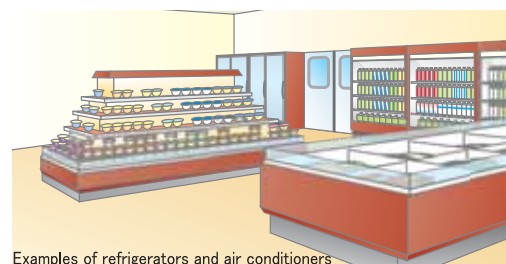


Natural Refrigerant-Based Refrigerators and Air-conditioners

What are natural refrigerant-based refrigerators and air-conditioners?



Examples of refrigerators and air conditioners

In order to enjoy a comfortable indoor temperature and keep food fresh, we use air-conditioners, freezers and refrigerators. These machines move heat from inside the room or machine to outside to reduce the temperature. Substances that carry the heat are called the "refrigerant."

Due to their excellent properties, "fluorocarbons," man-made fluorine compounds, were used as

refrigerants. However, since fluorocarbons deplete the ozone layer and contribute to climate change, substitutes with less impact on the environment are being developed and commercialized. These refrigerants include ammonia (NH₃), carbon dioxide (CO₂), water (H₂O), air and hydrocarbons (HCs), which are called "natural refrigerants" since they all naturally exist in nature.

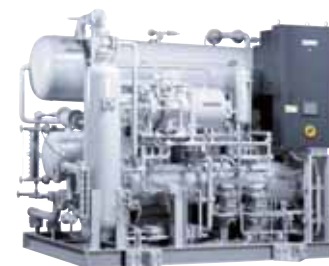
Features of Major Natural Refrigerants

Ammonia Refrigerant (NH₃)

Ammonia was used widely as a refrigerant before the dissemination of fluorocarbons. However, due to disadvantages such as "poor performance below -30 °C", "being toxic and odorous, dangerous to use in situations where there may be contact with people", fluorocarbons became the dominant refrigerant.

Recently these disadvantages have been overcome, and as fluorocarbons' impact on the environment has become recognized, ammonia refrigerant has been reevaluated as a superior refrigerant and ammonia-based products are being commercialized.

In the past, since ammonia refrigerant is toxic, the "indirect cooling method" was recommended, but the energy efficiency of this method was worse than the "direct cooling method" in some conditions. Today, with technology development, the efficiency has been improved by combining with CO₂ refrigerant for the indirect cooling method, while high safety has been achieved for the direct cooling method.



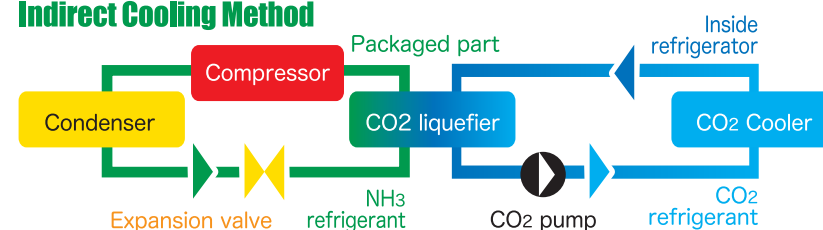
Ammonia Refrigerant Freezer

<Features of Ammonia Refrigerant>

- Requires small quantity of refrigerant (heat transfer coefficient is better than fluorocarbon refrigerants)
- Better COP* than fluorocarbon refrigerants in temperature range for freezers, refrigerators and air-conditioners.

<Usage Example> Commercial cold storage

Indirect Cooling Method



Example of System using Ammonia Refrigerant

*What is a Coefficient Of Performance (COP)?

Just as the "gas mileage", how many miles a car can travel on one gallon of gasoline, is important, the amount of cooling that a refrigerator can deliver from one kW of input energy is important. The amount of motive power and heat (input) consumed versus the refrigerating capacity (output) is known as the "COP": Coefficient of Performance. It is a measure of energy efficiency. The larger the COP value, the more energy-efficient the device is.

