Principle of refrigeration air dryer

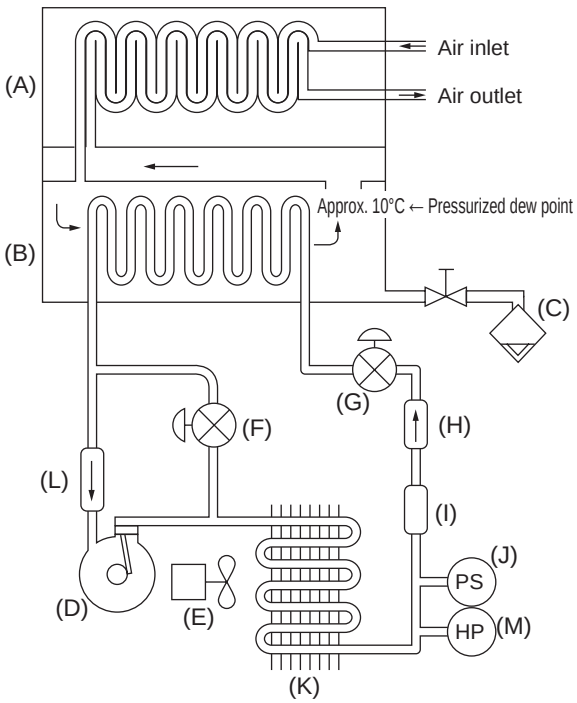
Air circuit

Warm humid compressed air is precooled by cold and dehumidified compressed air in the air balancer (A) (precooler). Precooled compressed air is led to the cooling chamber (B) (evaporator) and cooled to the pressured dew point of 10˚C by cold Freon gas vaporization heat. Water vapor in cooled compressed air condenses and changes into water drops (drain). Water drops are automatically discharged outside by the auto-drain (C).
The compressed air cooled in the cooling chamber (B) is led to the air balancer (A) (reheater) again, and is reheated by warm compressed air from the inlet.
This reheated compressed air becomes warm dry air and is discharged from the air outlet.

Refrigerant circuit

High temperature/high pressure Freon gas discharged from the refrigerating compressor (D) is led to the condenser (K). It is cooled by the cooling fan (E) using ambient temperature and condensed to warm high-pressure liquid. Warm/High pressure Freon liquid is led to the filter dryer (H) where dirt and water in the refrigerant are caught. Then it is compressed and expanded into specified low pressure/low temperature liquid by the automatic temperature expansion valve (G) (or capillary tube), and led to the cooling chamber (B) (evaporator). Low pressure/low temperature liquid (mist) in the cooling chamber is evaporated to gas by heat exchange with warm wet compressed air and is sucked into the refrigerating compressor.
The capacity regulating valve (F) bypasses refrigerant gas when thermal load in the cooling chamber is lowered, and returns the gas to the refrigerating compressor inlet. This suppresses the amount of refrigerant that flows into the cooling chamber, and prevents freezing from over-cooling.
When the refrigerating compressor suction pressure drops to the set pressure or lower, the valve opens automatically, and high humidity/high pressure gas is bypassed. Thus, the refrigerating compressor can be continually run even in a no-load state.
The fan control switch (J) is used to turn the cooling fan (E) ON/OFF and maintain high pressure (condensed pressure) at a constant range. This pressure switch activates when high pressure is detected.

(System diagram)



Function of service parts

No.	Name		Operation
(A)	Heat exchanger	Precooler/reheater	Exchanges heat between high temperature/high humidity compressed air and low temperature compressed air
(B)		Evaporator	Cools compressed air with liquid refrigerant evaporative latent heat and condenses water vapor to remove moisture
(C)	Auto-drain (drain discharger)		Automatically discharges drain
(D)	Refrigerating compressor		Compresses low pressure refrigerant vapor to turn it to high pressure refrigerant vapor
(E)	Cooling fan		Sends cold air to condenser
(F)	Capacity regulating valve		When air flow drops, flows high temperature refrigerant gas to prevent overcooling
(G)	Automatic expansion valve		Depressurizes high pressure liquid refrigerant to turn it to low pressure/low temperature liquid
(H)	Filter dryer		Filters out foreign matters from the refrigerant circuit (water, dirt)
(I)	Receiver		Collects refrigerant liquefied by the condenser, separates it into air and liquid, and feeds only liquid refrigerant to the automatic expansion valve
(J)	Fan control switch		The cooling fan operates when refrigerant pressure on the high pressure side rises to the specified pressure and stops when the pressure drops to the specified level. This controls refrigerant temperature.
(K)	Condenser		Cools high temperature/high pressure refrigerant vapor to turn it to high pressure liquid refrigerant
(L)	Accumulator		Separates liquid refrigerant from vapor so that liquid refrigerant is not sucked into the refrigerating compressor
(M)	High pressure switch		Stops refrigerating compressor operation when high pressure side refrigerant pressure rises to a specified pressure

