η max Project Refrigeration system engineering with leading-edge technology …
for a better global environment

Achieving

$$\eta\,max = \oint \Delta\,Smin$$

in Refrigeration

η max Refrigeration System®

In pursuit of precision emRS leads the future in refrigeration

What is the η max Project?

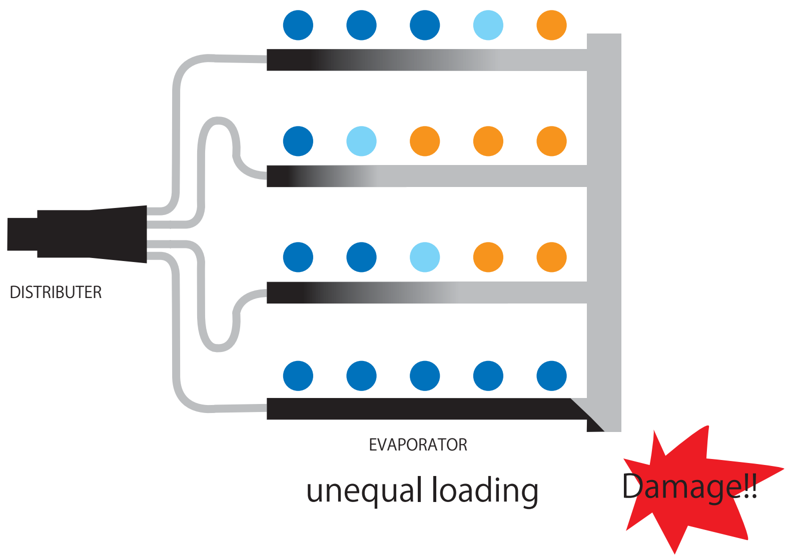
The Eta-max Project is dedicated to increasing the efficiency of refrigerator systems. The Eta-max team has developed an improved refrigerator system that increases efficiency and the coefficient of performance (COP) while maintaining the quality of frozen products. This is achieved by monitoring system and local environmental conditions, determining (in real time) the ideal pressures and temperatures required for maximum efficient freezing and controlling these conditions. This allows the Eta-max refrigeration system (emRS) to reduce energy requirements by up to 50% and increase freezing capacity by up to 30% resulting in a more economical and environmentally friendly system.

The project team at Nakayama Engineering has also cooperated with research institutes and Japanese governmental agencies, facilitating the application of this technology to transportation and distribution systems in order to save energy and reduce greenhouse gas emissions.

"Contributing to world-wide environment and resource protection by promoting our innovative refrigeration system technology around the globe." This is the goal of Nakayama Engineering and its supporting partners.

Multidiscipline engineering System Development: Nakayama Engineering K.K.

Conventional freezing systems
Limited by technology



Low tk and Small TD are the keys to perfect freezing

Today' s refrigeration systems are plagued with a number of problems when operated at a condensation pressure of 0.9MPa to 1.1MPa or less, leading to a failure in freezing. This is because the distribution of refrigerant within the evaporator becomes so degraded that the refrigerant starts to backflow, damaging the refrigeration unit. Cooling capacity is also drastically reduced, causing faulty freezing. When the temperature differential (TD) between the refrigerant and the air is less than 10℃, the system cannot produce sufficient freezing due to poor refrigerant control and reduced efficiency.

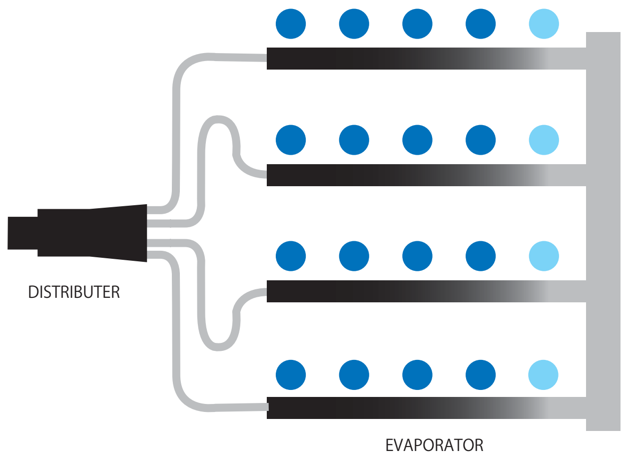
- Limited condensation pressure: No energy savings from low outdoor temperatures
- Low condensation temperatures aggravate distribution within the evaporator, causing failure
- Reduced capacity due to frost on the evaporator, and energy loss due to frequent defrosting
- Increased sublimation within the product by exposure to high temperature differentials causes quality deterioration because of drying

