

We built the first CO₂ supermarket in the Middle-East.

SUSTAINABLE FOOD COLD CHAIN

REFRIGERATION INNOVATION TO **EMPOWER**
YOUR BUSINESS AND THE ENVIRONMENT.



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION



ON

COMPETITIVENESS AND BUSINESS OPPORTUNITY ON

Our goal: promoting green refrigeration together with saving resources.

Your goal: growing your business.

Let's do it together.

By choosing green refrigeration technologies you can increase your business opportunities and gain better visibility.

Make it happen.



Do you know you can grow **your business whilst improving the world?** By investing in green refrigeration technologies you can help **reducing the world food waste by 40% and benefiting from energy savings at the same time.** Investing in our planet's future means **investing in your future.**

OFF



WASTED FOOD
OFF





ON

INNOVATION TECHNOLOGY ON

We analyzed the state of the art of refrigeration systems. We carefully studied every single component. And we brought to life an innovative and sustainable design for the cold chain that UNIDO will bring to the Middle East, Asia, Latin America and Africa.

Unthinkable? It could be your business.

OFF

Inefficiencies are resources-wasting practises. Energy consumption can be optimized by an efficient cold chain and new refrigeration technologies that substantially reduce the need for maintenance and repair. Our vision: eliminating waste and reducing energy and management costs.

Tomorrow? Right now.



**ENERGY AND
MAINTENANCE
COSTS
OFF**



ON

THE FIRST CO₂ SUPERMARKET

JORDAN ON

UNIDO, CCAC and the Ministry of Environment of Jordan, in partnership with innovative national and international technology providers, commissioned the first transcritical CO₂ supermarket in the Middle East.

MAIN PROJECT FACTS

- Donor: Climate and Clean Air Coalition (CCAC).
- Implementing Agency: United Nations Industrial Development Organization (UNIDO).
- GOV partner: Ministry of Environment, Jordan.
- Full replacement of HCFC-22 installation in a supermarket.
- Experiences and results disseminated throughout Jordan, other countries with high ambient temperatures and international community.
- Total budget: US\$ 605,000.

PROJECT SITE & TECHNOLOGY

- Selected system: State-of-the-art CO₂ transcritical system with parallel compressors and multi-ejector (for higher system efficiencies in high ambient temperature operation conditions).
- Selected beneficiary: AlSalam supermarket in Amman.
- Selected technology provider: cabinets and installation 100% from Jordan, in partnership with leading European manufacturer.

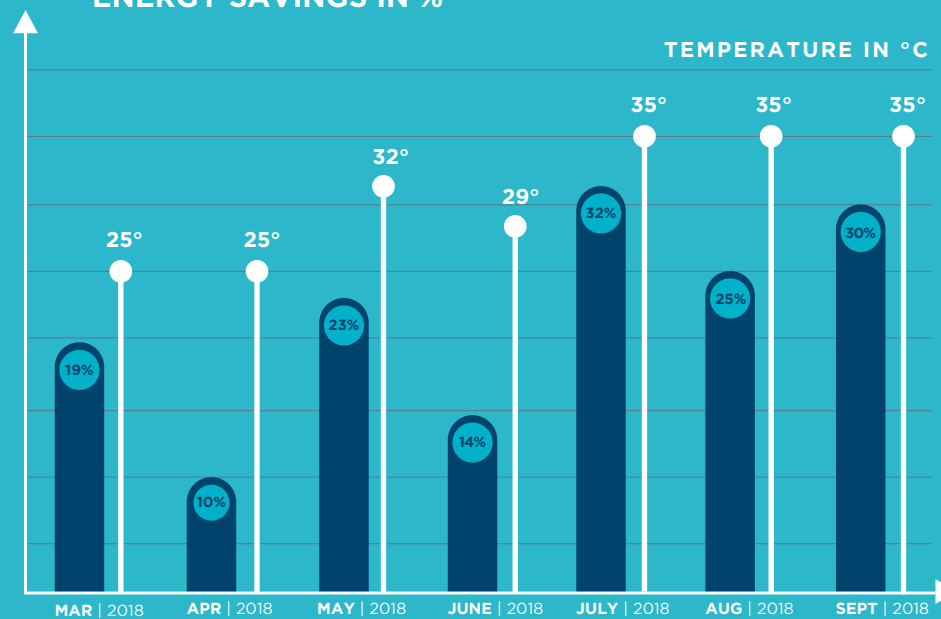


ON

PROJECT RESULTS AFTER ONE YEAR OF OPERATION

- 20% energy reduction (compared to the previous HCFC system).
- Food loss: 0 (food spoilage due to unstable refrigeration was a big problem for the supermarket before).
- Maintenance cost: 0.
- Feedback from supermarket & suppliers: extremely positive.
- Closure time in supermarket during installation: 0.

