



ENGINEERING
TOMORROW

Danfoss

A complete portfolio of **CO₂** refrigeration solutions

CO₂ has long proven to be one of the most sustainable natural refrigerants. And for the last 20 years, Danfoss has developed innovative solutions to ensure supermarkets and food retail applications in climates all over the world can take full advantage of CO₂ refrigeration.

More than
30%
reduction of
carbon footprint
on store level

> **START HERE**

Introduction / CO₂ Refrigeration Systems eBook

Discover the opportunities of CO₂ refrigeration

CO₂ has proven itself to be a highly reliable, cost effective, and environmentally friendly natural refrigerant. And transcritical CO₂ refrigeration technology delivers game-changing benefits to supermarkets and small retail stores alike – in cold and warm climates.

Danfoss has pioneered transcritical CO₂ technologies for food retail applications around the world – and because no two systems are the same, there is a complete portfolio to suit any need.

In this eBook, discover how to take full advantage of the environmentally compliant, efficient, safe, and future-proof benefits of CO₂ refrigeration systems.



FORWARD
CO₂ REFRIGERATION SOLUTIONS
NATURALLY

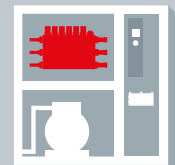
Why choose
CO₂ refrigeration?



Danfoss partnership
and expertise



A full portfolio of
CO₂ solutions



Why choose **CO₂ refrigeration?**

- ✓ Reduced complexity with low and medium temperature compatibility
- ✓ Zero ozone depletion and one of the lowest possible Global Warming Potentials (GWP), one.
- ✓ Viable and profitable solution even in warmer climates
- ✓ Outperforms traditional HFC systems on energy efficiency in all climates



CO₂ is the **refrigerant of tomorrow**

Since 1850, CO₂ has proven to be one of the most reliable, efficient, and environmentally friendly refrigerants. Now, CO₂ is being used worldwide to provide a sustainable and cost-effective refrigerant solution – one that is compliant with the increased environmental requirements of today – and tomorrow.

CO₂ is a natural, sustainable refrigerant suitable for food retail stores of all sizes, and in all climates.

Superior **thermodynamic properties**



EXPERIENCE HIGH VOLUMETRIC COOLING CAPACITY

- Small volume – high capacity
- Up to 5 times greater than R404A
- Possible to use smaller pipes and compressors



HIGH PRESSURE REFRIGERANT

- +30°C - 71 bar
- Very low pipe pressure drop effect

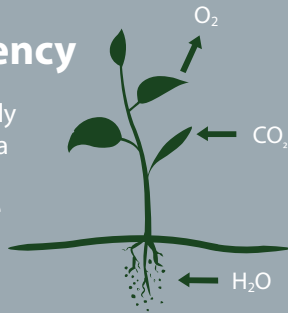


HIGH DENSITY GAS

- Increases heat exchanger efficiency
- Greater capacities with smaller surfaces

A wonder of **natural efficiency**

Environmentally friendly and sustainable, CO₂ is a natural substance that plays an important role in many natural and industrial processes.



CO₂ provides the lowest cost of ownership for end-users because of high volumetric efficiency, low power consumption, and refrigerant charge reduction.



Supermarket systems can easily leak up to **20%** of their refrigerant. Replacing HFCs with CO₂ reduces refrigeration cost and accelerates a positive climate impact.

More than
30%
reduction of
carbon footprint
on store level

CO₂ HAS

0 ozone depletion

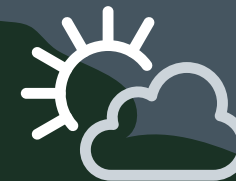
and one of the lowest possible Global warming potentials (GWP) = 1.

A refrigerant accompanied **by cool cash**

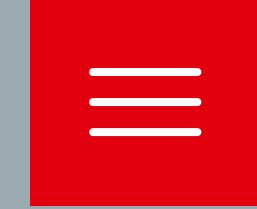


SAVE UP TO
20%

on energy by replacing HFCs with CO₂ in warmer climates.



Transcritical systems provide an efficient, simple, and cost-effective solution **in all climates.**



Danfoss **partnership** **and expertise**

Our engineers are on the frontline of CO₂ refrigeration, developing the solutions needed for CO₂ transcritical systems – with installations all over the globe.

- ✓ Achieve unparalleled energy efficiency while protecting food safety
- ✓ An all-in-one solution customized to your need – with expert support and training
- ✓ Heat recovery unlocks business-critical efficiency and cost benefits
- ✓ CALM™ is a truly optimized CO₂ refrigeration solution for all climates
- ✓ Comprehensive portfolio of high-performance sub- and transcritical CO₂ compressors



BOCK® compressors for food retail

Transcritical CO₂ compressors

Achieve the highest EER/COP values within their range of applications – officially confirmed by ASERCOM (Association of European Refrigeration Component Manufacturers) certification for several displacement stages. Further advantages of reciprocating compressors: Highest reliability and durability due to proven BOCK CO₂ design.

Subcritical CO₂ compressors

The subcritical series for use in low temperature applications is based on the advantages of the proven BOCK compressor technology, which has been holistically optimized to meet the requirements of CO₂ operating conditions. Its wide range of applications enables tailor-made, cost-saving solutions for low temperature applications.

[READ MORE HERE](#) >

flexxCO₂NTR0L – the capacity regulator

BOCK flexxCO₂NTR0L technology, the compressor capacity regulator for the almost stepless capacity adjustment of transcritical BOCK CO₂ compressors to the current system requirement.

LSPM motors for highest efficiency

New transcritical BOCK CO₂ compressor series, equipped with LSPM motor technology (Line Start Permanent Magnet). Economical system solutions with higher efficiency and a plus in capacity – with lower operating costs at the same time.

UL-recognized CO₂ compressors

The UL-HG CO₂ series includes all transcritical and subcritical compressors in 2-, 4- and 6-cylinder versions. Equipped with all CO₂ relevant features. Approved for US and Canadian safety standards.



Outstanding running comfort

Low noise and vibration, compact and lightweight design and minimal oil carry over rate



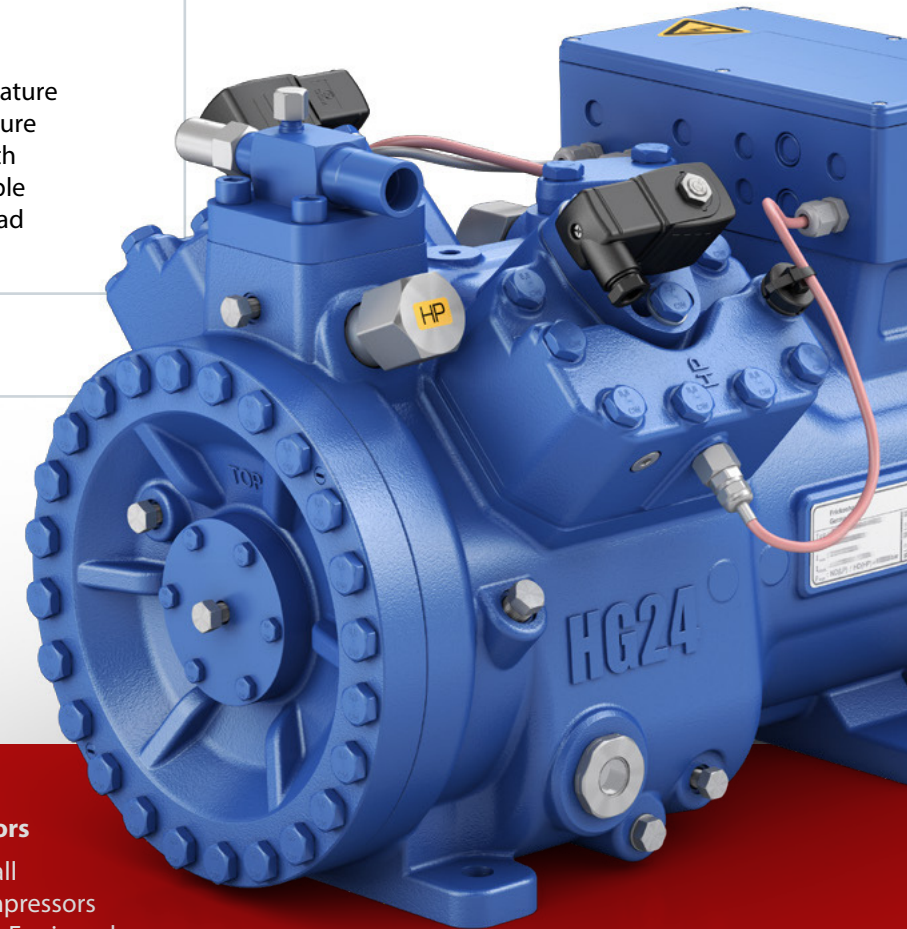
Wide range of applications

From low temperature to high-temperature heat pumps – with reliable and flexible partial and full load