tk = condensation temperature

TD = temperature differential between the refrigerant evaporation and the ambient air

tk≧1.1MPa TD≧10℃

A standard for the future emRS pursues accuracy



The emRS difference: Refrigeration at a low tk and a small TD.

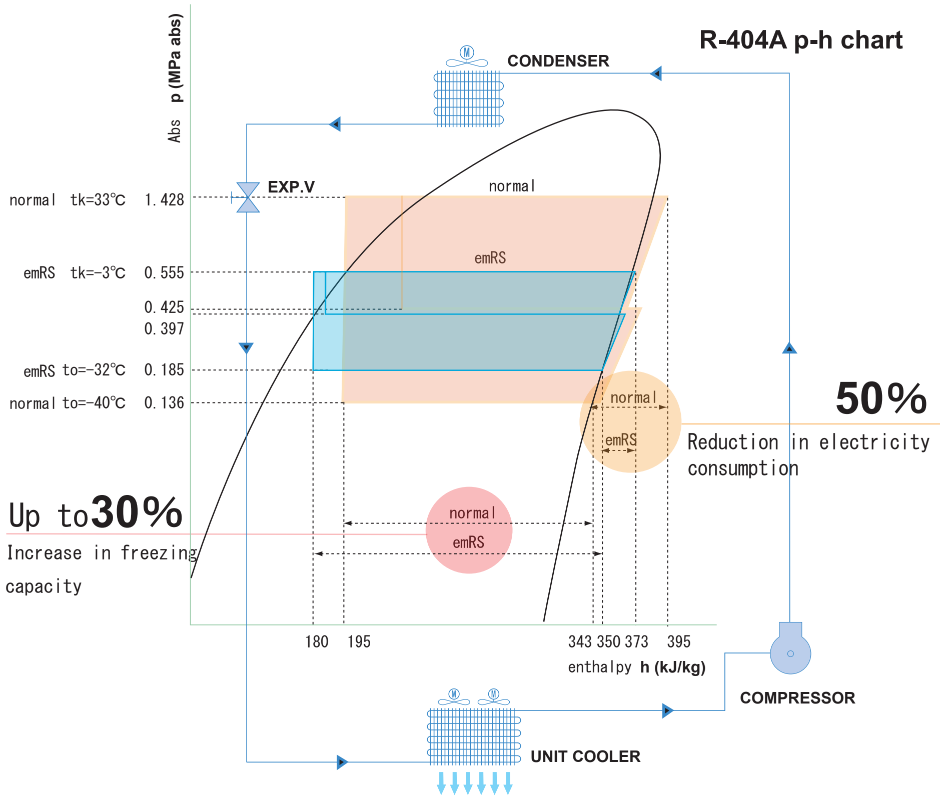
η max Refrigeration System operate at optimal efficiency even with a minimum condensation pressure(0.3 MPa) when the outdoor temperature goes down in winter. The same can be said when TD falls to 2℃. The emRS unit always behaves in an ideal manner in accordance with load changes. The result is as follows:

Synergy effects from these three features:

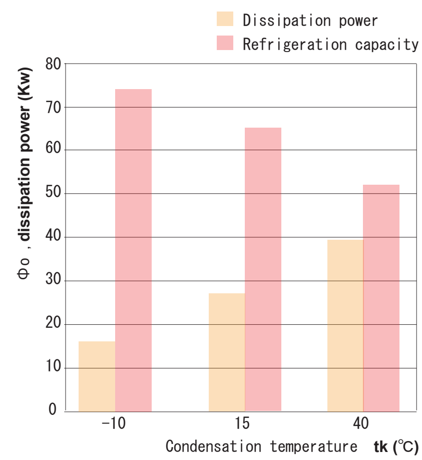
- Energy efficient (less CO2) ……. Electricity consumption is reduced by 50%, while the freezing capacity is increased by 30%.
- Suppressed frost formation on the heat exchanger …. Stabilization of freezer room temperatures prevents freezer burn.
- Higher food quality through cryogenic freezing (-70℃)…….Virtually no change in taste thanks to ice crystals not rupturing cells.

