Innovative refrigeration technologies at a glance

HOF has a long-standing commitment to the issues of environmental protection, climate protection and greenhouse gases. We consequently offer our plants based on conventional refrigeration technology as well as a whole range of refrigeration technologies that are based on the use of natural refrigerants. Instead of refrigerants with a high impact on the climate, such as R404A/R507A, these plants use hydrocarbons (ethane/propene), liquid nitrogen or – as in the case of our innovative HOF CryoBlizzard cold air machine – air as a refrigerant.

Air as a refrigerant

Using air for refrigeration offers multiple advantages. For one, air is available everywhere, can be used safely and – with a GWP of 0 – does not promote climate change in any way. In addition to this, temperatures below -80 °C can easily be achieved with cold air machines such as the HOF CryoBlizzard. Legal regulations regarding the F-Gas Regulation consequently do not apply.

Compression refrigeration

Refrigerants such as R452A, R404A, R410A or R507A are used in conventional refrigeration systems, which we offer with two-stage compressors for refrigeration in the freeze drying process if requested by the customer. As known and well-tried refrigerants, these have the advantage of being non-flammable and non-toxic. They also require little space and low investment costs. With respect to the F-Gas Regulation, however, some legal regulations have to be taken into account.

Nitrogen as a refrigerant

Our plants with liquid nitrogen as a refrigerant offer immediate cooling performance, because the -196 °C cold nitrogen is supplied directly from nitrogen tanks installed outdoors. In addition to this, these plants offer easy commissioning and a future-proof design because they are not affected by new legal regulations. They also impress with low maintenance costs while offering a high level of temperature flexibility.

Hydrocarbons as a refrigerant

Our two-stage CAR6 cascade system allows us to achieve low temperatures with natural refrigerants. The refrigerants used are the hydrocarbons ethane and propene, which allow a very high level of efficiency to be achieved with maximum flexibility. The cascade systems ensure safe operation of a plant which is also future-proof.

Freeze drying with

air as a refrigerant
The new innovative technology: HOF CryoBlizzard central refrigeration

Ambient air as a natural refrigerant

This approach is at the core of the new and innovative HOF CryoBlizzard for refrigeration. This cold air machine allows low temperatures to be generated at a very low operating pressure using the cold air process with heat recovery. The HOF CryoBlizzard as a closed cold air machine is speed controlled and can therefore be run under partial load very efficiently.

The cooling capacity is provided by a buffer tank from which several consumers can draw cryogenic oil. The thermal oil tank allows a high refrigeration demand to be satisfied with the relatively low refrigeration capacity of the cold air machines. And even temperatures below -80 °C can easily be achieved with the innovative and forward-looking refrigeration technology of the HOF CryoBlizzard.

A technology sets new standards

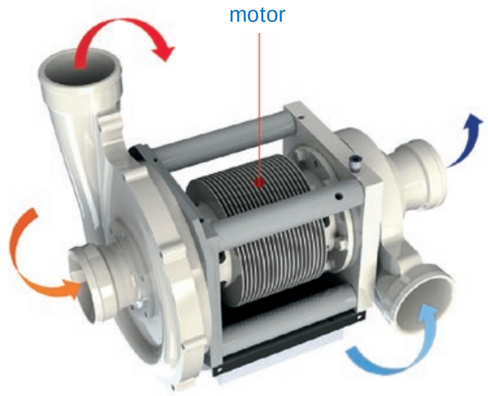
As an innovative market leader, HOF has always been thinking and acting with foresight when it comes to customer requirements. This is also true for the development of the new process of the HOF CryoBlizzard together with project partner Mirai Intex *(mirai-intex.com)*.

A freeze drying plant from 1998 was retrofitted for this purpose. The plant is a freeze dryer with a batch capacity of 40 kg for insulin production. Before the retrofit, refrigeration was achieved with two refrigeration sets, each with 12 kg of the R404A (GWP 3922) refrigerant. The process plant was controlled by a Siemens S5 controller.

compressor – outlet
high pressure
high temperatur

motor

turbo expander – outlet
low pressure
extrem low temperatur



compressor – inlet
low pressure
low temperatur

turbo expander – inlet
high pressure
low temperatur

Fig.: Turbo expander Mirai Intex

„We knew that we would have …

to tread new paths for our customers. The advantage of air as a refrigerant is obvious. Air is available, non-flammable, non-toxic and poses no risk of suffocation. Air has no GWP and is therefore not subject to the F-Gas Regulation or other directives. That is the future," says Oliver Fleischer.

Department for Refrigeration Technology Development and Service Management

HOF has developed a new process

which uses ambient air as a refrigerant and exceeds the current requirements for freeze drying and blast freezing.