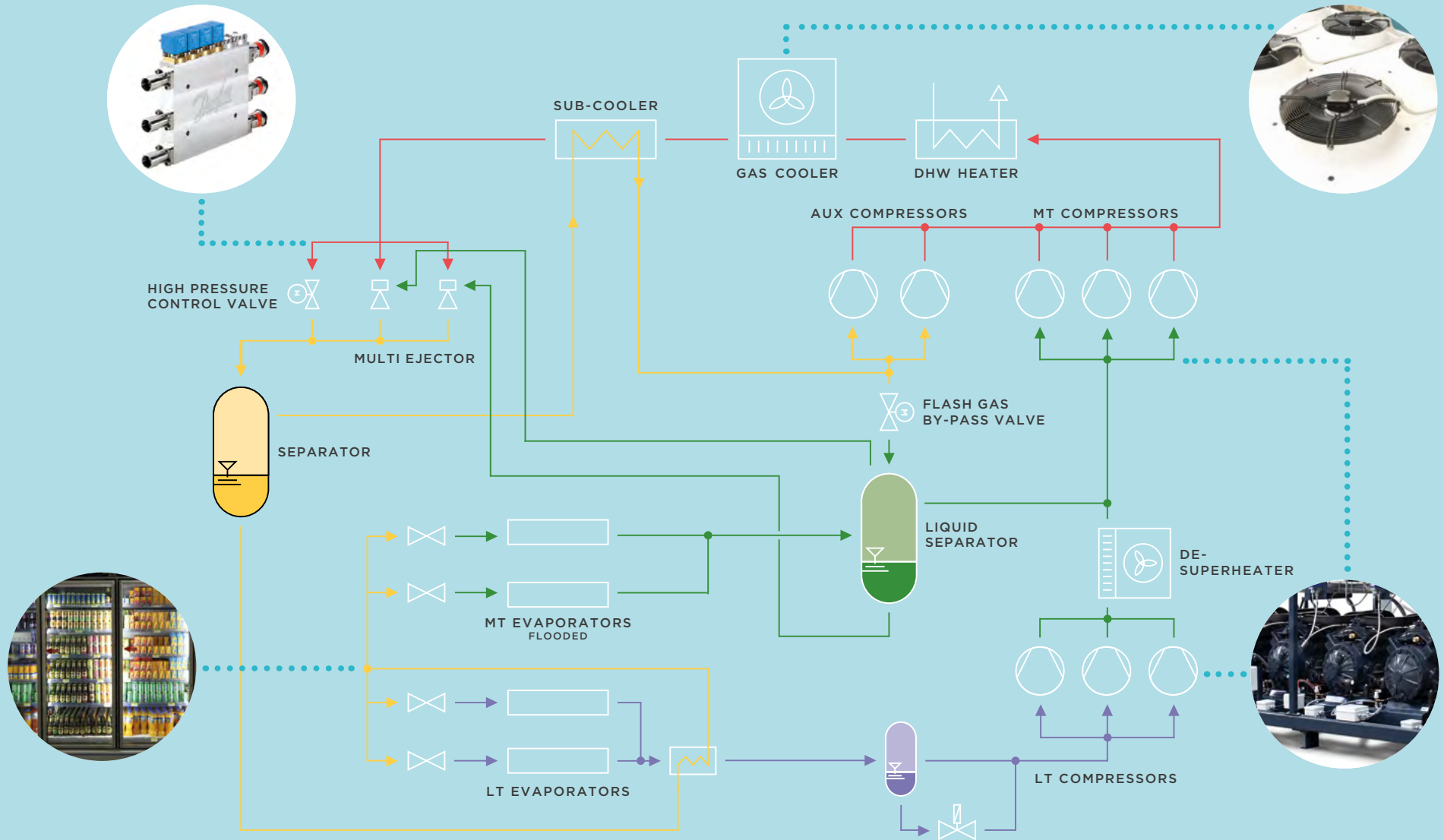
ENERGY SAVINGS IN %



Comparison between HCFC system and newly installed transcritical CO₂ system in Amman, Jordan.

TECHNOLOGY ON

How to save energy without wasting resources? How to protect the environment and developing your business?
A more sustainable food cold chain: this is what our planet needs to **light ON** again.



