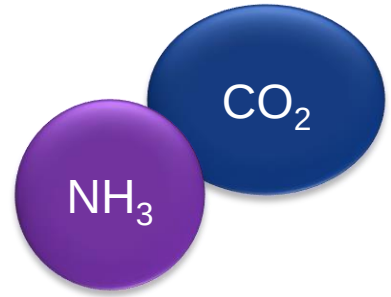


Lets talk about…

Ammonia/Carbondioxide Cascade

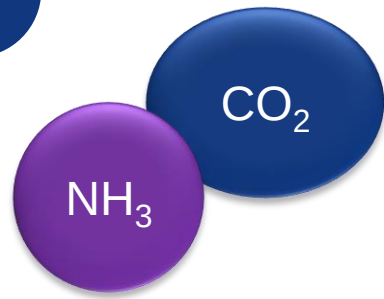
Reliable NH_3/CO_2 cascade heat exchangers

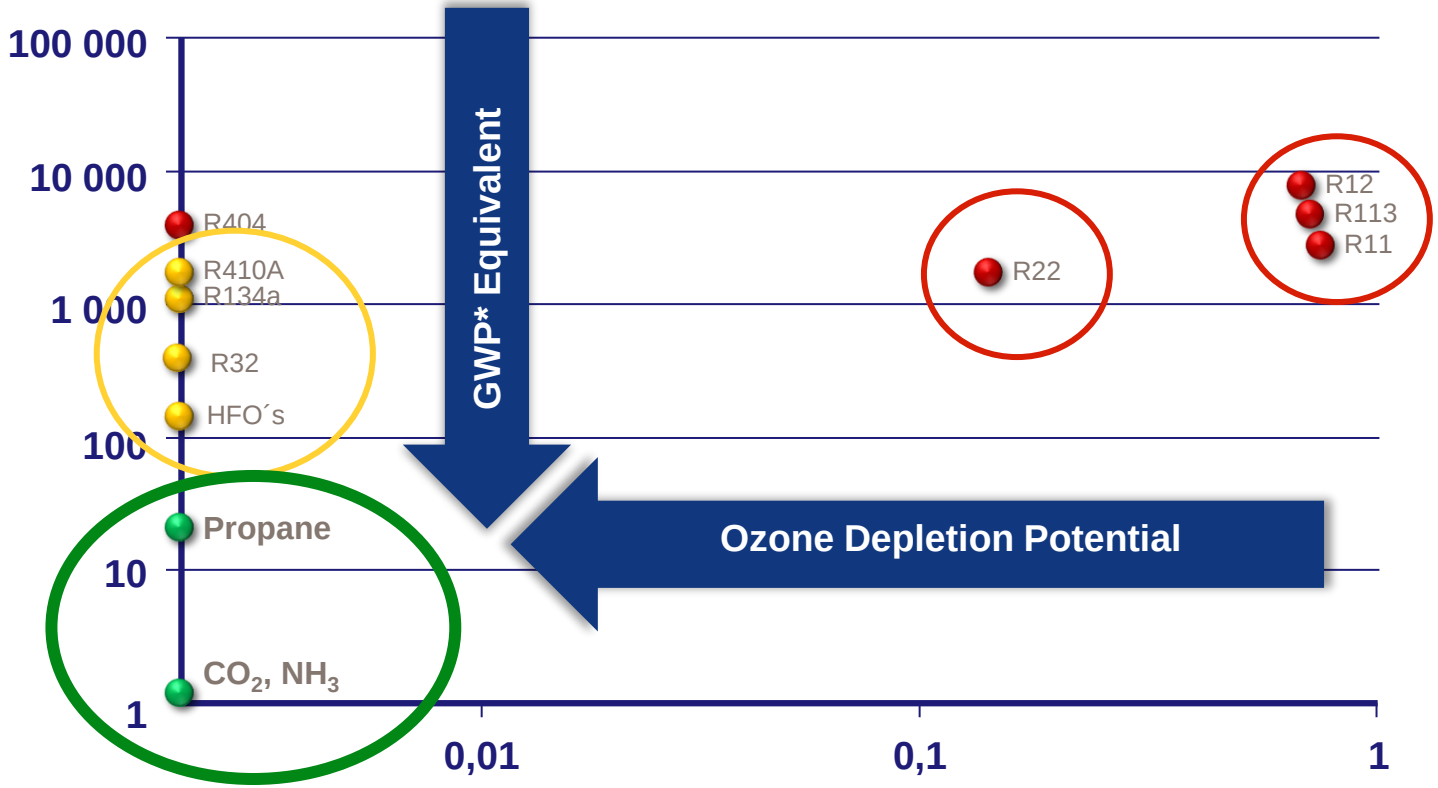
Tommy Angback
Sales Manager
Refrigeration
at Alfa Laval