Lowest energy and operating costs

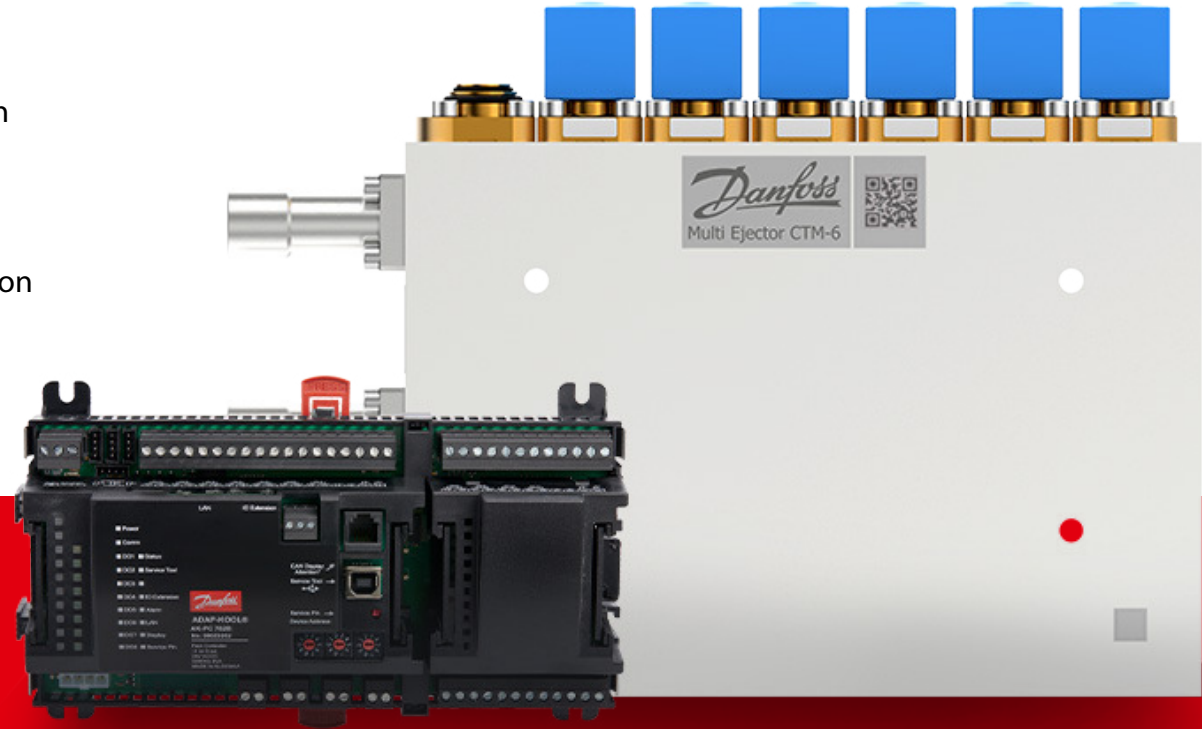
Highest efficiency and reliability thanks to more than 30 years of expertise in CO₂ compressor technology



Embrace the power of CO₂ with **future-proof technology**

Our portfolio of pioneering CO₂ technologies for transcritical refrigeration systems has evolved from more than 20 years of frontline experience – and thousands of installations around the world.

And because there is no one-size-fits-all solution, our adaptive refrigeration technology makes it possible to harness the environmental and energy-saving benefits of CO₂ in food retail stores of all sizes, and in all climates.



The Danfoss **Multi Ejector Solution™**

With a complete portfolio of Multi Ejector solutions for all store sizes, CO₂ systems, and climates, it's possible to take full advantage of the future-proof technology.

✓ **Optimization of compressors**
15% – 25% less compressor capacity needed, controlling three suction groups.

✓ **High system reliability**
Max uptime and reliability with 4–6 redundant ejectors, backup systems, and emergency operations.

✓ **One solution for all climates**
Apply transcritical CO₂ refrigeration systems in all climates for optimal performance.

✓ **Easy installation**
Reduced complexity with built-in strainer and connectors for welding and soldering.

✓ **Service**
Easy service with tools, fast strainer and ejector operation, and an LED plug for troubleshooting.

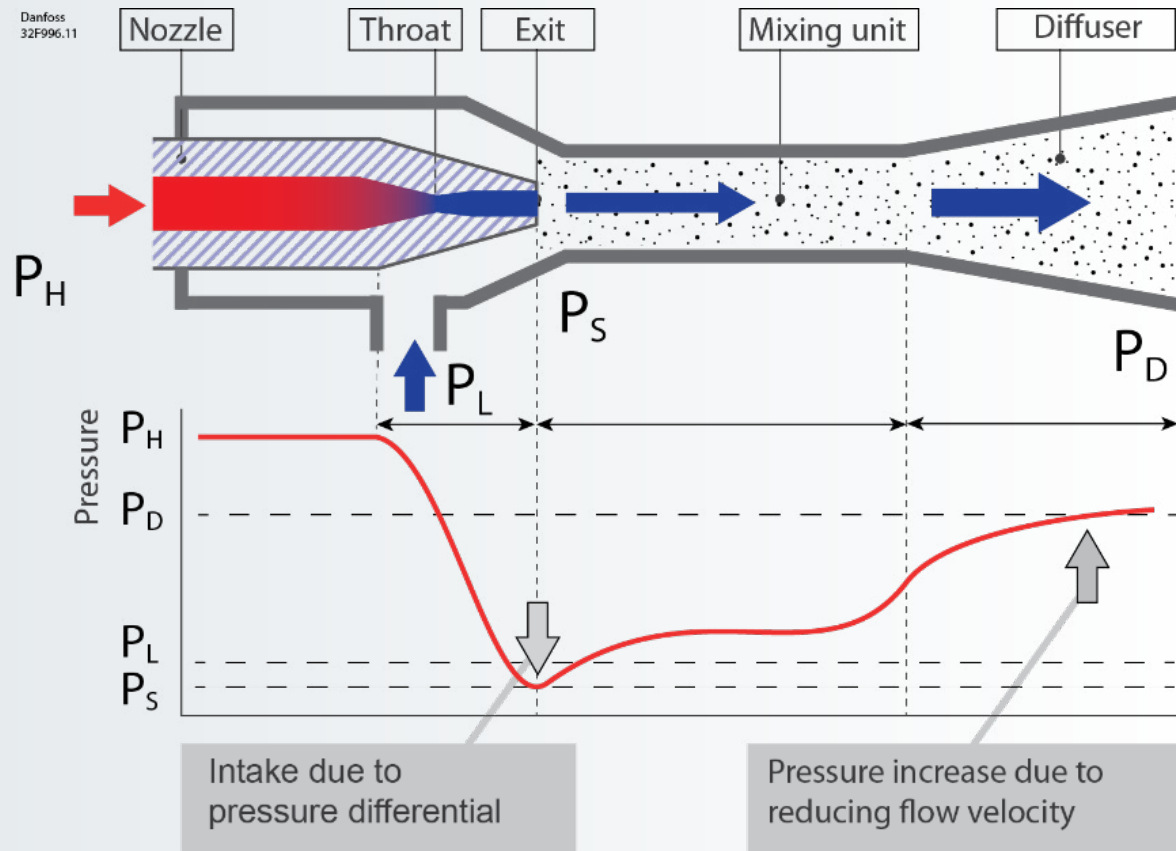
✓ **Savings**
Gain initial operational savings with easy installation, reduced compressor needs, and lower energy consumption.

How the Multi Ejector Solution™ works

1. CO₂ leaves the gas cooler. Then, the high-pressure CO₂ (P_H) enters the motive nozzle where the expansion takes place.
2. At the exit, the speed is very high resulting in low pressure. The low pressure then drags in gas from the MT suction (P_L).
3. The two units are then combined in the mixing unit where the pressure is higher than at the outlet due to mixing gas from a higher pressure.
4. After mixing, the flow enters the diffuser where it slows down. The shape of the diffuser enables the conversion from kinetic energy (velocity) to potential energy (pressure). From the diffuser, the flow returns to the receiver.