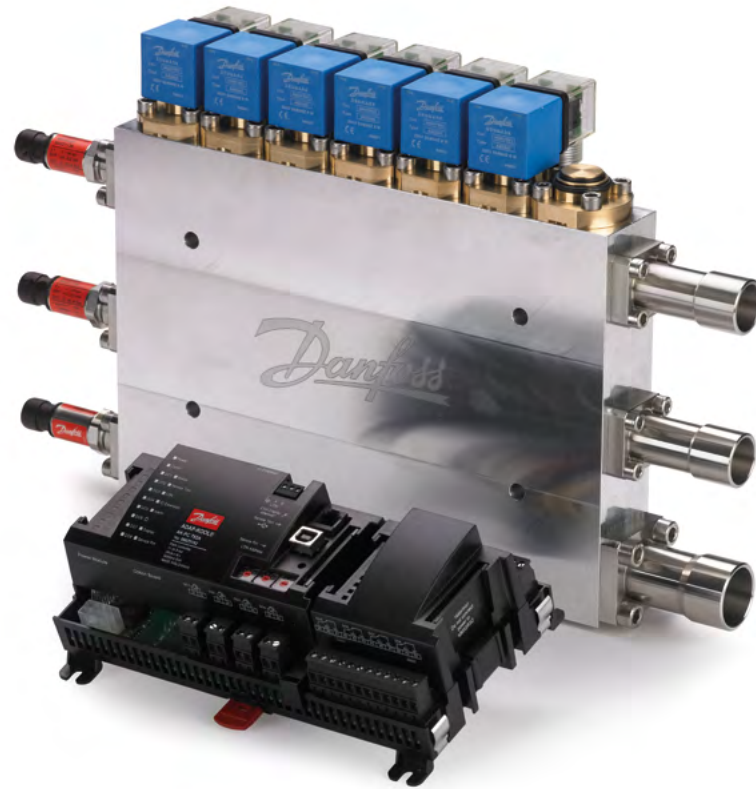


REFRIGERANT: R744

CO₂ FEATURES

- Natural working fluid: carbon dioxide - CO₂.
- Environmental friendly > no unforeseen environmental impact in the future.
- Non-flammable.
- ODS: 0.
- GWP: 1 (CO₂ is the reference fluid = 1).
- Excellent fluid properties related to heat transfer.
- Predictable and future-proof, compliant with all future international agreement.
- Widely available in every market.





EJECTORS

EJECTORS enable expansion work recovery & working principle: high pressure fluid enters the nozzles where pressure energy is converted to kinetic energy. Fluid at low pressures is sucked into the mixing chamber where the two streams are mixed and momentum exchange takes place. The pressure increases in the diffuser as the velocity of the stream decreases.

MULTI EJECTOR

- Fixed geometry at various capacity steps (1-2-4-8-8-8).
- Applied as high pressure control device.
- Supports operation of parallel compressor.
- Enables to operate cabinets without superheat all year.

DISPLAY CABINET

ENERGY EFFICIENT DESIGN

- Non superheated operation of evaporators all year.
- Able to operate at high evaporation temperatures (LT @ -25 °C ; MT @ -2 °C).
- Glazed doors.
- Efficient defrost.