Carbon Dioxide Refrigerant (CO₂)

Although carbon dioxide is known as a major greenhouse gas, it is a promising refrigerant as one of alternatives to fluorocarbons since its Global Warming Potential (GWP) is significantly lower (GWP=1) than fluorocarbons and it is non-toxic and non-flammable.

When carbon dioxide is used as a refrigerant, it must operate at high pressure and this made it difficult to commercialize in compact appliances. Today more efficient and compact appliances have been developed by using a two-stage compression method.



Drinks showcase

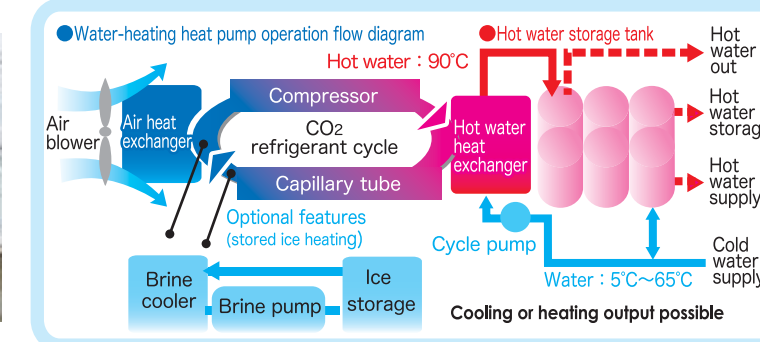
When used as a refrigerant in freezers, carbon dioxide has comparatively low efficiency, but it is suitable for heating equipment that transfers heat from outdoors to make hot water. For this application, carbon dioxide has become the most suitable and popular refrigerant in recent years.

For example, it is used in "Eco-cute" water heaters, which make use of cheaper nighttime electricity to heat water for use in our daily life.

Example of system using CO₂ refrigerant



Eco-Cute

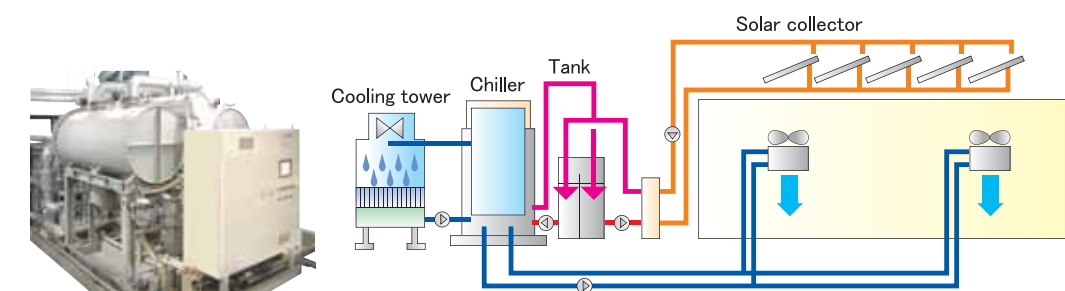


<Features of carbon dioxide refrigerant>

- non toxic, odorless ● non-flammable
- High COP for water-heating compared to fluorocarbon refrigerants
- <Usage Example> water-heating in domestic houses, hospitals, hotels, and spas. Cooling in vending machines and drinks showcases.

Water Refrigerant (H₂O)

Water is a safe refrigerant with no toxicity and flammability. It can be used as a refrigerant by combining with other substances. Absorbent cooling systems combined with a solid absorbent (Silica gel) and absorption freezers and refrigerators combined with lithium bromide etc. have been commercialized. These types of equipment are not relatively energy-efficient, but water is non-toxic and non-flammable and can make use of solar heat and waste heat from factories. In these cases, these systems are very energy-efficient.



Absorbent chiller

Example of water chiller system using solar heat

<Features of water refrigerant>

- non-toxic, odorless ● Main drive mechanism is a pump: compressor is not required
- non-flammable ● Solar heat or waste heat can be used to produce chilled water
- <Usage Example> Cooling equipment using waste heat from Industrial reactors or engines, or natural energy etc.