High capacities with homogeneous temperature distribution

The retro□tting converted the plant to the new HOF CryoBlizzard refrigeration system and to the current S7-1500 controller. The new refrigeration process consists of redundant cold air machines which are switched to a central buffer tank in a modular system.

The buffer tank supplies the consuming units such as adjusting shelves, ice condenser or blast freezer directly with the refrigerant medium and can therefore generate large capacities with homogeneous temperature distribution within a very short time. The primary tank means that cooling water and power consumption remain constant and that no load peaks occur in the supply.

Air as a refrigerant – free and always available

The cold air machines are chillers which operate with air as a refrigerant using the Joule-process. The maximum overpressure in the machines is 3 bar and can be compared to that in a bicycle tyre. These machines are therefore especially safe and environmentally friendly. No special requirements result from this with regard to the machine room, employee training and recurrent testing. In addition to this, air as a refrigerant is free and always available, has a GWP of 0 and is therefore not affected by any regulations.

Fig.: Condenser with ice formation

The HOF CryoBlizzard turbo compressor – oil-free and virtually wear-free

The refrigeration circuit is driven by an oil-free turbo compressor-expander unit with air bearings which runs with up to 88,000 rpm with virtually no wear. The refrigeration medium is cooled in the buffer tank, in a heat exchanger integrated into the chiller.

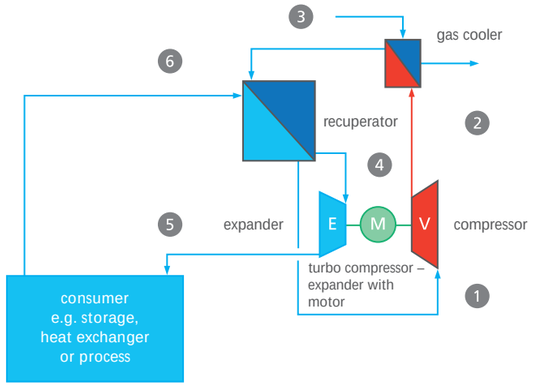


Fig.: Refolution process □ow chart

The turbo compressor aspirates and compresses the air heated in this way. The energy in the gas chiller is then transferred to the cooling water. In an internal heat exchanger – the recuperator – the air is strongly cooled down and then relaxed for effective use in the expander. The work is returned to the compression.

Fig.: System from 1998 after conversion to HOF CryoBlizzard

Fig.: HOF CryoBlizzard ProPhase
process cooling for exhaust gas cleaning and solvent condensation – compliance with the new “TA-Luft” Regulation

The energy is absorbed through heating of the air in the cold medium/heat exchanger. After the air in the recuperator has come back up to temperature, it is aspirated by the compressor and the cycle starts again.

Based on this technology, the cold air machine can cover temperatures down to around -110 °C, so that the -80 °C often required in the condenser can be achieved easily.

Retro□tting existing plants or implementing new plants with the HOF CryoBlizzard

The modular design allows the capacity of the HOF CryoBlizzard to be scaled up or down, allowing it to be adapted to anything from a laboratory freeze dryer or a production plant to a central cooling system for complete factories.

Existing plants can be retro□tted and new plants can be implemented with the HOF CryoBlizzard. HOF has developed a future-proof solution for freeze drying and blast freezing which is not only safe for employees and the environment, but also sets new standards with regard to the quality and availability of the application.

The energy balance is also impressive

The energy balance of the retro□t was compared to the existing sister plant. This re□ects the exact 100 % comparison. A specialised external engineering of□ce was commissioned to examine the potential of this technology: a 5 to 10 % saving over the comparable process in the sister plant.

Another reference is the HOF CryoBlizzard and the associated data that is used as a scienti□c basis for applying for future cold air plants. For example: HOF participated in the application for the funding eligibility of cold air plants with the German Federal Of□ce for Economic Affairs and Export Control (BAFA).

Bene□ts at a glance:

- Natural refrigerant (GWP 0)
- Uses ambient air
- “Scale up” using central cooling
- Future-proof and not affected by regulations
- Low maintenance effort
- High temperature □exibility
- Low noise emissions
- Nearly no requirements for machine room installation (pressure analysis/refrigerant)
- Very low training required and good safety aspect for employees and site

Freeze drying with compression refrigeration

The objective: combining proven technology and the F-Gas Regulations

The compression refrigeration cycle used to be the most commonly used refrigeration cycle. This refrigeration process is based on boiling and condensing refrigerants. These will have to be replaced or reduced in the future to meet the targets of the European F-Gas Regulation.

This entails a gradual reduction of the quantities of hydro-fluorocarbons which can be placed on the market in the EU. This will result in a shortage of the available conventional refrigerants such as R404A, for which HOF has been preparing with alternative refrigerants and technologies for many years. While these refrigerants with a GWP > 2500 may still be used in the low-temperature sector (product application below -50 °C) until the year 2030, there are already supply bottlenecks paired with strongly rising prices today. After setting up an in-house test bench in 2015, HOF was the first manufacturer to establish the LOW-GWP alternative R452A (GWP 2140) in the field of freeze drying/blast freezing.