See how the **Multi Ejector Solution™** works

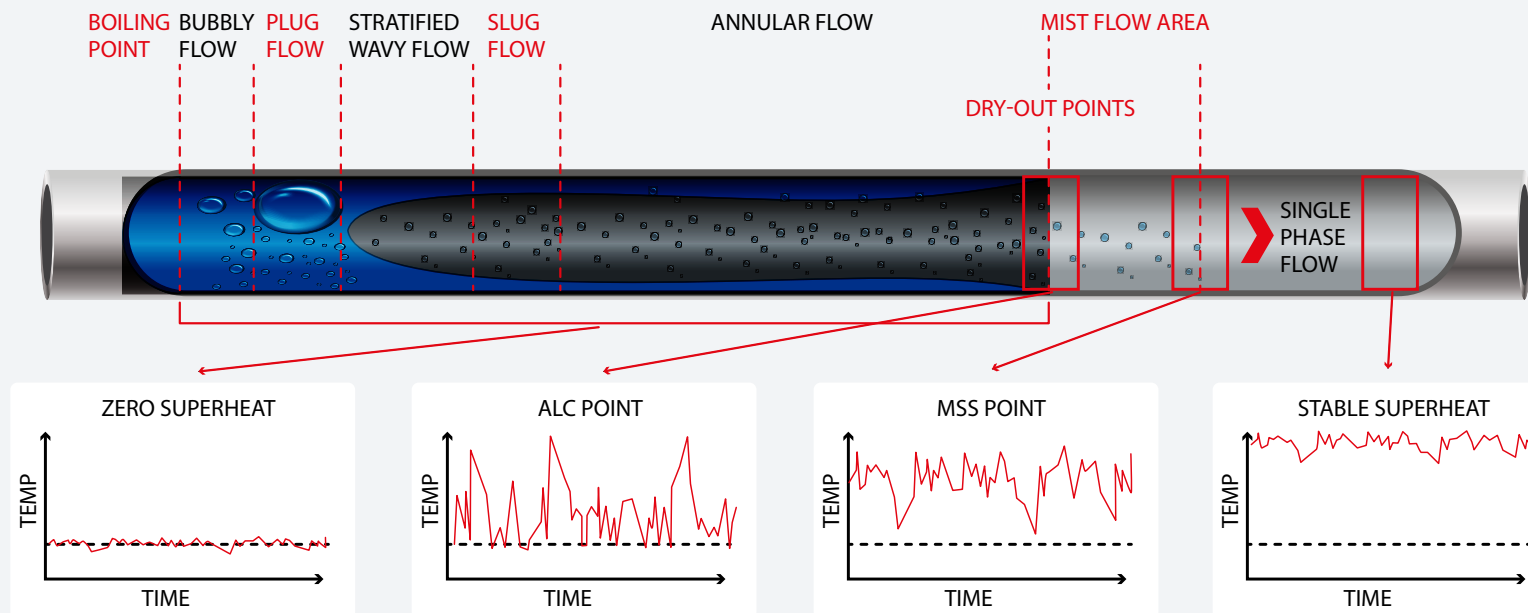


Save energy and enhance food safety **with adaptive control algorithms**

Adaptive superheat control has proven to be a robust, efficient, and superior solution, saving 8–12% of energy use by ensuring the evaporator is always fully utilized under all conditions. Plus, adaptive controls mean you no longer have to manually adjust system operation for changing conditions – reducing operating and maintenance costs.

[READ MORE HERE](#) >

The evaporator illustrated as a tube presenting the **evaporation process**

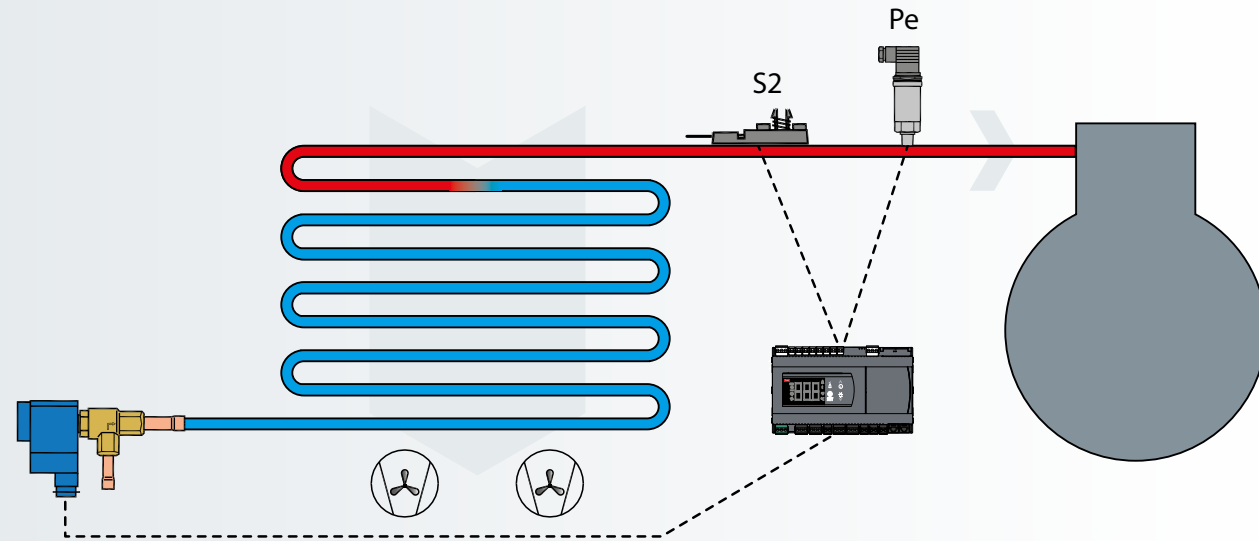




Danfoss Adaptive **Minimum Stable Superheat** Control (MSS)

Utilization of the evaporator surface is maximized while ensuring that no liquid exits the evaporator – safeguarding the compressor and delivering significant energy savings and optimal food safety.

- Maximum system efficiency in systems with dry expansion
- Exceptional precision, stability, reliability, and efficiency
- Minimum energy consumption regardless of fluctuating ambient temperature
- Ensures all liquid is evaporated before reaching the end of the evaporator, optimizing suction pressure while keeping a fully loaded display case at the desired temperature

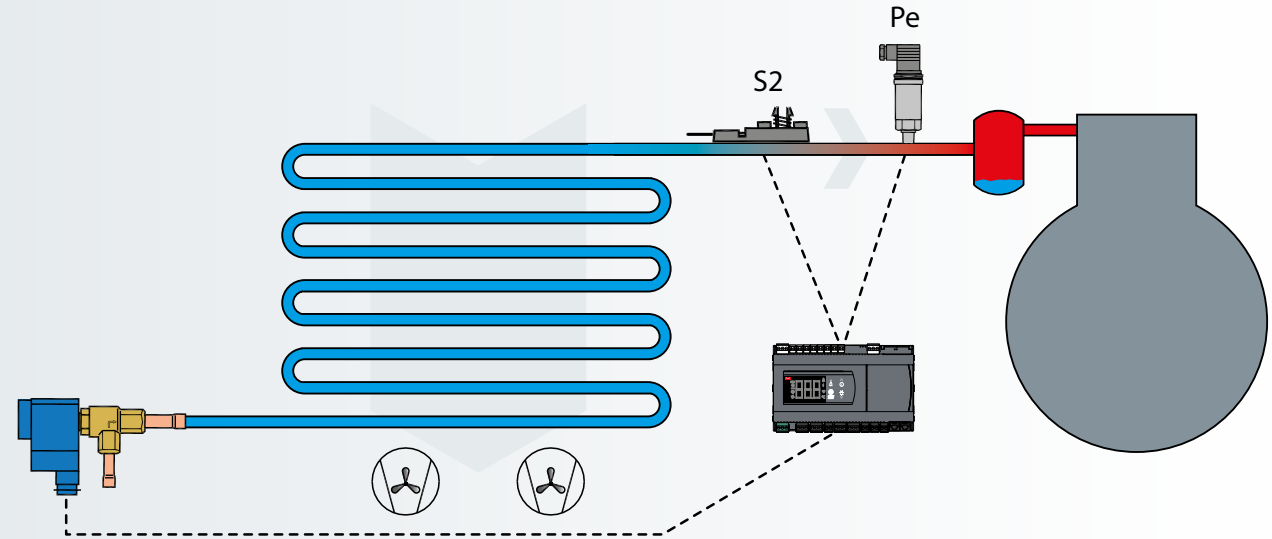




Danfoss **Adaptive Liquid Control** (ALC)

Greater amounts of refrigerant are injected into the evaporator, fully utilizing the entire surface – bringing the superheat very close to zero.