R744 COMPRESSOR PACK

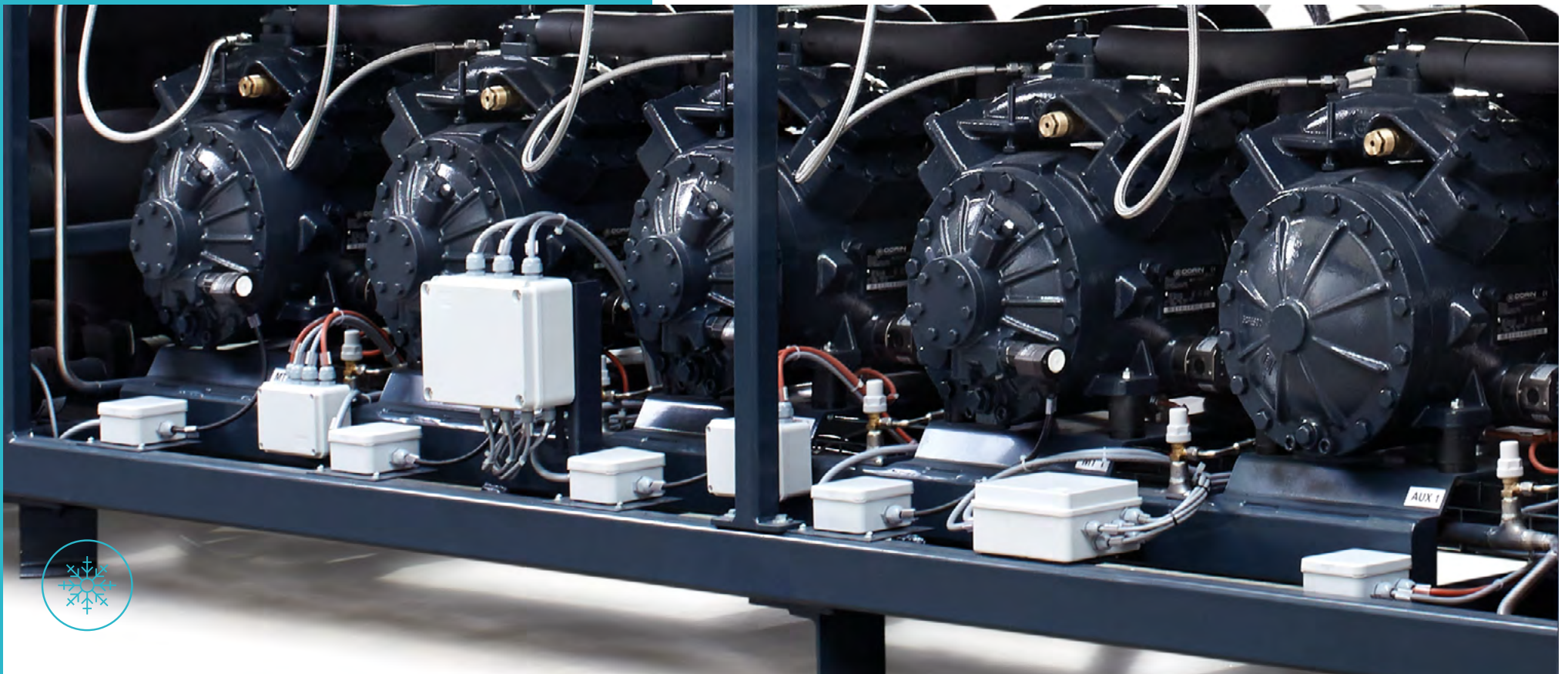
CO₂ BOOSTER TECHNOLOGY

One refrigeration unit (and single working fluid = CO₂) for both the freezing (LT) and chilling (MT) part of the system.

HIGH ENERGY EFFICIENCY

- Parallel compression.
- Inter-cooling after LT compressors.
- Integration of Multi-Ejector.

Maximum reliability and maintainability.

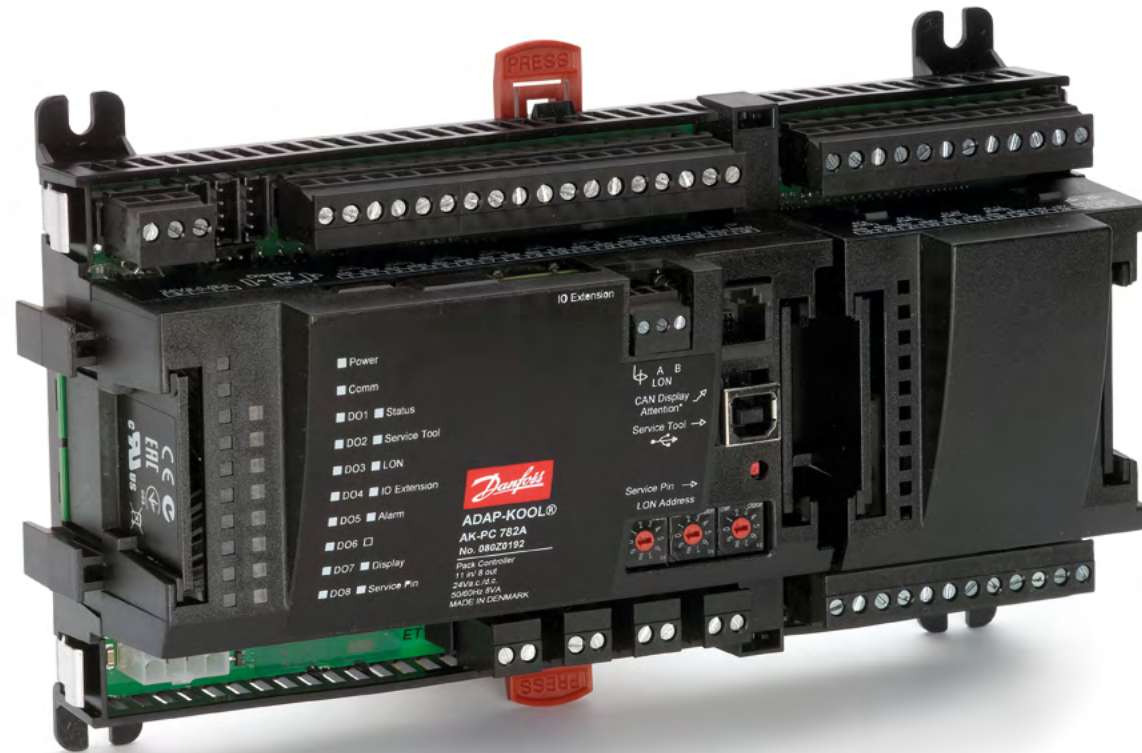




HEAT REJECTION

ENERGY EFFICIENT GAS COOLERS

- Heat recovery to produce domestic hot water (up to 90 °C water temperature).
- De-superheating after low temp. compressors.
- Power adapted main gas cooler, able to achieve a 2K temperature difference at the refrigerant outlet side.



CONTROL UNIT

Adjusts the parameters to operate the unit at high energy efficiency. Safe mode operation under all circumstances.