This refrigerant is ideal as a drop-in for existing plants and as a proven refrigerant for new plants. The high-pressure refrigerant R410A (GWP 2088) is another alternative for conversions or new plants.

This allows us to offer all customers options for complying with the F-Gas Regulation (GWP < 2500).

Fig.: Module structure of six compressors

Two-stage compression chiller

In contrast to air refrigeration, steam refrigeration is the idealised CARNOT process. In practical application, this two-stage compression refrigeration cycle is a sophisticated technical design. Firstly, the technology depends on the material properties of the refrigerants and on the properties of the components. Secondly, it is important to find an ideal process solution for oil transport and the underpressure operation required by the design.

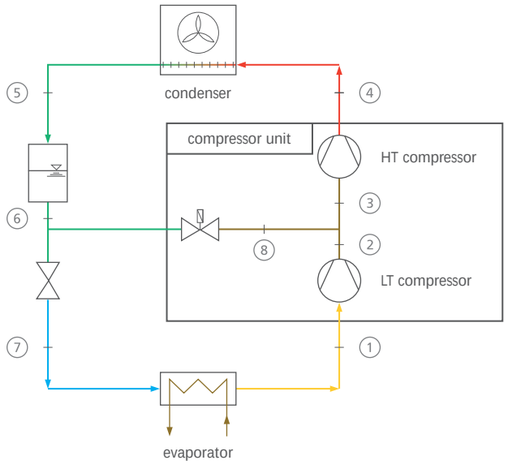


Fig.: Conventional 2-stage compression refrigeration process

In two-stage compression chillers/displacement chillers, the entire pressure ratio is divided between two compressors or, by design, in a two-stage chiller. The compressor in the first stage compresses the refrigerant from the lowest pressure level to a medium pressure. With the booster placement, the second compressor compresses the refrigerant from the medium pressure to the high pressure.

Benefits of conventional compression chillers:

- No special requirements for the material
- Proven, tested and optimised technology since 1988
- Refrigerant in safety group A1
- Space requirement

Freeze drying with nitrogen as a refrigerant

A simple process with a natural substance from the atmosphere

The advantages of the HOF freeze drying process with liquid nitrogen as a refrigerant are based on the refrigerant itself: Nitrogen is a naturally occurring component of the atmosphere. Delivered by the nitrogen supplier and stored in outdoor tanks, the refrigeration capacity is available immediately and without restrictions.

A factory nitrogen network can be used as an alternative, so that no additional operating costs are incurred with regard to the infrastructure. The high refrigeration capacity is achieved by vaporising the nitrogen. The used nitrogen can then be utilised for other processes such as pre-chilling, or safely discharged into the atmosphere.

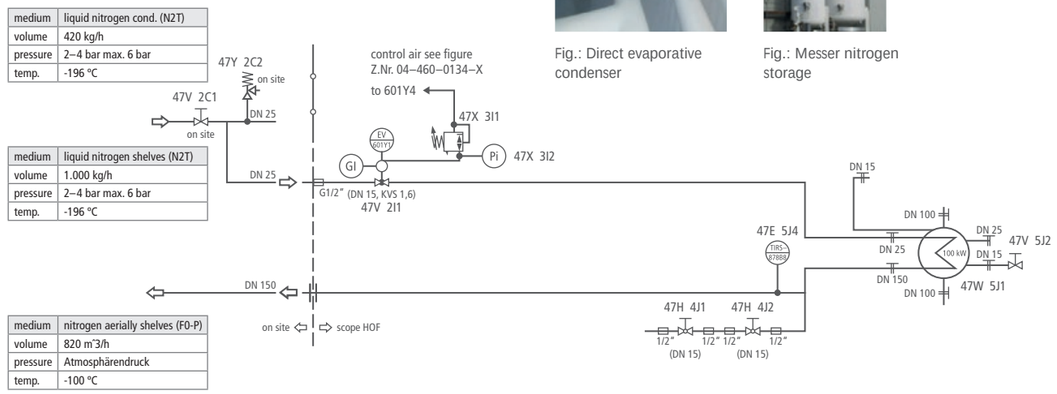


Fig.: LN2 R728

Low failure frequency and low maintenance

In addition to the benefits provided by the nitrogen, the HOF plants offer additional advantages: The systems have a very simple design and only few moving parts, because the nitrogen is conveyed in the system by means of the pressure in the tank. This ensures a high level of durability and low maintenance effort.