October 13th , 2020

We are talking about using Natural refrigerants

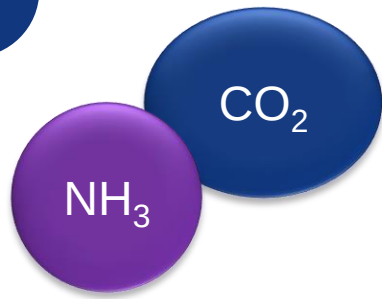
– Low GWP (Global Warming Potential) and ODP (ozone depletion potential)





Why Ammonia/ Carbondioxide in cascade?

– Main reasons for using in CO2 in combination with NH3

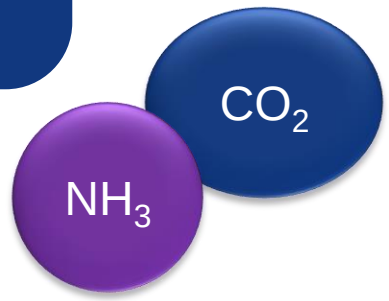


1)
Benefit the use of the very efficient refrigerant NH_3 combining it with a secondary fluid
> limiting the ammonia charge increasing safety

2)
Benefit the advantages of CO_2 on low temperature/secondary side
>increasing efficiency due the relatively better thermal properties

The Cascade Heat Exchanger

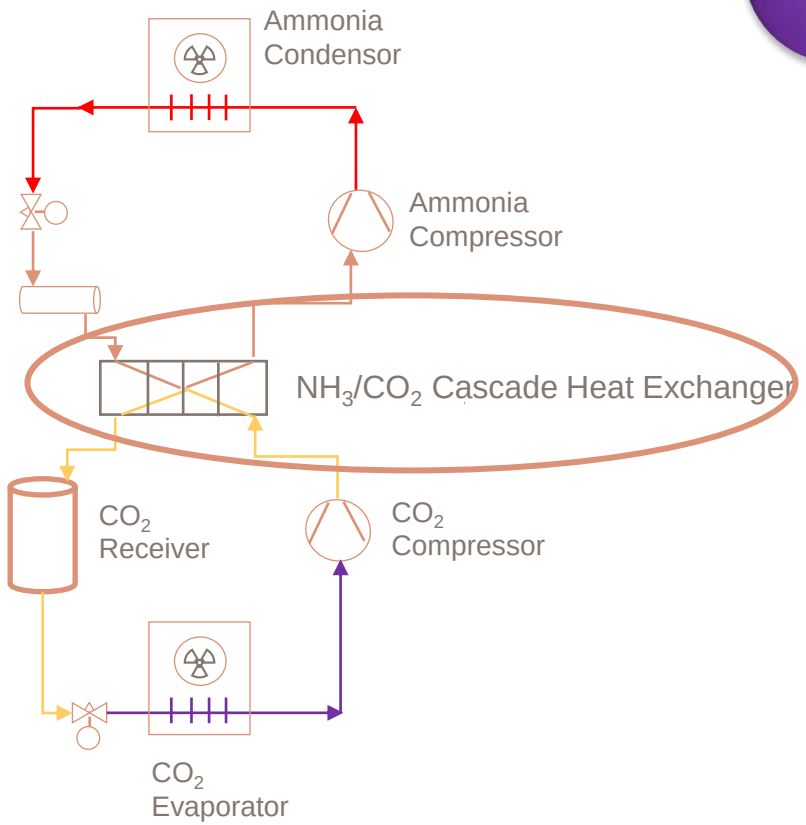
– one of the most important components*



It is handling a challenging duty of high importance and must deliver:

- efficient close temperatures approach
- high design pressure CO_2 side
- resistance against high fatigue forces from cyclical patterns of temperature and pressure.
- low risk of intermixing Ammonia and CO_2

*>It is a well-known fact that ammonia and carbon dioxide mixing results in an ammonium carbamate powder**



*Source: Zahid Ayub, M. Sultan Khan, Amir Jokar, Tariq S. Khan & Niel Hayes (2013) Recent Developments in Plate Exchangers—Ammonia/Carbon Dioxide Cascade Condensers, Heat Transfer Engineering, 34:5-6, 401-408,

Plate Heat exchangers

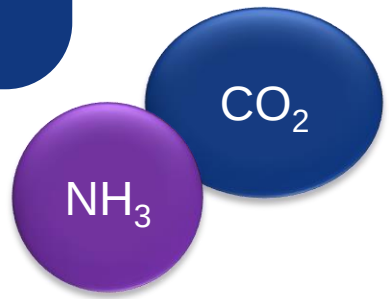
– efficient alternatives

Factor	Fully Welded Plate HEX	Semi Welded Plate HEX
Temperature approach 2-3 K	Yes	Yes
Design Pressure min 40 Bar	Yes	Yes
Reliability factors	Fatigue resistance	Depends	**Very high**
	Risk of intermixing	Yes*	**Very low**

* Source: Zahid Ayub, M. Sultan Khan, Amir Jokar, Tariq S. Khan & Niel Hayes (2013) Recent Developments in Plate Exchangers—Ammonia/Carbon Dioxide Cascade Condensers, Heat Transfer Engineering, 34:5-6, 401-408,

Semi welded plate heat exchanger

– the most reliable solution*

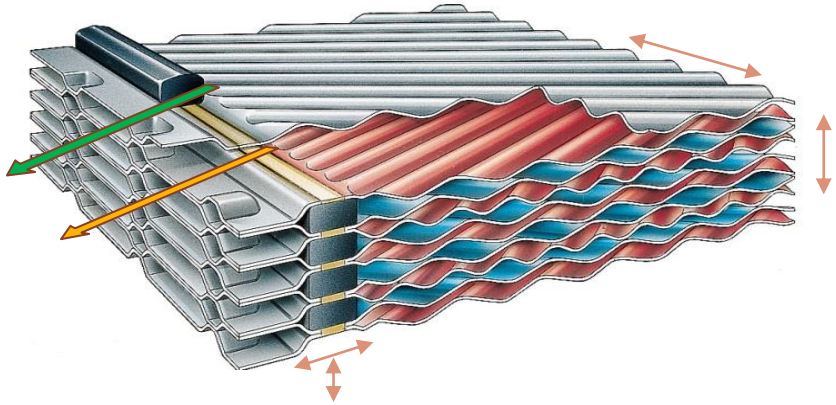


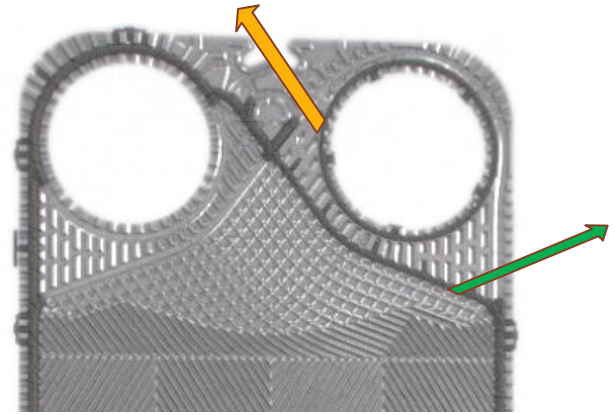
- The Gaskets absorbs metal plate or frame movements,