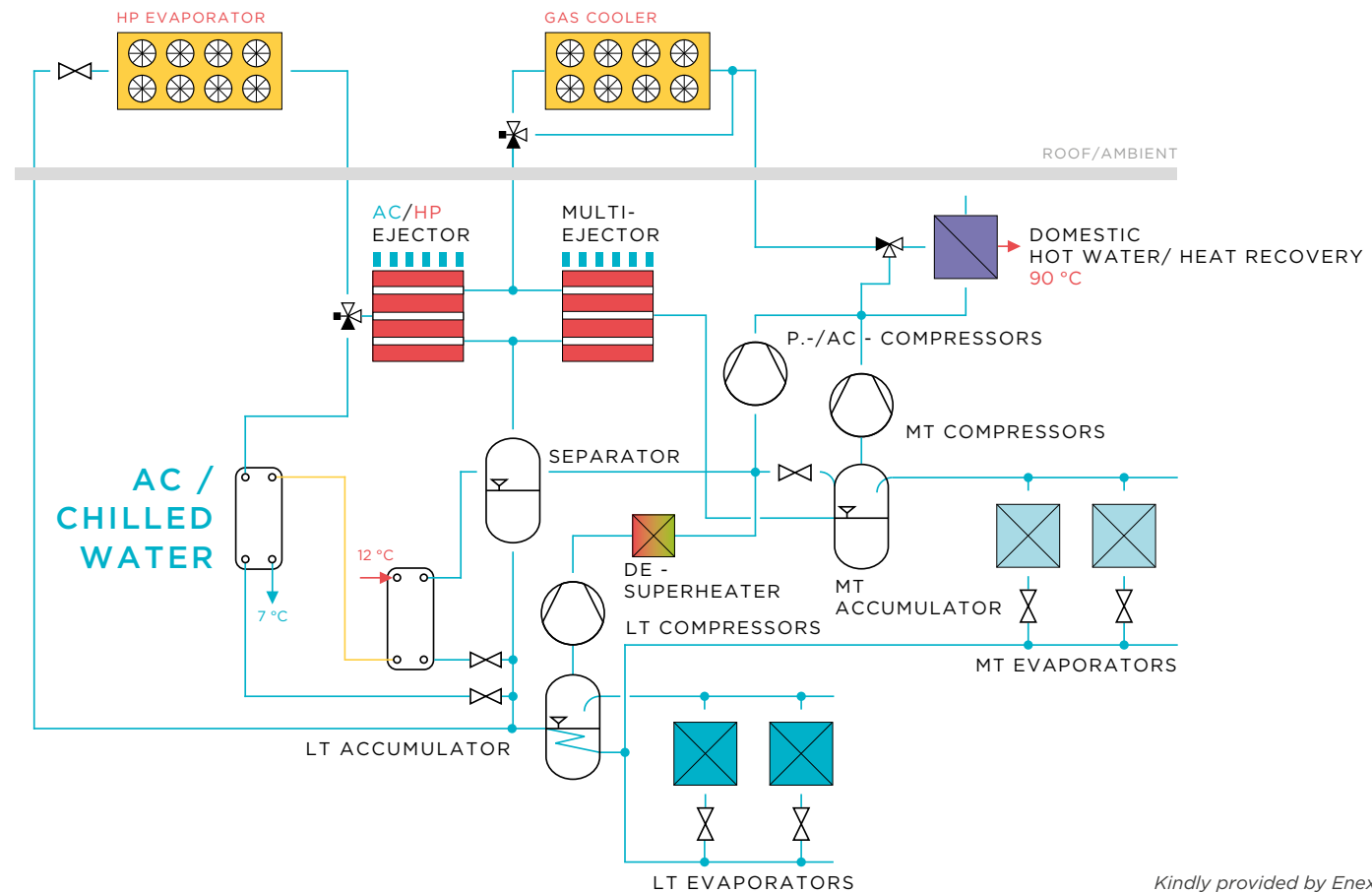
MONITORY SYSTEM

- Enable energy efficient operation modes.
- Outputs are key performance indicators (energy demand, pressure levels and stability of cabinet temperatures).

AC SYSTEM

INTEGRATION OF AIR CONDITIONING

- Reduces service and maintenance costs.
- One refrigerant for the entire heating and cooling system.
- Efficient utilization of parallel compressors.
- Option A: new installation > direct air cooling devices inside the shop.
- Option B (as shown): > chilled water production.



