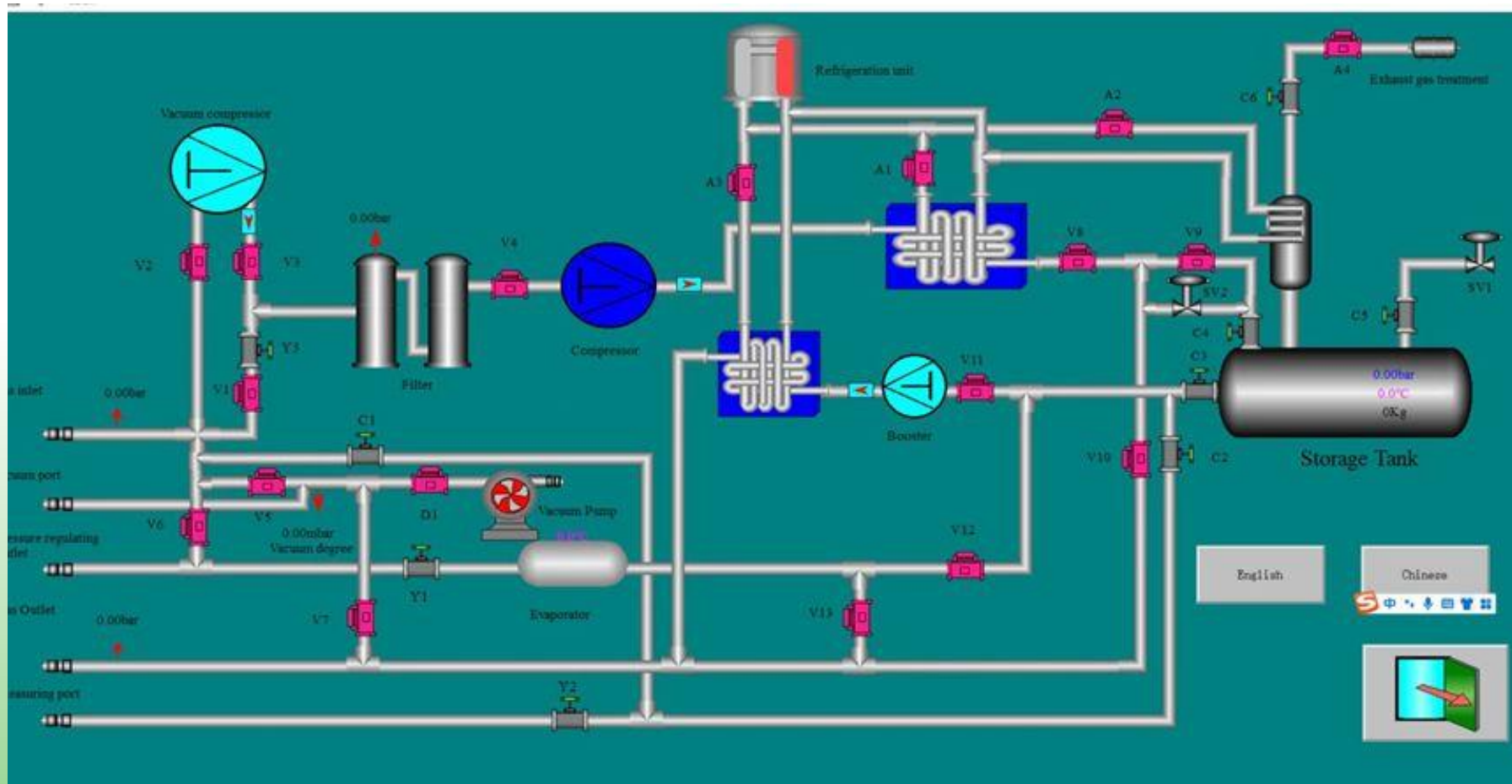
- Rapid liquid storage of SF<sub>6</sub> gas into cylinders or pressure vessels
- Technical specification:
  - Inlet pressure: < 0.6MPa outlet
  - Outlet pressure ≤ 5.0MPa