- Suitable for systems with a suction accumulator and Liquid Ejector
- Reduced compressor load with high suction pressure
- Significant energy savings with increased evaporation temperature up to 5 Kelvin compared with MSS systems
- Highly precise liquid control ensures limited liquid to be captured in the suction accumulator

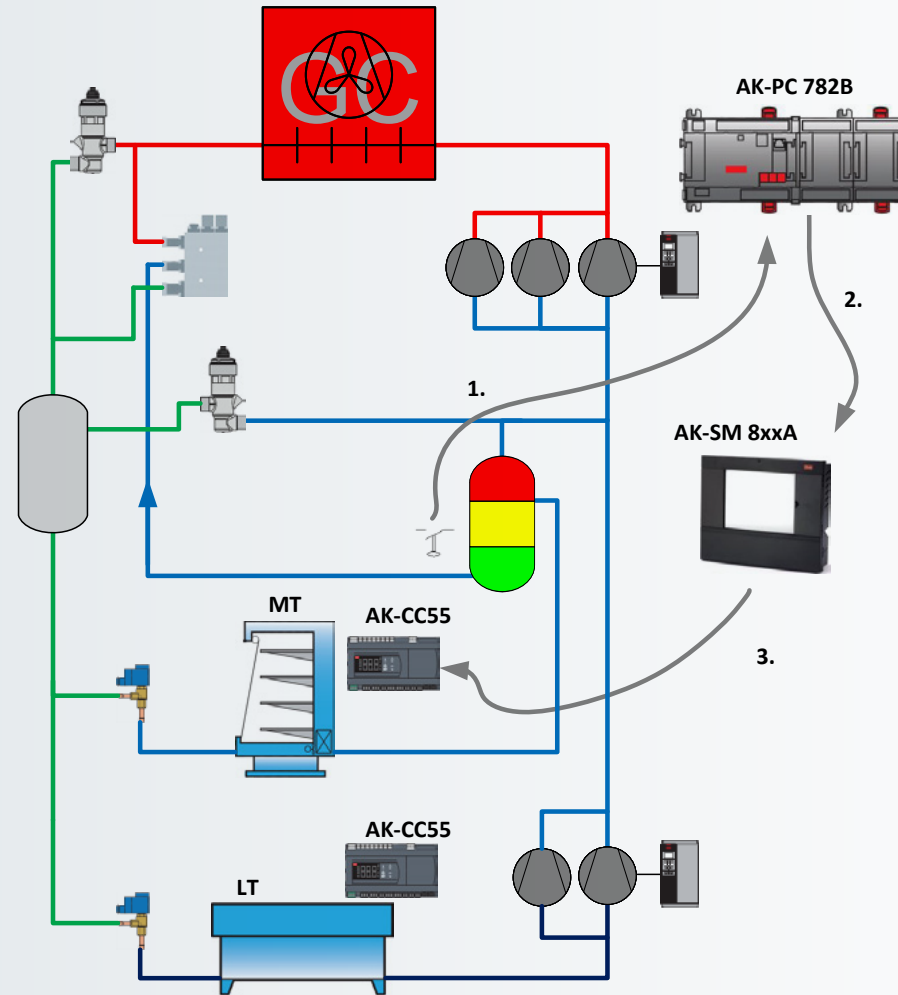


CO₂ Adaptive Liquid Management (CALM™)

CALM™ is a complete solution for the entire system, optimizing all evaporators in a store. This is only possible when all components are optimized to work perfectly together, This is the case for Danfoss AK-CC55, AK-PC 782B, AK-SM 8xxA and Liquid Ejector.

- Globally optimized for any climate, efficient in all ambient temperatures
- Significant energy savings and cost reductions with a reduced risk of first-cost investments
- Liquid Ejector optimizes any transcritical CO₂ booster or parallel compression refrigeration system
- Optimized evaporation effect from refrigerant with superheat controlled close to zero and fully utilized evaporator

[READ MORE HERE >](#)



CALM™ solution:

1. If Liquid Ejectors are unable to take all the liquid collected in the suction accumulator, the liquid level will rise. When the liquid level switch (ideally positioned 1/3 from the bottom of the total height) indicates too high a level, a digital signal triggers AK-PC 782B input.
2. Information about high level is transmitted via a communication line to the System Manager AK-SM 8xxA.
3. By using a communication line to the MT evaporator controllers, superheat control will switch from ALC to MSS (dry SH control) and stop releasing liquid to the MT return line.

Heat reclaim technology

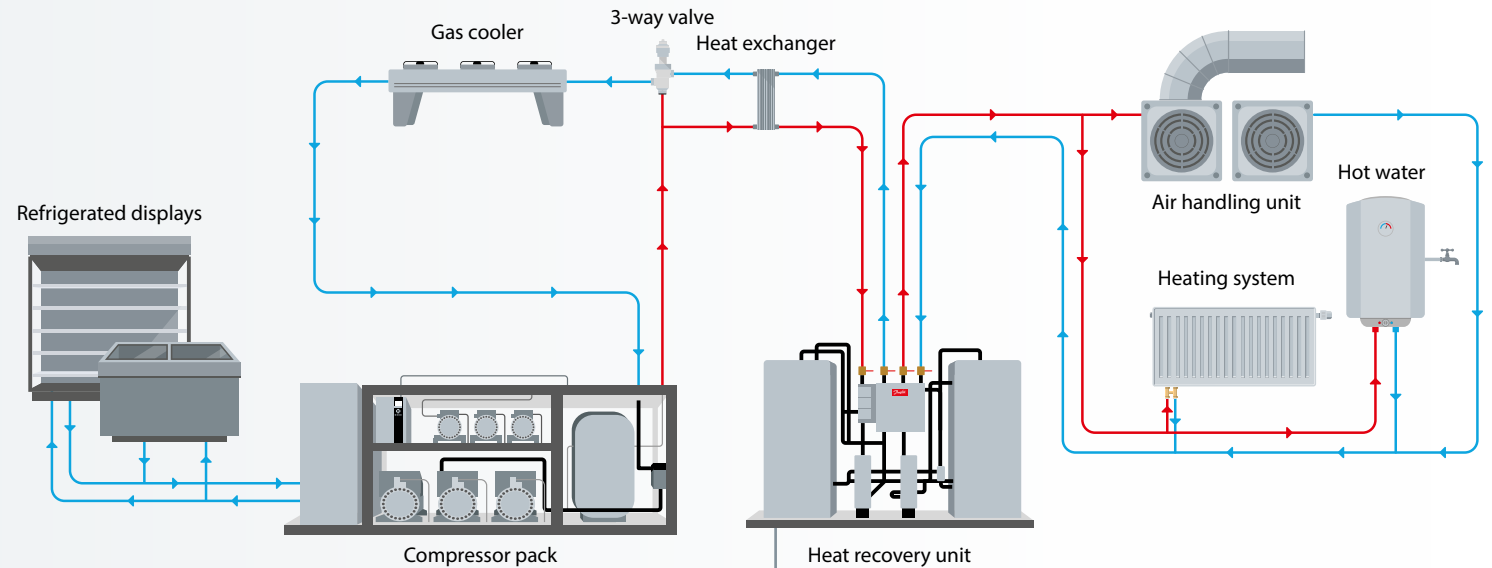
maximizes energy efficiency

CO₂ is a highly suitable refrigerant for heat reclaim. By closely aligning heating, ventilation, air conditioning, and refrigeration systems, you save money, safeguard stock, and reduce your environmental impact.

The Danfoss Heat Recovery Unit (HRU) helps to eliminate the technical challenges of managing heat recovery. The HRU is an integrated solution managing and buffering the heat from the refrigeration pack – to be reused for space heating, hot tap water, or even sold to neighbors or district heating grids.

- Maximum heat recovered and reused
- Standardized solution – tested and proven
- Easy to install and commission
- Stable and efficient solution
- Eliminates the need for a boiler

With an HRU unit, **get maximum heat recovered and reused** with no or minimum need for additional heat sources.



Easy to install
and commission



Stable and
efficient system



Standardized
solution – tested
and proven



ECL controller
enables diagnostics
and remote
monitoring



Buffer tanks for
heat storage –
heat available
when needed



HRU insulated
– no energy wasted

[LEARN MORE >](#)



Case Study

A supermarket turned into a **heat supplier**

A Danish supermarket fulfills 95% of its heating demand from its own cooling display cases.

With Danfoss Heat Recovery Units installed in 12 of its 13 stores, BALS (Brugsen for Als og Sundeved) has managed to halve its CO₂ footprint in just five years – and saves 70% on district heating costs and 37% on electricity.

- Excess heat supplies store with heating and hot water
- Surplus heat can heat up to 15 households in the neighborhood

[READ THE STORY >](#)



Case Study

Recycling heat to cut costs and CO₂

A busy Danish supermarket has significantly reduced its annual heating bill and carbon footprint by utilizing the waste heat from its refrigeration system.

In supermarket chain Meny's Fredericia store, a Danfoss Heat Recovery Unit (HRU) was installed to recycle heat from the CO₂ refrigeration system to warm up its 1,900 m² and provide plenty of hot tap water all year round.

Today, the store manager can see exactly how much energy, money, and CO₂ has been saved. During the first year alone, energy consumption was reduced by 135 MWh in total—and as a bonus, installation was so simple that employees didn't even notice the new unit for the first year of operation.