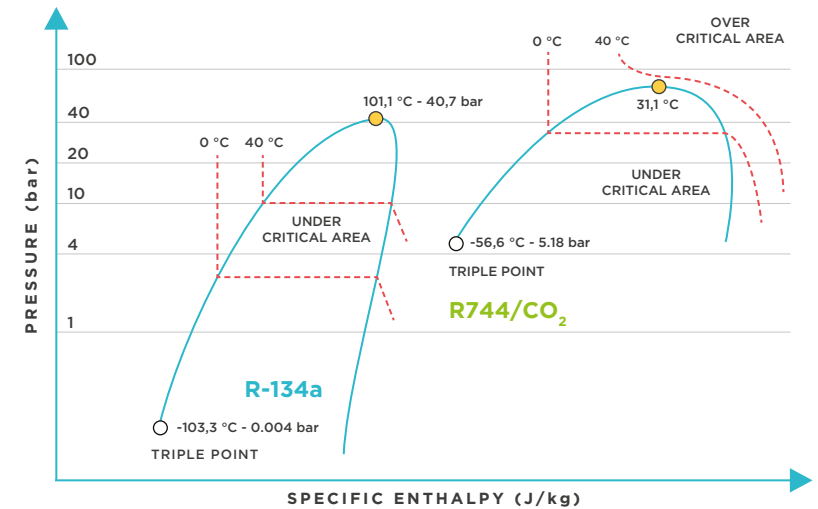
Kindly provided by Enex

TECHNICAL FACTSHEETS

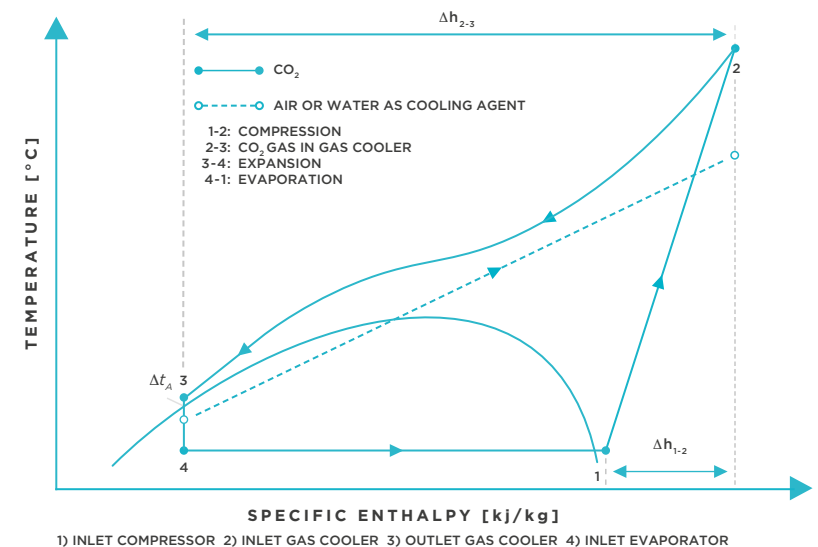
DIFFERENCES OF A CO₂ SYSTEM TO A STANDARD SYSTEM

| | |
|--|--|
| HIGH PRESSURE WORKING FLUID | Low critical temperature: 31,1 °C High critical pressure: 73,8 bar Triple point at 5,18 bar & -56,6 °C Evaporation: 10-40 bar Heat release: 65-130 bar |
| CONDENSATION | Only below ambient temperatures of +28 °C |
| HEAT RELEASE AT 30-100 °C | Transcritical process at gliding CO ₂ temperatures |
| HIGH VOLUMETRIC REFRIGERATION CAPACITY (VRC) | 4 to 10 times smaller compressor volume |
| HIGH PRESSURE, HIGH DENSITY, LOW ($\Delta t/\Delta p$) | Small dimension on pipes, valves for gas/two phase/liquid NO SUPERHEAT IN HEAT EXCHANGERS |
| REFRIGERANT CO₂ | Use special refrigerant CO ₂ or CO ₂ of purity class 4.5 (max. 5 ppm of moisture) |
| LOW PRESSURE RATIO GOOD THERMO PHYSICAL PROPERTIES | > High compressor efficiency > Efficient heat transfer in heat exchangers |
| Consequence: transcritical operation at elevate ambient temperatures. Properties of CO ₂ are unique and in favour for refrigeration and heat pumping applications. | |

DIFFERENCES OF A CO₂ SYSTEM TO A STANDARD SYSTEM



HEAT REJECTION AT GLIDING TEMPERATURE IN CO₂ SYSTEM



CO₂ MULTI EJECTORS FOR HOT CLIMATES

MULTI EJECTORS

- Liquid (flooded evaporators)
- Vapour (boost parallel compressors)