tk≧to+0.3MPa TD≧2℃

Energy Savings (reduction in CO2 emissions) Outstanding efficiency in energy conversion reduces environmental footprint



p-h map of a two-stage compressor at a room temperature of −30℃



Electricity consumption and freezing capacity by condensation temperature

※Extrapolated from the performance table of a screw compressor of Mitsubishi Erectric with an evaporation temperature of to=-45℃
to=evaporative temperature (MSA-SP550A,55kW Two stage compressor)

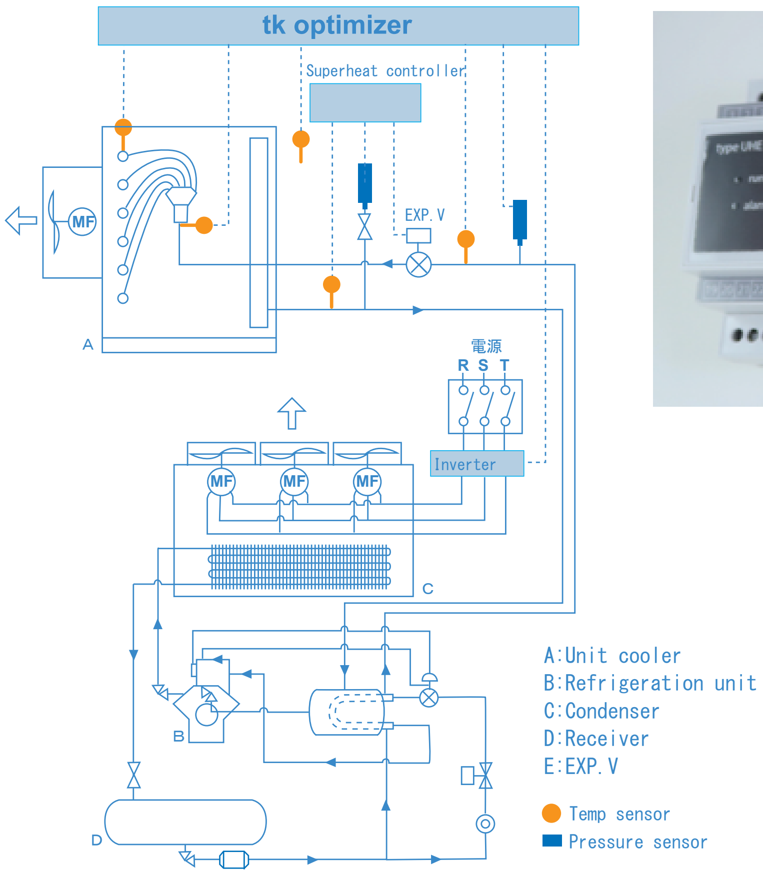
Unprecedented energy savings in refrigeration, thanks to low condensation pressures.

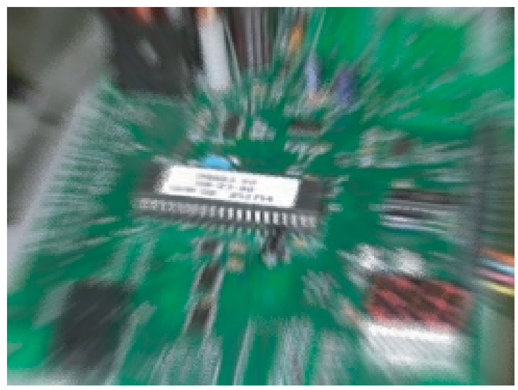
It is common knowledge throughout the world that operating at a low condensation pressure will save energy. emRS utilizes the dynamic programming of sophisticated mathematical algorithms in its design. The system actively reduces the condensation pressure to a level that is the lowest value possible for the condensation temperature, emulating the outdoor temperature. This produces the following benefits:

- Reduced electricity consumption:
  Smaller compression ratios in the refrigerator equipment mean reduced axial power requirements.
- Improved refrigeration capacity:
  A decreased refrigerant liquid temperature and an increased specific enthalpy differential mean a larger freezing capacity.
- Longer life for refrigeration machinery:
  Lower mechanical loads mean a longer overhaul cycle and longer mechanical life.
- Less greenhouse gas emissions:
  Reductions of 41% in Kushiro, Hokkaido (sub-boreal climate); 26% in Chiba (temperate); and 16% in Okinawa (subtropical), all in Japan.