Features of CKD refrigeration air dryer

1 Highly efficient

2 Environment-friendly new refrigerants R-134a, R-410A, and R-407C in various sizes (capacities) from compact to super large are adopted

3 Energy saving

① Energy-saving operation with 50% decreased power by limiting the number of refrigerating compressors (GT9300(W) to GT9450(W))

② Energy-saving operation with 60% decreased power through inverter control (GT9000WV2 Series)

4 Stainless steel is used as standard for compact to super large heat exchange vessel (container)

5 Dust filter is standard for air cooling condenser

Air cooling and water cooling

● Refrigeration air dryers are generally categorized into air cooling and water cooling.
Refer to the following explanation to select a model according to required applications and performance.

○ Refrigeration air dryers use evaporative latent heat of the refrigerant to cool compressed air, and condense and remove the moisture content.

○ In a set closed circuit, the refrigerant repeatedly changes: high temperature/high pressure gas → high temperature/high pressure liquid → low temperature/low pressure liquid → low temperature/low pressure gas → high temperature/high pressure gas.
When evaporating and changing from low temperature/low pressure liquid to low temperature/low pressure gas, the heat is drawn from the surroundings. It means that the compressed air loses heat and cools. This part is called the evaporator in the refrigerating cycle.

○ Conversely, the section to liquefy high temperature/high pressure gas is called the condenser. High temperature/high pressure gas discharged from the compressor must be changed to high temperature/high pressure liquid. So the refrigerant is forced-cooled.

○ For forced cooling, air-cooled and water-cooled are available.

Air cooling (compact to ultra large)

Air (outer air) is fed by a fan to cool refrigerant piping, to which fins are installed for improving conductivity. The air around the dryer is used for cooling, so efficiency is affected by air temperature. During summer, the place where the dryer is installed (compressor room) gets very hot, so this method is not effective for cooling. The fan runs continually, but is still insufficient for cooling. By contrast, the air temperature is low during winter, so the fan starts and stops to adjust the state to avoid overcooling.

Advantages: (1) Maintenance is easy.
The condenser's dust filter must be cleaned for clogging once every several months, but this only involves blowing with air and requires barely any expertise. (If the filter is heavily contaminated, it must be washed or replaced.)
(2) Only space required for taking in and exhausting air must be secured. There is no impact by other installation work.

Disadvantages: (1) The refrigerant's high pressure is adjusted by turning the fan ON/OFF, so it is hard to stabilize the high pressure side. It is also harder to stabilize the dew point compared to the water cooling method.
(2) Cooling performance is often insufficient in the summer, and the overload state occurs easily.
(3) A large amount of air is fed by the fan, so the noise level is high and dust is raised.
Heat exhaust (ventilation) may be required.

Water cooling (medium to ultra large)

The refrigerant pipe is cooled with water in this method. A plate or double pipe type condenser is often used. The cooling water rate is adjusted by the water regulating valve on the top of the cooling water pipe. The high pressure value of the refrigerant is detected, and valve opening is automatically adjusted by the pressure balance mechanical structure.

Advantages: (1) Cooling water is adjusted variably so high pressure stability is high, and it is easy to stabilize the dew point.
(2) A stable cooling effect is obtained in summer so the system does not fail easily. Stable dew point performance is achieved through the year.
(3) The installation environment is not affected. Dust is not raised. There is no fan noise. There is no heat by discharged wind, so the room temperature does not rise.

Disadvantages: (1) Accompanying work, such as water piping, is required.
(2) The condenser must be back-washed by qualified personnel once every 6 to 12 months.