ALWAYS FLOODED EVAPORATORS

> +10% in COP

PRESSURE LIFT

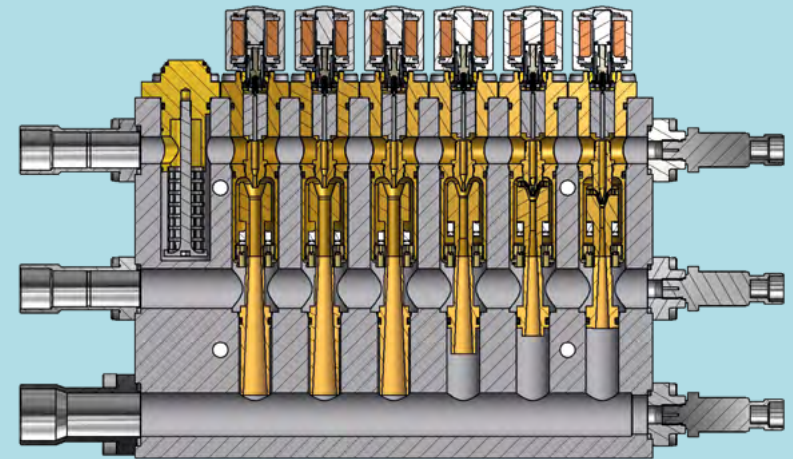
10-15 bar

COP INCREASE

Of up 17%

EJECTOR EFFICIENCY

Of 30% under optimum operational conditions.



WHY EJECTOR?

- WORKS LIKE A “JET PUMP”

- ‘FREE’ PRESSURE LIFT

- NO MOVING PARTS

high RAM* values

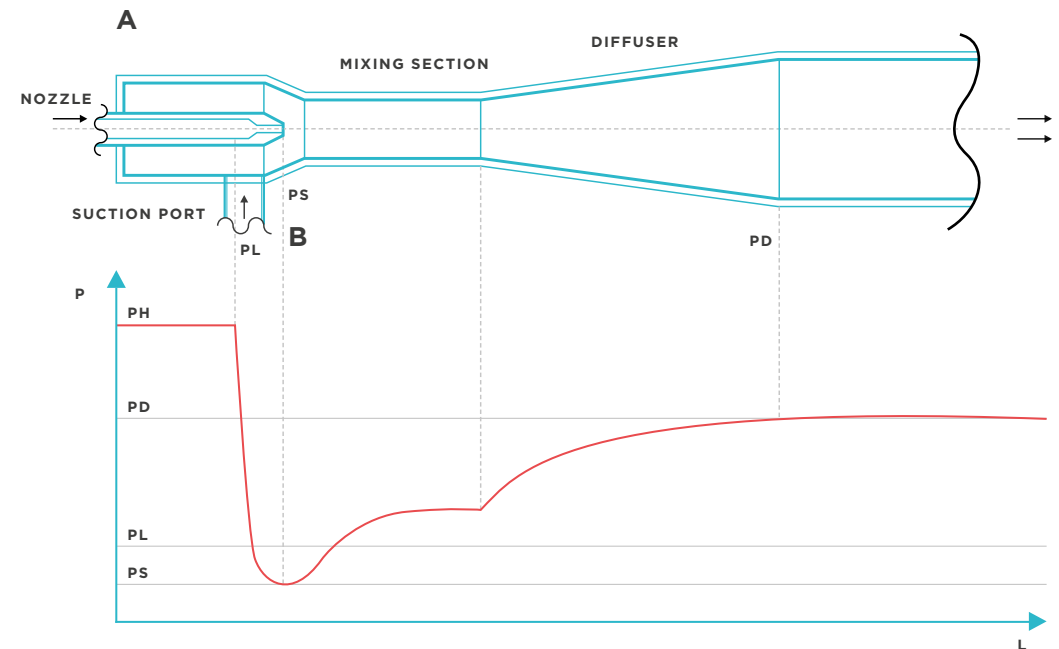
- BERNOULLI’S PRINCIPLE

When the speed of a fluid increases its pressure decreases and vice versa.

High pressure fluid enters the nozzle (A) where pressure energy is converted to kinetic energy. Fluid at low pressures (B) is sucked into the nozzle and the two streams are mixed.

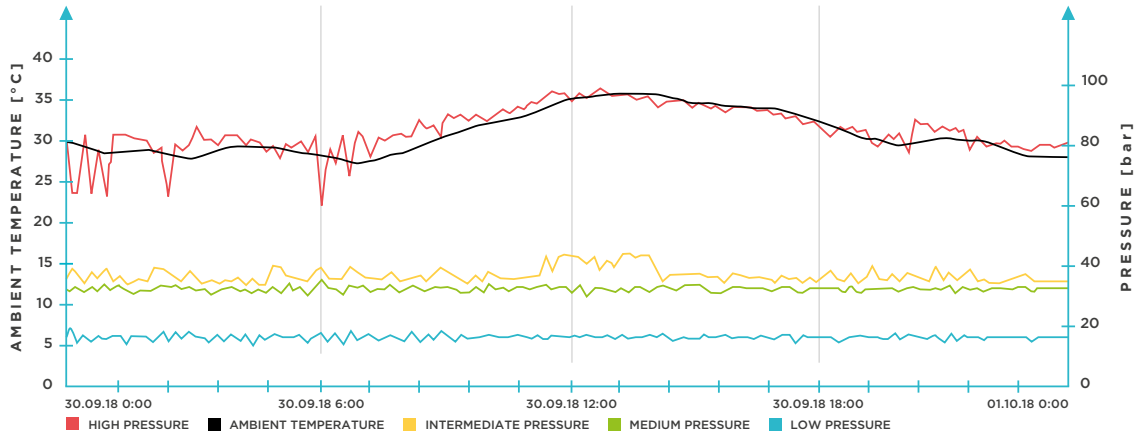
The pressure increases in the diffuser as the velocity of the stream decreases.