- External heat requirement reduced with 89.7%
- Carbon footprint reduced by 6.7 tons
- No operational disruptions



[READ THE STORY >](#)

Case Study

CO₂ technology transforms German supermarket

Danfoss Multi Ejector technology optimizes reliability, efficiency, and sustainability at one of EDEKA's mid-sized supermarkets in Germany.

EDEKA, Germany's largest supermarket corporation, installed the Danfoss Multi Ejector Combi HP/LP together with the CO₂ Adaptive Liquid Management (CALM™) system in one of its mid-sized supermarkets to boost energy efficiency, reduce its carbon footprint, and leverage heat recovery to heat the entire store.

- Installation of CO₂ parallel compression system, Multi Ejector technology, and CALM™ system increased reliability and efficiency in various ambient climate conditions
- Multi Ejector Combi HP/LE decreases thermal stress on the MT compressors
- CALM™ system includes Danfoss case controllers that enable MT evaporators to run at maximum by getting superheat control close to zero

[WATCH THE VIDEO >](#)



Worldwide training in CO₂ refrigeration

Take the next step in CO₂ refrigeration – together.

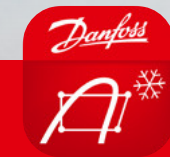
CO₂ has become industry standard in food retail refrigeration with proven technology and components for transcritical refrigeration readily available today. But, there is no one-size-fits-all solution – which is why our team of CO₂ champions is ready to guide you on your refrigeration journey.

Get industry-leading application support and guidance – and access to a series of e-lessons available through Danfoss Learning:

- Introduction to Carbon Dioxide: Properties and Impact
- Advantages of Carbon Dioxide as a Refrigerant
- System Understanding
- Phase Change
- Food Retail Systems and Product Selection



Join our **webinars, e-lessons and face to face courses**



We did complex —
you do awesome

Coolselector®2 helps you optimize energy consumption and increase efficiency in any HVACR system.



Hands-on CO₂ training is coming your way

The Mobile CO₂ training unit has provided more than 2,000 installers, service technicians, and OEM engineers with hands-on CO₂ training since 2016 – providing easy-to-access, hands-on training on how to take full advantage of the natural refrigerant.

Manned by dedicated Danfoss CO₂ champions, visitors can view demonstrations and experience hands-on training with actual systems and interactive panels.

- Simple booster system
- Parallel compression
- Parallel compression with ejector
- Commissioning of CO₂ systems
- Set up of pack and case controls
- Service procedures
- Troubleshooting and correction



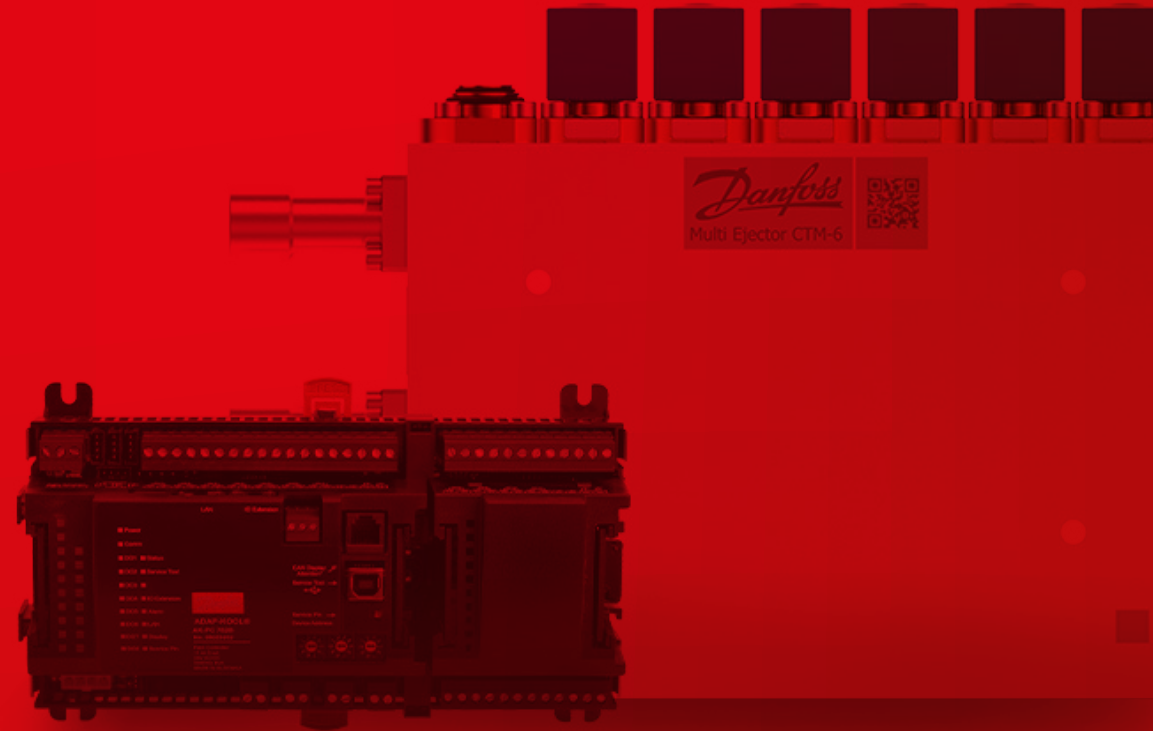
Learn more about the
Mobile Training Unit



A full portfolio of **CO₂ solutions**

Because no two applications are alike, choose from a full portfolio of CO₂ solutions – tailored to your specific need.

- ✓ Small Commercial Cold Room Solution
- ✓ CO₂ MiniPack Solution
- ✓ Transcritical Booster Solution
- ✓ Transcritical Booster with Parallel Compression Solution
- ✓ Multi Ejector Solution™
- ✓ Heat Recovery Solution
- ✓ Cold Storage Solution
- ✓ Comprehensive portfolio of high-performance sub- and transcritical CO₂ compressors





CO₂ solutions for small commercial cold rooms

Get a complete CO₂ cold room package with just four components. Follow these simple steps to find the right match for your application.

1. Expansion device TE2 for R744



Valve
(MWP 90 bar, MOPD 60 bar)



Solder adaptor
– without orifice assembly and filter



Orifice assembly
with filter for solder adaptor

2. Solenoid valves



Solenoid valve EVUL + coil
(MWP 90 bar, MOPD 36 bar)

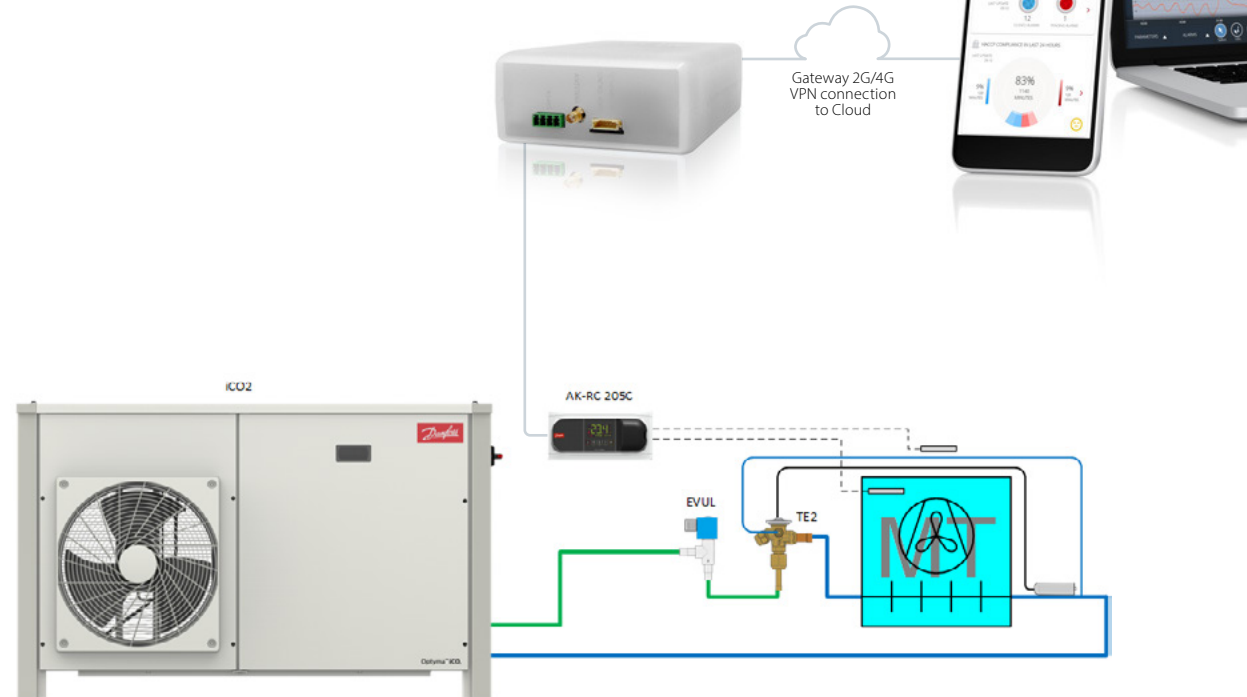
3. Optyma™ cold room Controller



4. Optyma™ iCO2 condensing unit



5. IoT cloud Enabler





CO₂ MiniPack Solution – from 20-70 kW

CO₂ made easy for small stores

The CO₂ MiniPack Solution empowers owners of small stores to harness the energy efficient, cost-saving benefits of CO₂ refrigeration systems, combining five compatible products into a single solution.