→ **eliminating any risk of fatigue failures.**

… and in case of sealing failure, all the gaskets and welds are facing the external atmosphere

→ **eliminating the risk of fatal media intermixing**





*Source: Alfa Laval,

Full range of Semi welded Plate Heat Exchangers

– Design pressure and Design temperature fitting Cascade duties

CO_2

NH_3

Pressure resistance

	M6-MW	M10-BW	T10-EW	MK15-BW	TK20-BW	T20-BW	MA30-W
16 bar	Yes	**Yes**	**Yes**	**Yes**	**Yes**	Yes	Yes
25 bar	Yes	**Yes**	**Yes**	**-**	**-**	-	Yes
30 bar	-	**Yes**	**-**	**Yes**	**Yes**	Yes	Yes
40 bar	-	**Yes**	**Yes**	**Yes**	**-**	-	-
55 bar	-	**Yes**	**-**	**-**	**-**	-	-
63 bar	-	**-**	**Yes**	**-**	**Yes**	-	-

Lifetime expectancy of gaskets *

16-18 years*

NH_3/CO_2 cascade heat exchanger

*Refers to a general operation of equipment with original gaskets and the ammonia or carbondioxide containing mineral compressor oil only..

We recommend doing preventive maintenance with original spare parts, well before the time above.

Ammonia/Carbondioxide Cascade Heat Exchangers

– Available as standard from our factories in Sweden, China and US

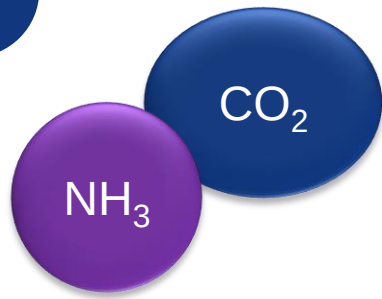
Industry can increasingly benefit the advantages of this kind of system for industrial refrigeration with:

- **No global warming refrigerants**
- **High efficiency**
- **High safety**

References

Example duties from the many hundreds of installations

– SWPHE in Europe installed since (2005) 2007*



EquipmentType	Equipment	Country	FlowRateHot	FlowRateCold	FluidHot	FluidCold	HeatLoad	DesignPressHot	DesignPressCold	TotalPlates	TempOutHot	TempinCold
PHE	MK15 BW	Germany	11590	3116	Carbon dioxide	Ammonia	950	40	16bar	422	-7	-10°C
PHE	MK15 BW	Germany	11590	3116	Carbon dioxide	Ammonia	950	40	16bar	422	-7	-10°C
PHE	MK15-BW	Germany	3,187	0,729	Carbon dioxide	Ammonia	800	40	16bar	386	-7	-10°C
PHE	MK15-BW	Germany	3,187	0,729	Carbon dioxide	Ammonia	800	40	16bar	386	-7	-10°C
PHE	M10-BW	Germany	3742	3388	Carbon dioxide	Propene	320	40	16barg	248	-7	-12°C
PHE	MK15-BW	Germany	1,551	0,456	Carbon dioxide	Ammonia	500	40	16bar	236	-7	-10°C
PHE	MK15-BW	Germany	2,366	0,883	Carbon dioxide	Ammonia	800	40	16bar	324	-7	-11°C
PHE	MK15-BW	Germany	2,366	0,883	Carbon dioxide	Ammonia	800	40	16bar	324	-7	-11°C
PHE	MK15-BW	Germany	10060	3092	Carbon dioxide	Ammonia	950	40	16bar	420	-10	-13°C
PHE	MK15-BW	Germany	5018	1904	Carbon dioxide	Ammonia	476	40	16bar	300	-5,5	-8,5°C
PHE	M10 BW	Greece	4136	1394	Carbon dioxide	Ammonia	350	40	16bar	174	-5	-10°C
PHE	TK20 BW	France	7232	2530	Carbon dioxide	Ammonia	630	40	16bar	236	-3	-7°C
PHE	MK15 BW	Belgium	1,638	0,575	Carbon dioxide	Ammonia	520	40	16bar	192	-6	-10°C
PHE	M10 BW	Netherlands	4841	1471	Carbon dioxide	Ammonia	435	52	17bar	272	-8	-12°C
PHE	M10 BW	Netherlands	4841	1471	Carbon dioxide	Ammonia	435	52	17bar	272	-8	-12°C
PHE	MK15-BW	Germany	7688	5472	Carbon dioxide	Ammonia	650	40	16bar	184	-3	-8°C
PHE	TK20 BW	France	12880	3770	Carbon dioxide	Ammonia	1067	50	12bar	550	-2	-5°C
PHE	MK15 BW	France	5194	1896	Carbon dioxide	Ammonia	480	40	16bar	292	-11	-13,3°C
PHE	M10-BW	Netherlands	1786	532,5	Carbon dioxide	Ammonia	153	40	19bar	134	-6	-10°C
PHE	M10-BW	Netherlands	1129	336,7	Carbon dioxide	Ammonia	97	40	19bar	82	-6	-10°C
PHE	M10-BW	Netherlands	1466	438,1	Carbon dioxide	Ammonia	126	40	19bar	108	-6	-10°C
PHE	M10-BW	Netherlands	4550	1057	Carbon dioxide	Ammonia	300	40	16barg	202	-2	-6°C
PHE	M10-BW	Netherlands	8724	2325	Carbon dioxide	Ammonia	578	40	16barg	402	-2	-6°C
PHE	MK15-BW	Netherlands	8268	2359	Carbon dioxide	Ammonia	600	40	20bar	204	-11	-15°C
PHE	MK15-BW	Netherlands	8268	2359	Carbon dioxide	Ammonia	600	40	20bar	204	-11	-15°C
PHE	M10-BW	Netherlands	7074	1981	Carbon dioxide	Ammonia	500	40	17barg	370	-8	-12°C
PHE	M10-BW	Netherlands	7074	1981	Carbon dioxide	Ammonia	500	40	17barg	370	-8	-12°C
PHE	M10-BW	Netherlands	5464	1500	Carbon dioxide	Ammonia	375	40	20barg	358	-5,5	-8,5°C
PHE	M10-BW	Netherlands	5464	1500	Carbon dioxide	Ammonia	375	40	20barg	358	-5,5	-8,5°C

*Source: Alfa Laval,

Dutch Case- in operation for 10+ years

– First planned maintenance

Case

Douwe Egberts Coffee factory, Netherlands.
Installer: ENGIE

- Installed 2x Alfa Laval M10-BWFT in 2007
- After 10 years of trouble-free operation first planned maintenance in May 2018

Finding:
Plates and gaskets looking fresh and functional

Result:
Heat exchanger back to as-good-as-new state after cleaning and re-gasketing