⚠ Cooling water of a water cooling air dryer

Observe the following cautions for cooling water for the water-cooled condenser in the refrigerating compressor.
If the following water quality standards are not met, performance may be compromised, and the service life of the condenser could be reduced significantly.

1 The cooling water quality should be as per the "Guideline of Water Quality for Refrigeration and Air Conditioning Equipment" provided by the Japan Refrigeration and Air Conditioning Industry Association.

Japan Refrigeration and Air Conditioning Industry Association

Item	Chemical formula	Unit	Cooling water of CKD water cooling dryer Water quality standard	Japan Refrigeration and Air Conditioning Industry Association Guideline of Water Quality for Refrigeration and Air Conditioning Equipment Cooling system - Circulating type - Circulating water (JRA-GL-02-1994) Water quality standard
pH	—	pH(25℃)	6.5 to 8.2	6.5 to 8.2
Electrical conductivity	—		0.2 to 80 {2 to 800}	80 or less {800 or less}
Chloride ion	Cl-	mg/ℓ (ppm)	200 or less	200 or less
Sulfate ion	SO4–		100 or less	200 or less
Acid consumption (pH 4.8)	CaCO3	mg/ℓ (ppm)	100 or less	100 or less
Total hardness	CaCO3		200 or less	200 or less
Calcium hardness	CaCO3	mg/ℓ (ppm)	150 or less	150 or less
Ionized silica	SiO2		50 or less	50 or less
Iron	Fe	mg/ℓ (ppm)	0.5 or less	1.0 or less
Copper	Cu		0.3 or less	0.3 or less
Sulfide ion	S--	mg/ℓ (ppm)	Not detected	Not detected
Ammonium ion	NH_4+		1.0 or less	1.0 or less
Residue chlorine	Cl	mg/ℓ (ppm)	0.3 or less	0.3 or less
Free carbonic acid	CO2		4.0 or less	4.0 or less
Stability index	—		6.0 to 7.0	6.0 to 7.0
Matson rate	HCO3-/SO4--		1.0 or more	
Hydrogen carbonate ion	HCO3-	mg/ℓ (ppm)	-	
Oxygen rate			0.1 or less	
Aluminum	Al	mg/ℓ (ppm)	0.2 or less	
Manganese	Mn		0.1 or less	
Nitric acid ion	NO3-	mg/ℓ (ppm)	100 or less	
Sodium ion	Na+		20 or less	
	PO4---	mg/ℓ (ppm)	2.0 or less	
	NH3		0.5 or less	
	Mn++	mg/ℓ (ppm)	10 or less	
	H2S		0.05 or less	
Evaporation residue		mg/ℓ (ppm)	50 or less	
Turbidity			2 degrees or less	

- Cooling water containing many elements that could accumulate or precipitate in the condenser/cooling water piping, or containing many corrosive elements must not be used.
- Soften hard water before use.

2 Install a 20 mesh strainer on the cooling water inlet.

3 Wash the condenser on a periodic basis.

⚠ Installation environment and air quality

Refrigeration air dryers use copper pipes (phosphorus deoxidized copper pipes) for the refrigerant gas pipes and pipes within the heat exchanger. When corrosion causes a hole in these copper pipes, the refrigerant gas will leak and make it impossible to operate the unit, or cause failure such as water leaking from the compressed air outlet side of the air dryer. In addition, copper is also used as conductive materials for the electrical wiring, etc. Corrosion thereof may cause failures which may lead to safety problems such as electrical leakage accidents.
Especially in the copper piping in the heat exchanger, dew formation and desiccation are repeated. If corrosive elements are present, they may condense on the surface of the copper piping and accelerate corrosion. Under such conditions, take special care with the air dryer installation environment and the air taken in by the air compressor. Failures caused by corrosion are not covered by the warranty.
Plant exhaust may contain corrosion-promoting elements such as NOx (nitrogen oxides), SOx (sulfur oxides), and CO_2 (carbon dioxide). Select the air dryer and air compressor installation position with care so that they are not affected by plant exhaust. In rare cases, if chlorine-based organic solvents (trichloroethylene, etc.), aldehyde or alcohol (formaldehyde generated from building materials or methanol in the chemicals used) are absorbed by the air dryer and hydrolyzed, the copper piping could corrode (like an ant nest). Caution is required in these cases.