Pack Controller AK-PC 572
An all-in-one solution that makes using CO₂ approachable



Stepper Valve Driver EKE 1P
An extension module for Danfoss controllers



Midi Drive VLT FC 280
Flexible and efficient motor control



BOCK® Transcritical and subcritical CO₂ compressors
Efficient and reliable CO₂ compressor for all applications



GBC 90 bar
Efficient and reliable shut-off ball valve for CO₂



Electric Regulating Valve CCMT Light 3-10
Highly robust and reliable electric valve



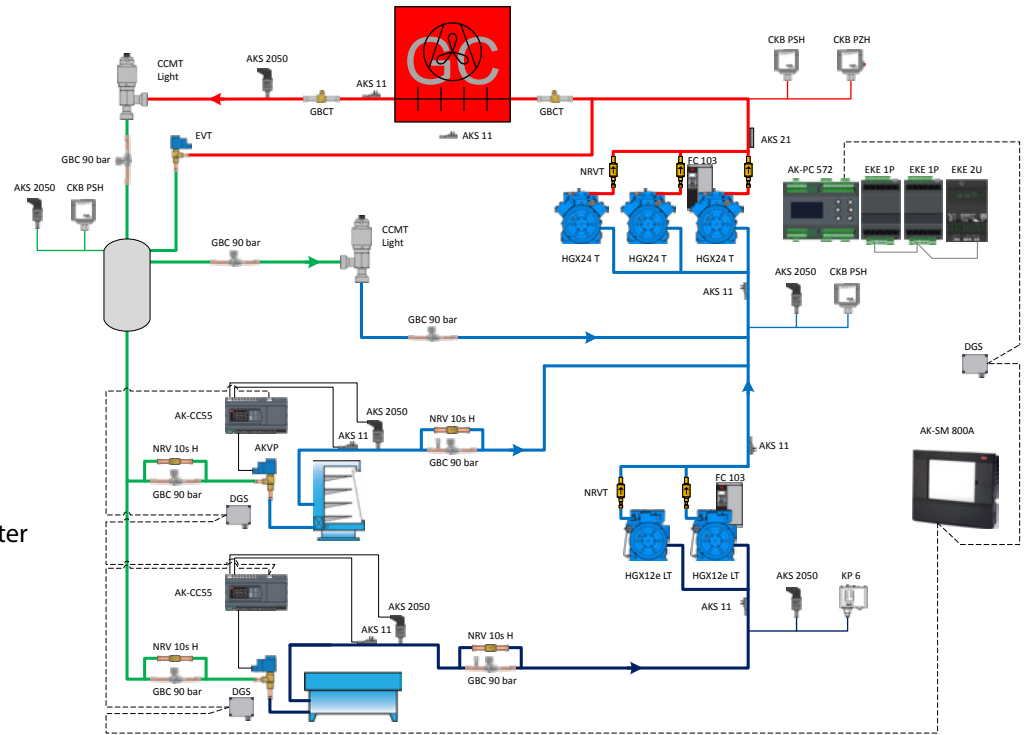
Backup Power Module EKE 2U
Effective energy storage device



Pressure Transmitter AKS 2050
Reliable, durable, high-performance pressure transmitter



NRVT
Check valve for high pressure CO₂ applications




— High pressure (50-120 bar)
— Receiver pressure (32-50 bar)
— MT suction pressure (22-36 bar)
— LT suction pressure (10-16 bar)




Transcritical Booster with Parallel Compression Solution – from 40-100 kW

Uncomplicated and reliable CO₂ solution for mild climates


The first generation of transcritical supermarket systems, the simple booster solution proves the efficiency and simplicity of CO₂ systems in mild and warm climates.




Pack Controller AK-PC 772B
Complete regulating unit for capacity control of compressors and condensers




Gas-Detecting Sensor DGS
Refrigerant gas detection to safeguard buildings




Case Controller AK-CC55
Complete control with excellent flexibility




Shut-off Ball Valve GBCT
Engineered specifically for use with CO₂




BOCK® Transcritical and subcritical CO₂ compressors
Efficient and reliable CO₂ compressor for all applications




Electric Regulating Valves CCMT 2-8 and CCMT 16-42
Highly reliable electric valve for all CO₂ systems



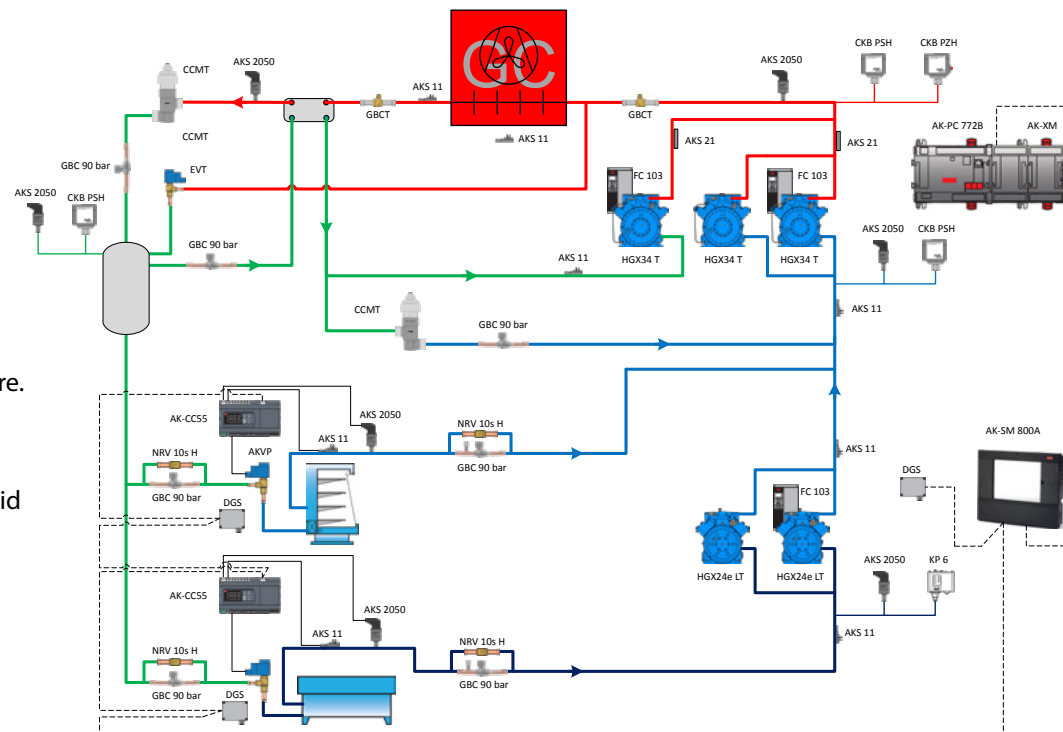
CKB Pressure Switch
CO₂ safety pressure switch to protect compressor and the system against too high pressure.



Solenoid valve EVT
EVT high pressure range is a direct or servo operated solenoid valve specially designed to fit into CO₂ transcritical refrigeration systems.



Electric Expansion Valve AKVP
Precise liquid injection for evaporators



- High pressure (50-120 bar)
- Receiver pressure (32-50 bar)
- MT suction pressure (22-36 bar)
- LT suction pressure (10-16 bar)



Transcritical Booster with Parallel Compression Solution – from 100 kW and up

An industry-leading CO₂ solution for warm climates

The most common CO₂ solution today, transcritical booster systems with parallel compression boost efficiency and increase viability in warmer climates.