RAM* = Reliability Availability and Maintainability



[30.09.2018]

MEASURED PERFORMANCE AT ALSALAM SUPERMARKET ON A HOT DAY



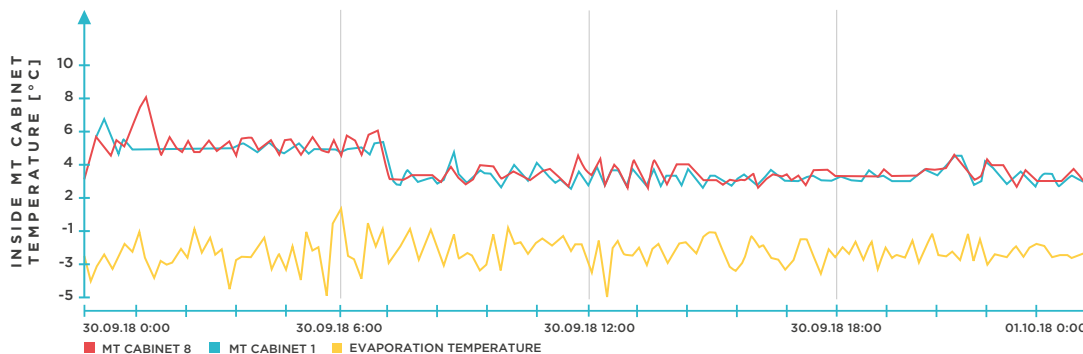
PART A

Ambient temperature and corresponding high side pressure of the CO₂ refrigeration unit. Stable pressure levels for the low temperature and medium temperature suction lines. Intermediate temperature represents suction pressure of the parallel/auxiliary compressor.



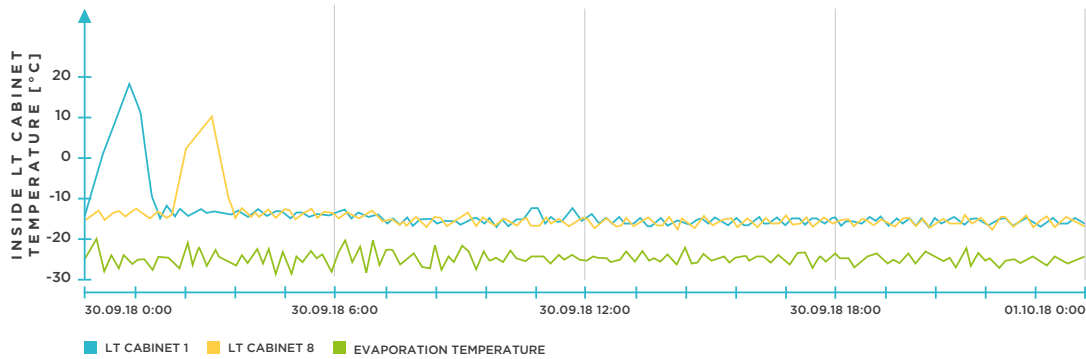
PART B

Air/Cabinet temperatures (1 & 8) and evaporation temperature (average value around -2 °C) for the medium temperature suction group.



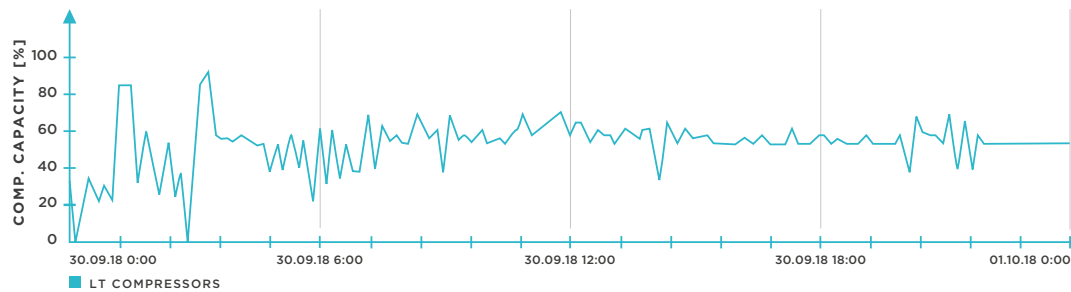
PART C

Applied compressor capacities related to the total installed compressor capacities (auxiliary and medium temperature).



PART D

Cabinet temperatures (1 & 8) and evaporation temperature (average value around -2 °C) for the low temperature suction group.



PART E

Applied compressor capacities related to the total installed compressor capacities (low temperature).



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