# Operation Interface

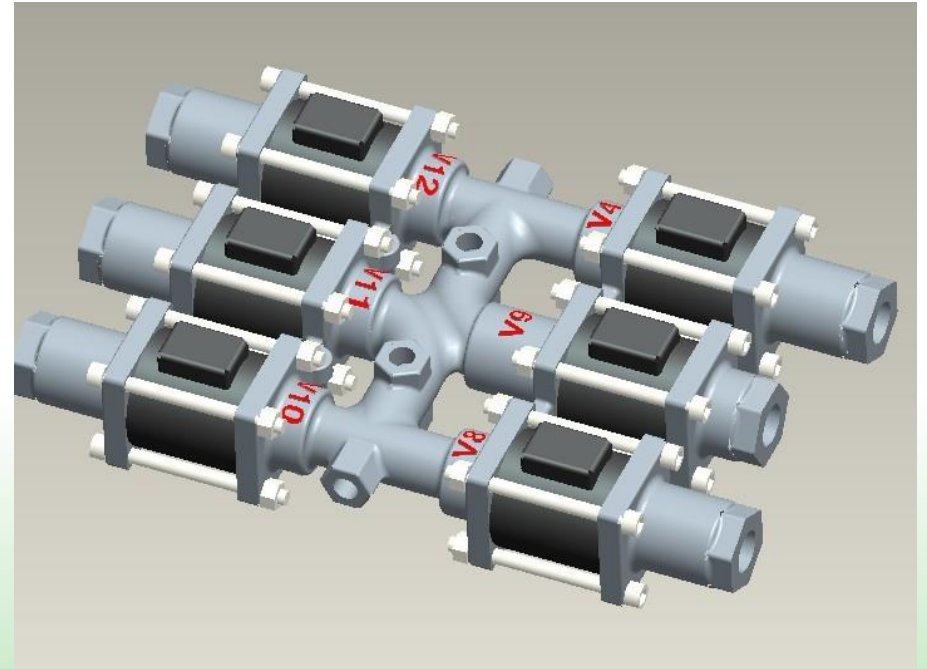
RF300J offers simple operation and control of the SF6 gas recovery device with functions of automated diagnosis and safety alerts to PLC. The device also adopts a one-button touch screen control to display each operation in real time.





## Solenoid Valve

With control from the PLC unit, the linked solenoid valves enables the SF6 gas recovery device to operate via the touch screen control with features of recovery, vacuuming purification and refilling.

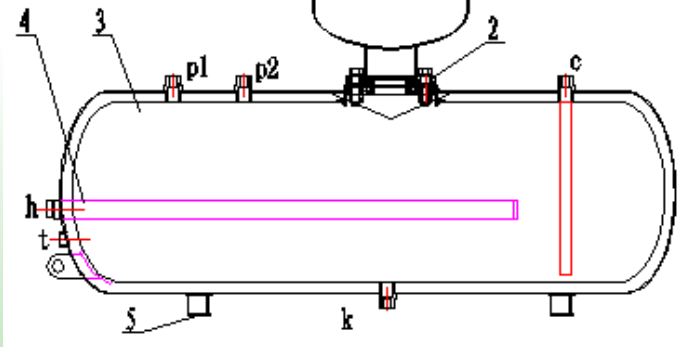


**Working principle :**

Under certain conditions, the light and heavy components of gas components that has various vaporization rates can be separated by conducting mass and heat transfer in a specific container as well as undergoing multiple partial vaporization and multiple partial condensations.

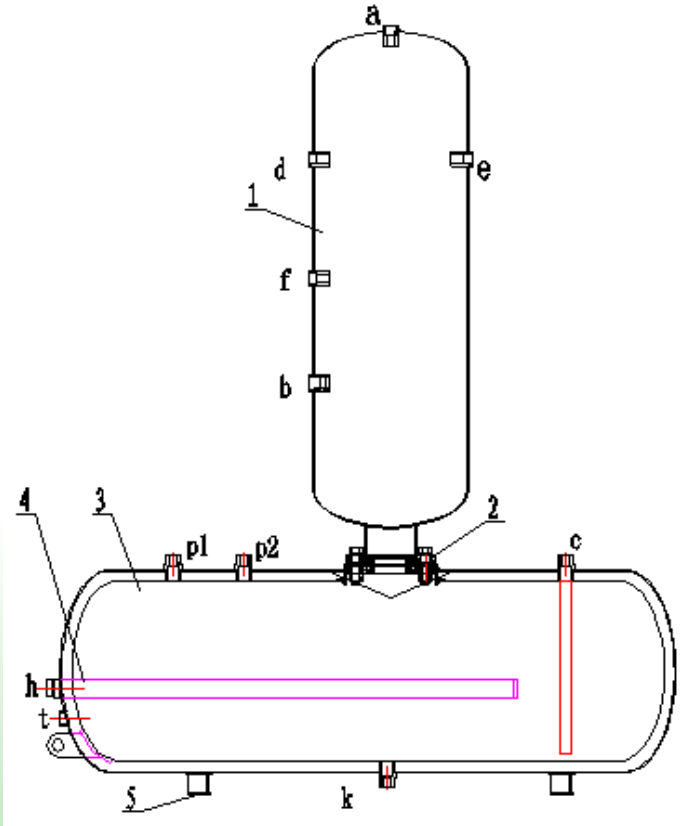
**Main function:**

Removing micro amount of air in SF6 gas; making the purified SF6 gas conforms to the new gas standard specified in GB/T12022-2006.