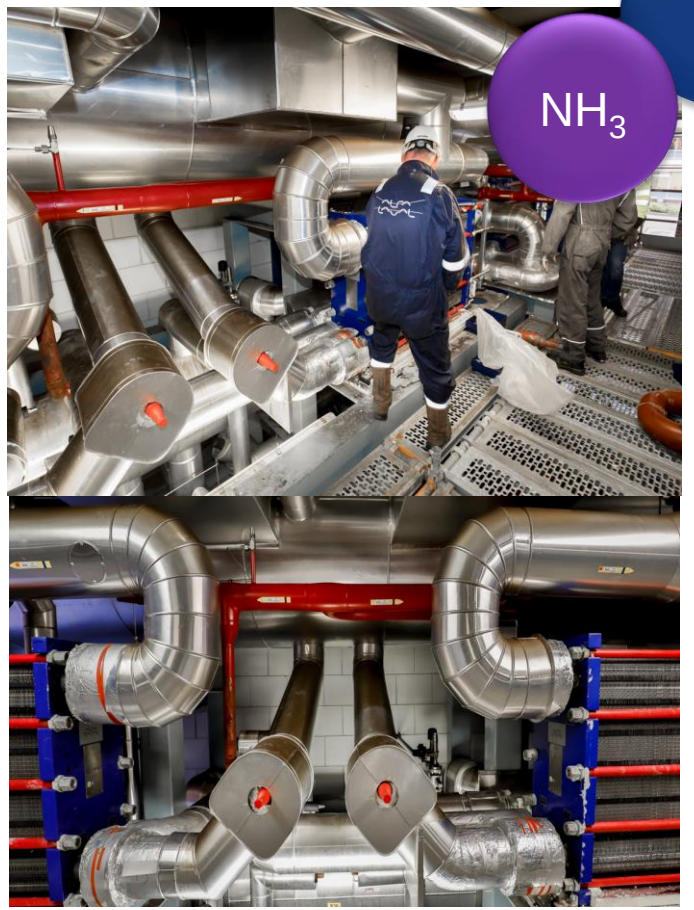
Plus:
It is possible to apply an extended period before next planned gasket maintenance

Alfa Laval semi-welded heat exchanger duty

Side 1	
Capacity	1200 kW
Media	
	Ammonia NH_3
Evap. temp.	-12° C
Design pressure	20 bar
Side 2	
Media	
	Carbondioxide CO_2
Temp in/cond. temp.	15° C / -8° C
Design pressure	40 bar

CO_2

NH_3



Recent supply Europe

CO_2

NH_3

Case

Systembuilder: TH. Witt Kältemachinenfabrik

- Incorporate 2 pcs Alfa Laval MK15-BWFT in 2020

Alfa Laval semi-welded heat exchanger duty

Capacity:	**2 x 960 kW**
Side 1	
Media	
	Ammonia R717 NH_3
Evap. temp.	-10° C
Design pressure	16 bar
Side 2	
Media	
	Carbondioxide R744 CO_2
Cond. temp.	-7° C
Design pressure	40 bar

Case 4 years Running Installation in China

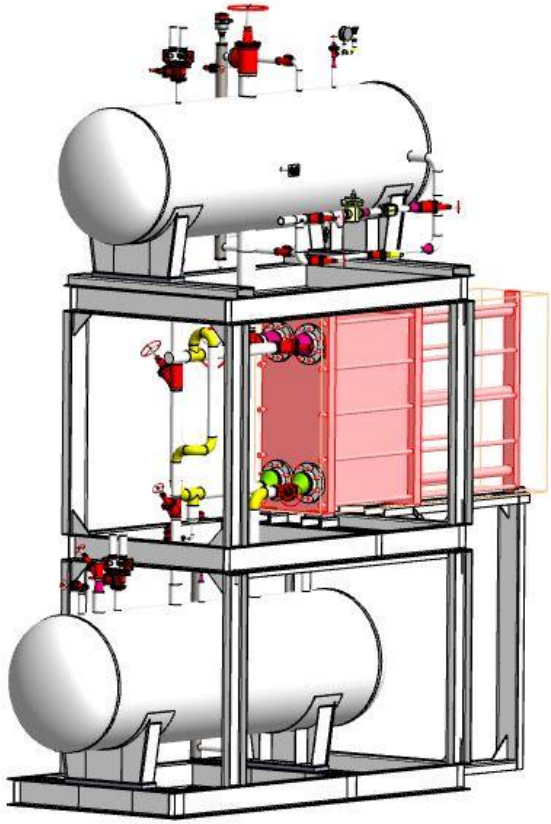
Case

International Food factory Cold storage Guangzhou
Systembuilder: GEA Refrigeration