(Compared to our existing model where the pressure and temperature losses are set at our standard values.
The energy savings and emissions reduction will be larger if compared to conventional freezer systems.)

Integrated with advanced control systems
In pursuit of higher accuracy and precision





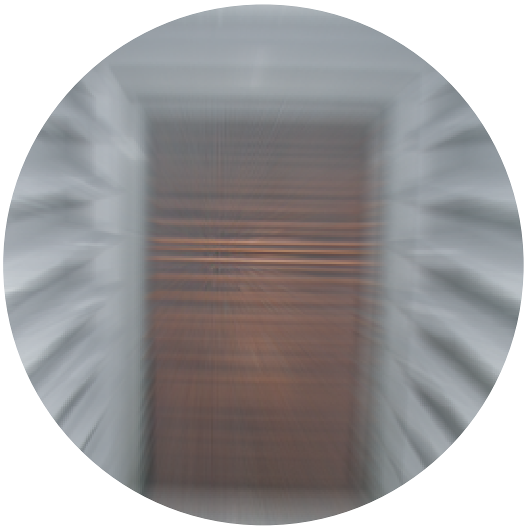
tk optimizer ® feedback control tracks rapid load changes

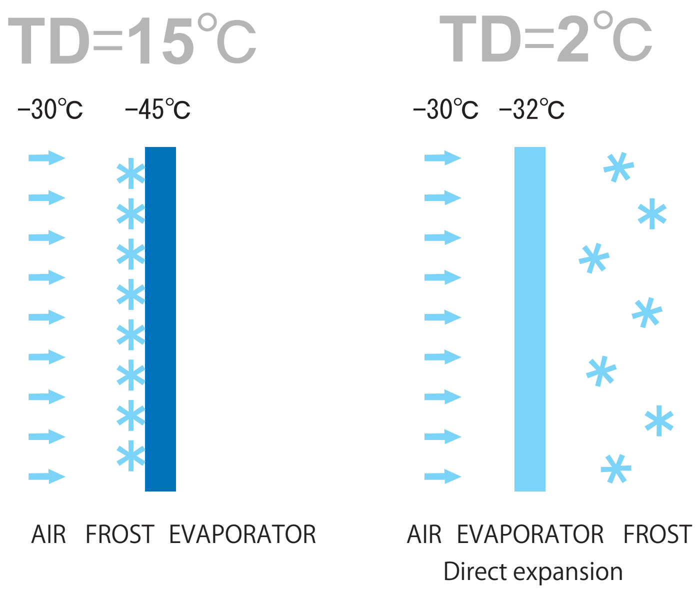
If the condensation pressure is simply allowed to drop in tandem with the outdoor temperature, the evaporation temperature increases when more load comes from the product or the room temperature increases at the end of a defrosting cycle. A higher evaporation temperature represents increased freezing performance, which in turn increases the final value of the evaporation temperature, causing a larger pressure drop to be required. If the pressure is not large enough to cover the pressure drop, then the evaporation temperature drops, eventually producing an operation failure.

This is where tk optimizer ® comes in. It constantly monitors the operation of the evaporator and calculates the pressure drop required for liquid refrigerant to reach an appropriate evaporation temperature. The Optimizer, in other words, performs a feedback control function by actively decreasing the condensation pressure to the limit of the pressure drop. The operation will thus be maintained at optimal levels, resulting in energy savings and high-quality frozen food.