Pack Controller AK-PC 782B
Scalable control for up to 12 compressors



Case Controller AK-CC55
Complete control with excellent flexibility



Refrigeration Drive VLT FC 103
Simple energy efficiency



BOCK® Transcritical and subcritical CO₂ compressors
Efficient and reliable CO₂ compressor for all applications



Compressor Oil Management COM
Continuous oil-level control for high system reliability



Electric Regulating Valve CCMT 16-42
Highly reliable electric valve for all CO₂ systems



Motor-Operated Valve ICMTS
Regulate the flow of transcritical gas or subcritical liquid



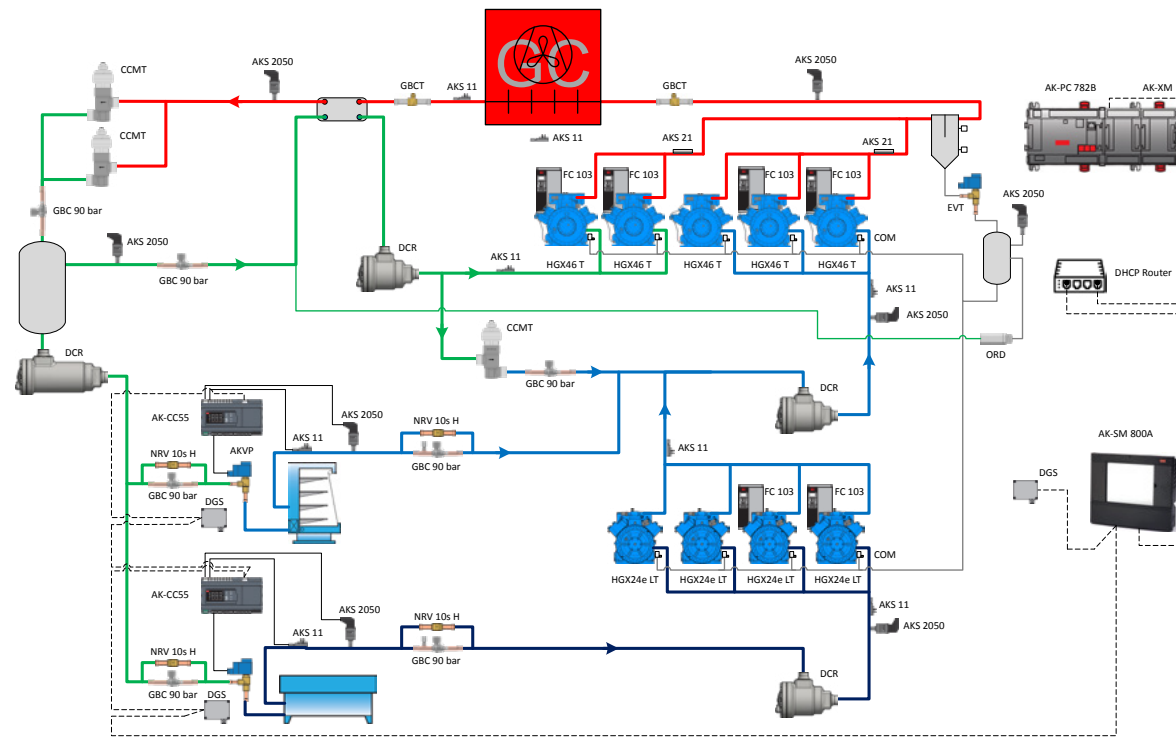
Electric Expansion Valve AKVP
Precise liquid injection for evaporators



Temperature Sensor AKS 11
Temperature-dependent resistance sensor



DCR filter driers
Reliable, high performance and easy installation



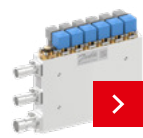
- High pressure (50-120 bar)
- Receiver pressure (32-50 bar)
- MT suction pressure (22-36 bar)
- LT suction pressure (10-16 bar)



Multi Ejector Solution™

A solution for every size and climate

The complete portfolio of Multi Ejector solutions covers the needs for all store sizes, CO₂ refrigeration systems, and climates.



Multi Ejector – High Pressure lift (HP)
Add-on to enhance efficiency in a parallel compression system



Multi Ejector – Liquid Ejector (LE)
Full evaporator optimization via CALM™



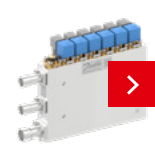
Pack Controller AK-PC 782B
Complete regulating unit for capacity control of compressors and condensers



System Manager AK-SM 800A
Take advantage of the CALM™ solution



Multi Ejector – Low Pressure lift (LP)
Add-on to the booster system improving efficiency during warm ambient conditions



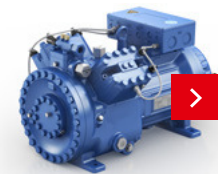
Multi Ejector – Combi HP/LE
The benefits of the High Pressure and Liquid Ejector in one solution



Case Controller AK-CC55
Complete control with excellent flexibility

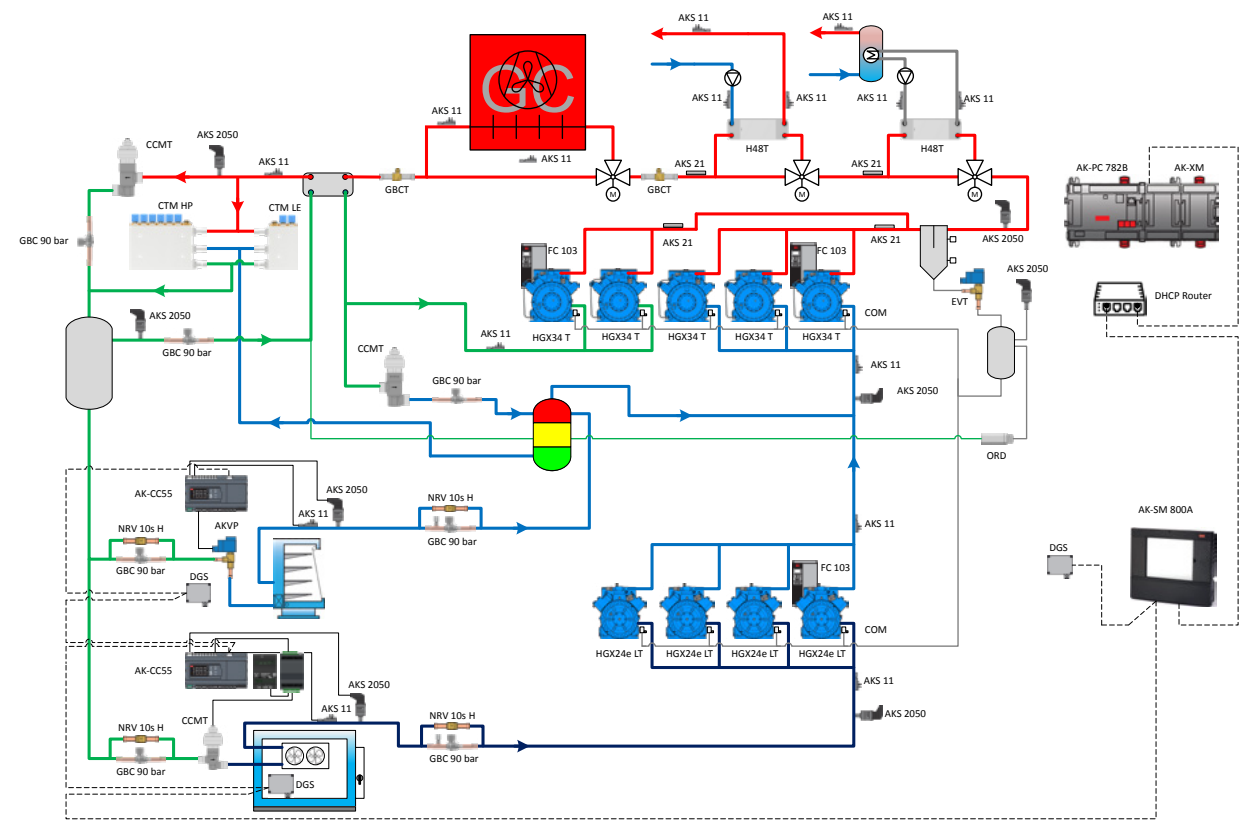


Electric Regulating Valve CCMT 16-42
EEV for larger cold rooms



BOCK® Transcritical and subcritical CO₂ compressors
Efficient and reliable CO₂ compressor for all applications

How to choose the right Multi Ejector >




— High pressure (50-120 bar)
— Receiver pressure (32-50 bar)
— MT suction pressure (22-36 bar)
— LT suction pressure (10-16 bar)





Cold Storage Solution


CO₂ transcritical system with large Industrial components

Use the parts designed for the job. Danfoss' built-for-purpose, built-for-industry, transcritical CO₂ solutions ensure your operation is future-proof. The larger components bring unmatched efficiency and simplicity to large systems. Creating a new industrial standard for transcritical CO₂ systems.