- Installed 2 pcs Alfa Laval M10-BWFT in 2014
- Now been 4+ years in operation - running very well
- Doubling of capacity in plan

Alfa Laval semi-welded heat exchanger duty

Capacity:	**800 kW**
Side 1	
Media	
	Ammonia R717 NH_3
Evap. temp.	-10º C
Design pressure	16 bar
Side 2	
Media	
	Carbondioxide R744 CO_2
Temp in/cond. temp.	30º C / -6º C
Design pressure	40 bar



CO_2

NH_3

Case in China

CO_2

NH_3

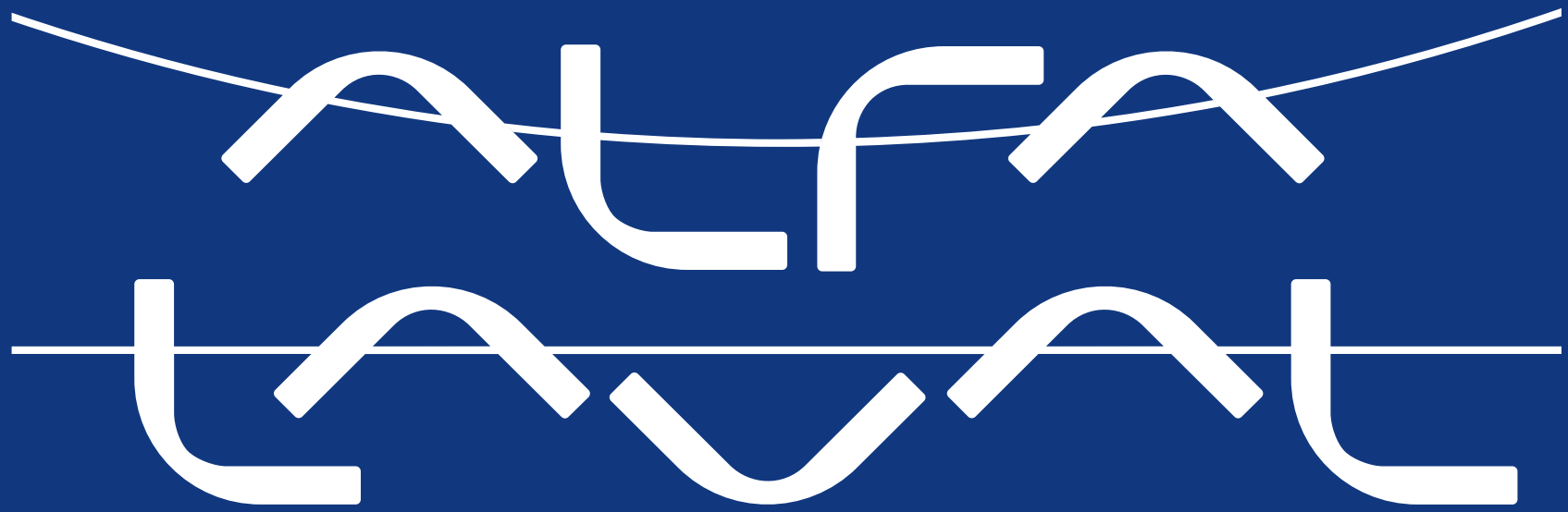
Case

Supermarket Chain Distribution center, Dongguan, China.
Design institute: Hua shang International Co Ltd
Systembuilder: Johnson controls

- Installed 2 x Alfa Laval MK15-BWFT in 2018

Alfa Laval semi-welded heat exchanger duty

Capacity:	**2512 kW**
Side 1	
Media	
	Ammonia R717 NH_3
Evap. temp.	-12º C
Design pressure	21,6 bar
Side 2	
Media	
	Carbondioxide R744 CO_2
Temp in/cond. temp.	50º C / -7º C
Design pressure	40 bar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