- Constantly monitors the evaporator conditions
- Optimizes the condensation pressure to the lowest possible level
- Immediately follows rapid load changes
- Allows for freezing capacity control

Frost suppression technology
Physical problems resolved by physical means



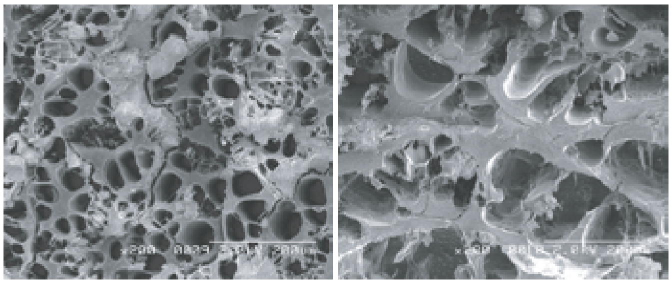


Fight the biggest foe of freezers: frosting on evaporators

The biggest physical challenge in freezer systems is the buildup of frost on evaporators. Typically, frost formation is assumed to be inevitable and has been solved through short-cycled defrosting using hot gas or a heater. Frost occurs when moisture in the air in the freezer room condenses and freezes on the surface of the evaporator. The larger the TD (temperature differential between the surface of the evaporator and the ambient air), the more likely it is that frost will be generated; this, in turn, increases TD. In conventionally designed systems, TD is usually set at around 10 to 15℃ or higher, requiring frequent defrosting procedures. emRS' s high-accuracy, low-pressure-differential refrigerant distribution technology has made it possible to maintain TD to within 2 to 5℃. The result is drastically minimized frost formation.

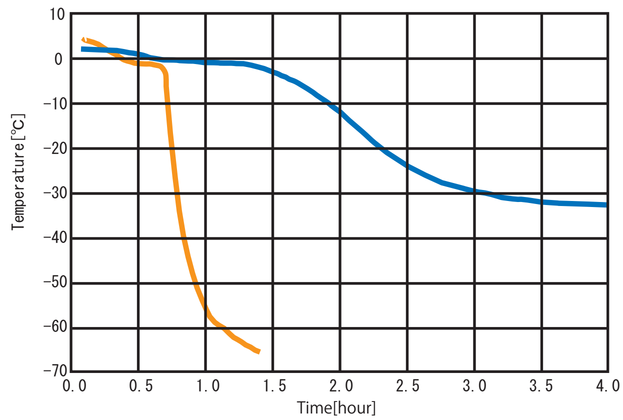
- **Frost suppression, thanks to a small TD within 2 to 5℃**
- **Control of sublimation by a reduced differential between the evaporation temperature and product (freezer burn is controlled)**
- **Energy savings through a reduced number of defrostings**
- **Consistent freezer room temperature through a reduced number of defrostings**

Higher Quality Food through Cryogenic Processing Cell Structures Remain Intact



η max Refrigeration System Freezer (-70℃) Conventional Shock Freezer (-38℃)

■Frozen muscle tissue (tuna: 60 mm thick)
Source: Hokkaido Food Processing Research Center



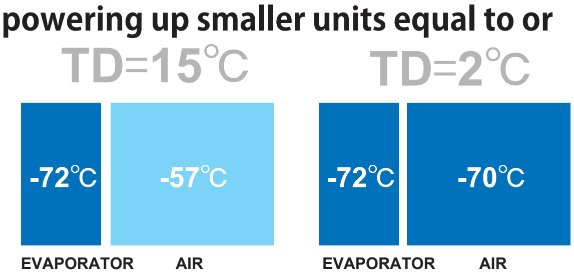
	Maximum transit time in the ice crystal generation zone	Time required to reach the core temperature of −20℃
Conventional (-38℃)	55minutes	140minutes
emRS (-70℃)	6minutes	46minutes

■Changes in Core Temperature
(Tuna at 60 mm in thickness)

Cryogenic Freezing: R-404a produces −70℃ for commercial applications
With a two-stage compression unit, a cryogenic temperature of −70℃ is now a reality using a hydrocarbon refrigerant.