Proven technology – the details

When nitrogen is used for refrigeration, HOF replaces the refrigeration machines with cryogenic heat exchangers. These can be a direct evaporative condenser, developed by HOF, or supplied by a secondary cycle with a heat exchanger.

As for all refrigeration types, even temperature distribution for the adjusting shelves is, of course ensured. Oil-controlled as well as direct evaporative condensers can therefore be adapted to any customer requirements.

Fig.: Direct evaporative condenser

Fig.: Messer nitrogen storage

Benefits of freeze drying with liquid nitrogen:

- Natural refrigerant (GWP 0)
- Simple process
- Proven since 1994
- Future-proof and not affected by regulations
- Low noise emissions
- Low maintenance costs

Freeze drying based on hydrocarbons as natural refrigerants

Compression chiller as a cascade

The cascade is another variation of the classic compression refrigeration cycle. The basic principle links several separate refrigeration systems with different refrigerants. For natural refrigerants, we use a two-stage cascade. The refrigerant ethane (R170) used in the first stage is available for any low temperature application. In the second stage, we use the natural refrigerant propene (R2170). In addition to liquefying the ethane (R170), this stage also supplies a control stage for the adjusting-shelf cycle.

also be disconnected from the power supply. The capacity exchange takes place in each individual module for each consuming unit. This means that the condenser as well as the adjusting shelves are implemented as oil-controlled consuming units. This special redundant design generates the product safety in the event of a fault. There is no substitute for experience – and more than 80 of individual modules implemented by HOF are proof of the know-how and pioneering spirit.

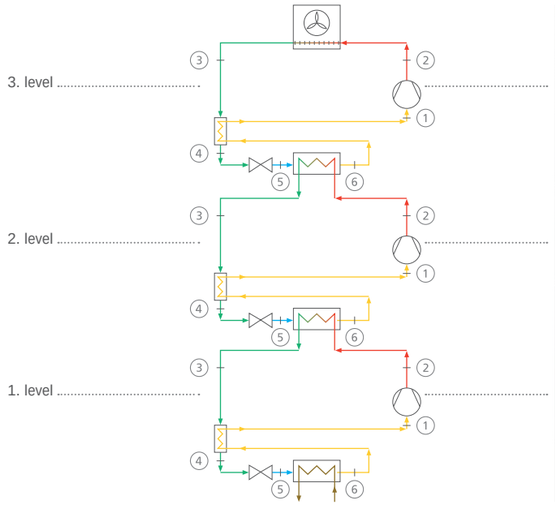


Fig.:
HOF-CAR6 generation, advantages through continuous further development

Successful launch of HOF-CAR6 in 2007

The objective of the European F-Gas Regulation is to substantially reduce the use of hydrofluorocarbons. In fact, HOF has been working on new processes with natural refrigerants for many years. A cascade system which uses ethane and propane was consequently established in the market far back in 2007. The cascade system consists of two separate cycles which form an individual module. To achieve redundancies or capacity increases, additional modules can be combined flexibly based on customer requirements.

Excellent safety based on excellent experience

Each individual module is placed in a special housing. This containment generates a hermetically sealed unit in the event of a fault. If a fault occurs, a fan removes the refrigerant atmosphere in the affected containment. The individual module can

Benefits of freeze drying with a natural refrigerant:

- Very low GWP ≤ 6
- High efficiency
- Experience since 2007
- Future-proof and not affected by regulations
- Modular system
- Reliability

Into a successful future with knowledge and power of innovation

Relying on knowledge and experience

With more than 30 years of experience, HOF Sonderanlagenbau GmbH has been the leading specialist in manufacturing individual freeze drying systems, loading and unloading systems, and freezing and thawing equipment for the pharmaceutical and biotechnology industries.

At our company sites in Lohra and Mornshausen near Marburg, highly motivated and highly qualified employees work on our own production area with approximately 13,500 square meters. Our flexible service team looks after the HOF systems and their users, maintaining close contact with customers in Germany and abroad.

Ensuring future success

Quality and reliability are the crucial parameters for the success of a company in the field of pharmaceuticals and biotechnology. This is guaranteed by the use of special-purpose systems from HOF – not in the least because the system technology of the company is developed to meet future requirements.

Power of innovation at the core of the company

HOF knows only one answer to its customers' constantly changing new requirements: innovation! The company is characterised by its striving for new, better solutions, always from the customers' perspective. The power of innovation at HOF is crucial to the success of its customers.

Top quality in all steps…

… has been a hallmark of the company specialising in individual solutions since its foundation: from concept design and fully developed planning to the conscientious manufacturing of reliable, customised systems.

HOF systems
are always an excellent investment in the future.

HOF Sonderanlagenbau GmbH

Freeze drying systems | Loading and unloading systems | Freeze-Thaw Units | Service | LYOPOOL

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HOF

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