**Note:**

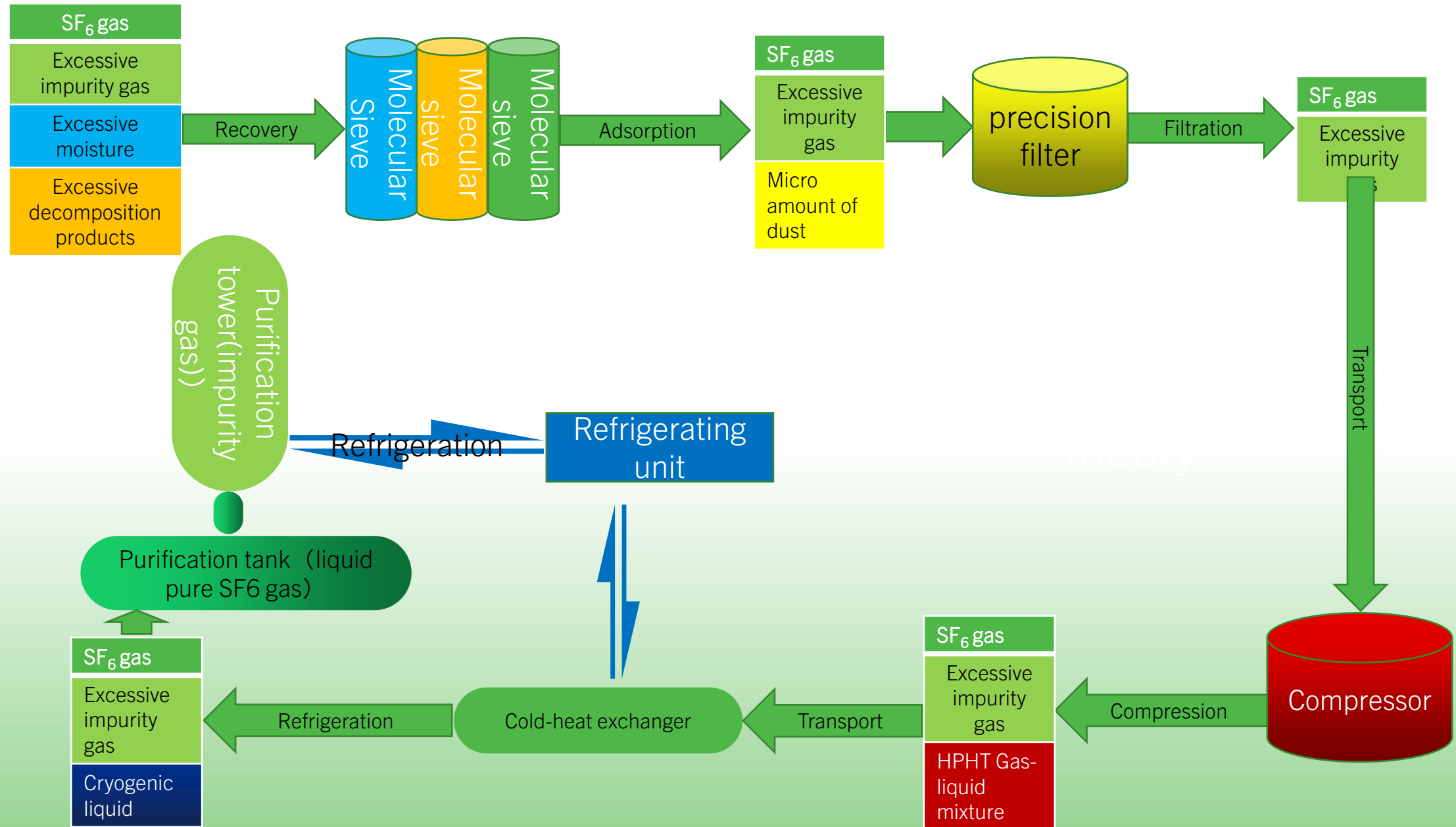
- Purification tower
- Flange
- Purification tank
- Heating rod
- Support



On site SF6 gas recovery from SF6 electrical equipment upon the need of SF6 gas purification, the device will automatically switch on purification lifting unit and execute the recovery and purification of SF6 gas.

When SF6 gas in SF6 electrical equipment meets the standard, it will directly recover SF6 gas to the purification tank (when purification treatment is not required), and the operation of purification and recovery process is switched and completed by the dedicated solenoid valve.

## Schematic diagram of SF<sub>6</sub> gas recovery and purification



# Thank You