The quality of frozen food is dependent upon transit time in the temperature range where water in the cell structure crystallizes (peak ice-forming temperature zone: -1 to −5℃). This is common knowledge in the industry. The lower the internal tissue temperature, and with the right wind velocity, the shorter the time required for freezing. The shorter the time spent in the ice-forming temperature range, the less the damage to the tissue in the freezing process. This is because the water will solidify into minute ice crystals without rupturing the cell walls. Hence, a stable cryogenic temperature (below -60℃) is required for high-quality freezing. Up until now, however, special freezing methods such as nitrogen freezing or dual freezing have been required to achieve this. η max Refrigeration System has succeeded at consistently operating the freezing process at a cryogenic temperature using the conventional freezing principle by developing a low-temperature differential operation.

- **Improved quality of frozen food as a result of small ice crystals within the cells.**
- **Achieve cryogenic temperatures by using a conventional freezing system (two-stage compression)**
- **Significant enhancement of freezing capacity achieved by powering up smaller units equal to or better than units one or two sizes larger.**



Products

For any refrigeration and cooling system

tk optimizer® system

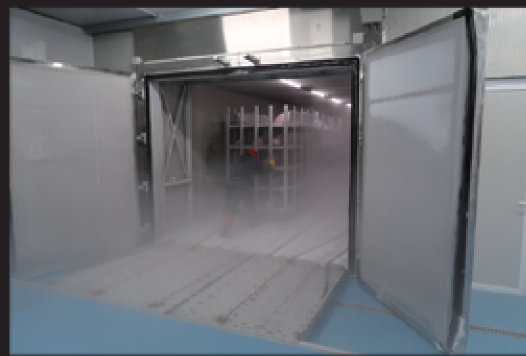
emRS Batch Freezer

emRS also offers a wide selection of freezers for any application, ranging from a compact 50 kg/h to as large as 40metric tons/Day. Thanks to newly developed frost control technology, these freezers deliver exceptional reliability and easy temperature control. With their high-speed freezing capability, you can make your product freezing schedule highly efficient and even save storage space!

Temperature range: -20℃ to -70℃

With Cascade system: -70℃ to -100℃

New



emRS Rack Freezer

The batch type ultra-low temperature freezer is CE certified.
You will be able to purchase it in the EU area as it complies with European standards.
The simple design makes it highly reliable and also greatly reduces the risk of system failure.

Temperature range: -20℃ to -70℃

emRS CO_2 Cascade System

The CO_2 direct expansion freezing system has been successfully developed for commercial usage. With all the excellent characteristics of the CO_2 refrigerant, we are able to maximize its full capability with our system.
With a compact and highly reliable compressor, it is now possible to implement our CO_2 system to small scale cold storages which require smaller cooling capacity as well.

emRS Reefer Container

By using η-max technology, a normal reefer container can be transformed to achieve the ultra-low temperature range of 5°C to -60°C while maintaining a high efficiency operating condition.

Temperature range: -20℃ to -60℃

We are just a call away…

New

emRS Cold storage warehouse

■Cold storage warehouse

Capable of operating with minimum temperature differentials and with temperature ranges from chilling to ultra-deep freezing, this stocker features rapid and infrequent defrosting with a lower operating cost and extended retention of product quality.

Operating temperatures: 5℃ to -70℃

With cascade system: -70℃ to -100℃

emRS Unit Cooler

The unit cooler is the most essential component of any refrigeration system. Our unit cooler has been built to our proprietary design, including cutting-edge refrigerant distribution technology that evenly supplies low refrigerant flows to multiple circuits. It also features pressure loss reduction technology with optimal circuit lengths.

※The unit is custom-built to meet the needs of any specific application, ranging from refrigeration to ultra-deep freezing.

emRS Continuous rapid freezer

■Spiral/tunnel type freezer

Temperature increases due to frost have been the number one problem confronting continuous rapid freezers. Our system, complete with steel conveyor belts designed for mass processing, successfully prevents temperature increases and consistently maintains a target temperature, thanks to the synergy effect between the frost control technology and the outdoor air control technology. It is designed for higher productivity and increased quality as well as for better space utilization.

Temperature range: +10℃ to −60 ℃

Other Products

■ emRS Refrigerated Ship

■ emRS Testing Device

■ emRS Condensing Unit

Consulting･R&D

■ Technology consulting

■ Cold Chain

■ Retrofit

■ Frozen Foods Development

η max Refrigeration System®

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