- 


Shut-Off valve SVA-140B
For isolating large components and high differential pressures
- 


Liquid Level transmitter AKS 4100
Accurate measuring of CO₂ liquid levels in IT and LT vessels
- 


BOCK® Transcritical and subcritical CO₂ compressors
Efficient and reliable CO₂ compressor for all applications
- 

ICF Flexline™ valve station
Replaces individual function and simplifies design, installation, service, and maintenance

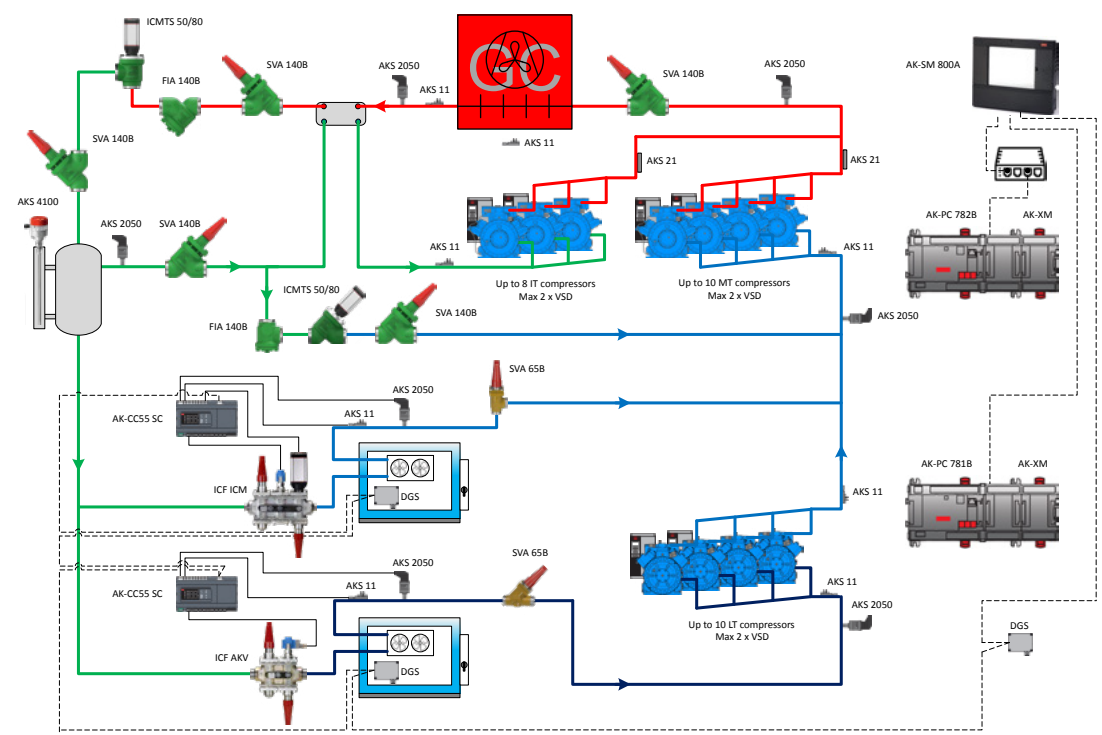
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Strainer FIA-140B
Housing with replaceable stainless steel insert
- 

Motor-Operated Valve ICMTS
Regulate the flow of transcritical gas or subcritical liquid
- 

SVL 65 bar Flexline™
Shut-Off, Stop/Check, Check, Regulating valve and strainers in one shared 65 bar valve house
- 

Pack Controller AK-PC 781B
Scalable control for up to 10 compressors



— High pressure (50-120 bar)
— Receiver pressure (32-50 bar)
— MT suction pressure (22-36 bar)
— LT suction pressure (10-16 bar)

Discover more about our industrial CO₂ portfolio for cold storage >



Heat Recovery Solution

Efficient and green CO₂ system with Heat Recovery

Unlock Sustainable Savings with Danfoss Heat Recovery Unit. The cutting-edge solution is designed to harness the excess heat from the cooling system and thereby maximize energy efficiency and reducing the carbon footprint of the store significantly.



Heat Recovery Unit- One tank
Introducing the one tank solution with the perfect capacity for smaller stores



Heat Recovery Unit- Two tank
Two tank solution is the optimal product for heat recovery in bigger mid size stores



Pack Controller AK-PC 782B
Complete regulating unit for capacity control of compressors and condensers



Electric 3-Way Valve CTR
For heat recovery and gas cooler bypass application.



System Manager AK-SM 800A
Take advantage of the CALM™ solution

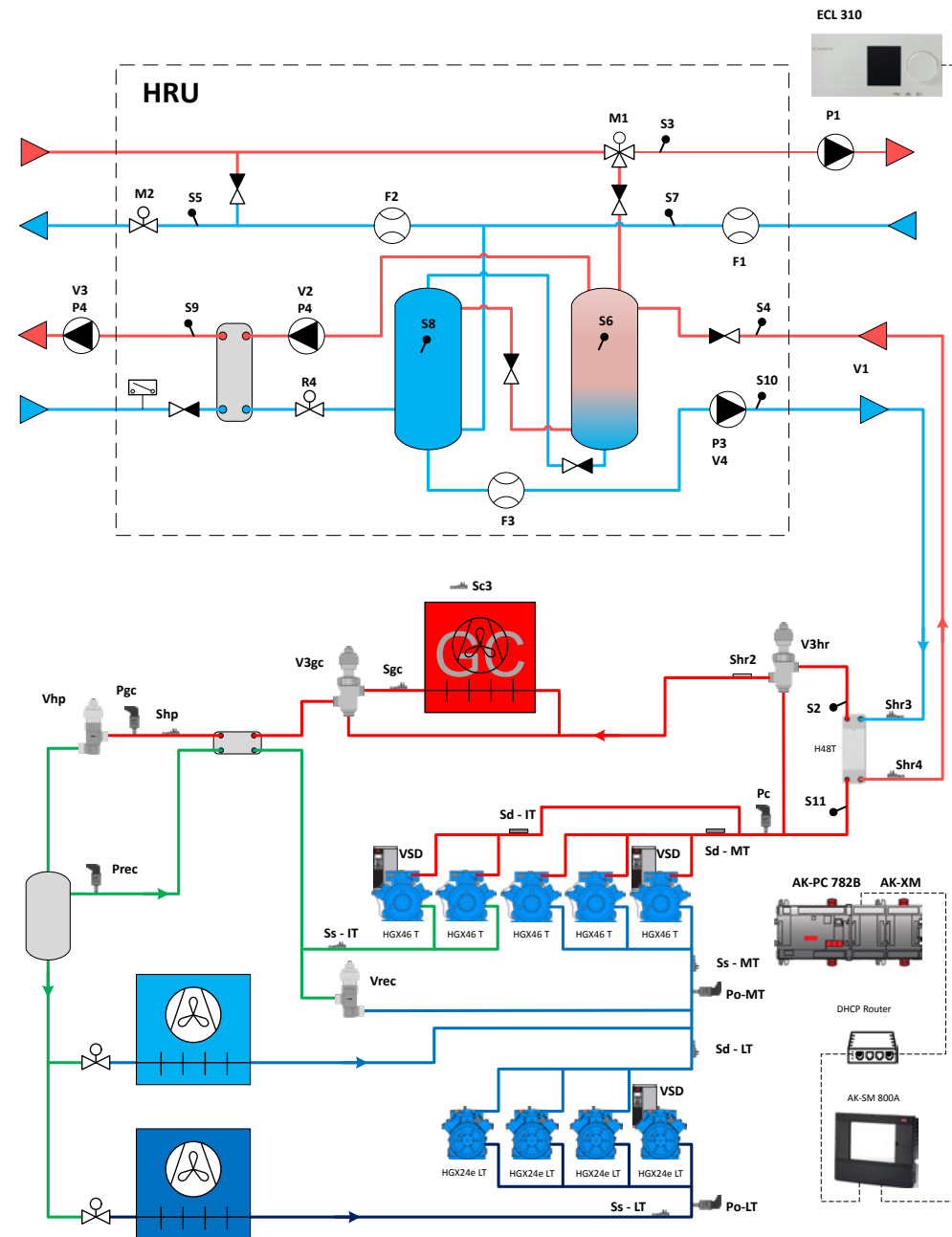


Pressure Transmitter AKS 2050
Reliable, durable, high-performance pressure transmitter



BOCK® Transcritical and subcritical CO₂ compressors
Efficient and reliable CO₂ compressor for all applications

- High pressure (50-120 bar)
- Receiver pressure (32-50 bar)
- MT suction pressure (22-36 bar)
- LT suction pressure (10-16 bar)



CO₂ refrigeration is part of the **Danfoss Smart Store**

Danfoss Smart Store solutions help build the supermarkets of tomorrow by reducing costs, minimizing environmental impact, and creating future-proof advantage – all while maintaining the highest level of food safety.

Installed in more than 50,000 food retail stores worldwide, smart store solutions:

- Use smart refrigeration to reduce operating costs
- Use connectivity to eliminate food waste and reduce service costs
- Provide long-term sustainability
- Integrate systems to gain economies of scale
- Reduce energy prices through optimized demand

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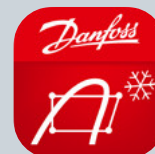
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