

SISTEMAS DE ÁGUA GELADA



PROGRAMA
BRASILEIRO DE
ELIMINAÇÃO DOS

HCFCs
Projeto para o Gerenciamento de Chillers

Projeto Demonstrativo para o Gerenciamento Integrado no Setor de Chillers

CHILLERS COM CARGA DE AMÔNIA REDUZIDA

Celina Bacellar – Johnson Controls Inc.
30/03/2016 - Fortaleza

Execução



Implementação



Empoderando vidas.
Fazendo a diferença.

Realização

Ministério do
Meio Ambiente



Industrial Refrigeration



1897: Founding of Thomas His. Sabroe & Co.

STAL
REFRIGERATION

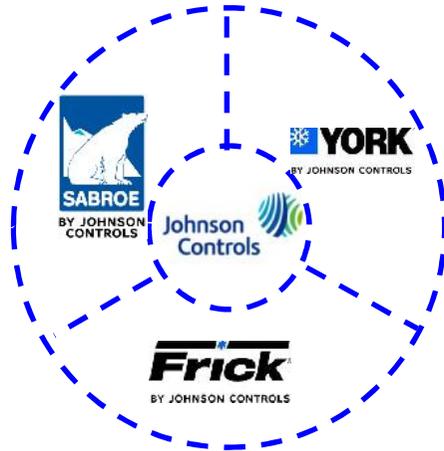
1997: Acquisition of ABB Stal Refrigeration

YORK

1999: Sabroe becomes part of YORK International



2004: Relaunch of the Sabroe brand name



Johnson Controls



1874: Founding of YORK Manufacturing Co.

Frick

1987: Acquisition of Frick

Gram Refrigeration

1995: Acquisition of Gram Refrigeration

YORK

2005: YORK International sold

Responsabilidade & Sustentabilidade

Posicionamento



A Refrigeração Industrial pode contribuir, significativamente, com soluções sustentáveis.

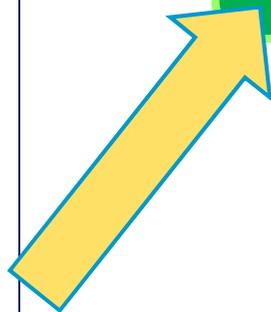
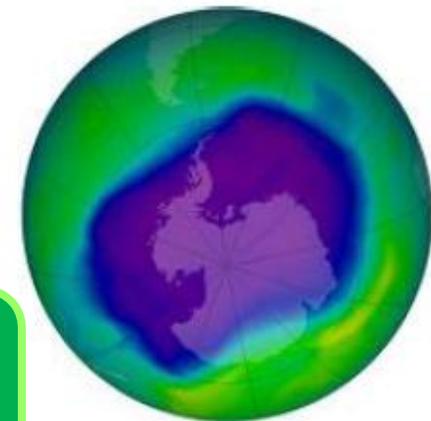
Como a Johnson Controls assume esta responsabilidade?

Foco em refrigerantes naturais como Amônia, CO₂ e Hidrocarbonetos.

Minimizar as cargas de refrigerantes nos sistemas.

Oferece uma ampla gama de compressores e chillers com alta eficiência energética.

Motiva, fortemente, minimizar o consumo total de energia em plantas.



Atual situação dos fluidos refrigerantes

Naturais

Amônia
Hidro-carbonetos
Dióxido de Carbono
Água
Ar

Sintéticos

CFC

R11
R12
...

R500
R501
R502
....

HCFC

R21
R22

R123
R124
...

HFC's

Substâncias simples

R23
R134a

Misturas

R507
R404A
R410A
R407C

1996

2040

GWP
ODP
\$
Conhecimento

Reduzido
0 (zero)
Baixo
Elevado

Elevado
0 (zero)
Elevado
Parcial

Refrigerantes



Refrigerante	ODP	GWP
1 – CFC		
R-11	1.00	3500
R-12	1.00	7300
R-502 (R22/R115)	0.34	4300
2 – HCFC		
R-22	0.055	1500
R-123	0.02	85
3 – HFC		
R-23	0.0	12000
R-32	0.0	650
R-134a	0.0	1200
R-143a	0.0	2900
R-507 (R125/R143a)	0.0	3800
R-404A (R125/R143a/R134a)	0.0	3700
R-407C (R132/R125/R134a)	0.0	1600
R-410A (R32/R125)	0.0	1900
4 – Inorgânicos ou Naturais		
R-717	0.0	0.0
R-718	0.0	0.0
R-290	0.0	3.0
R-744	0.0	1.0

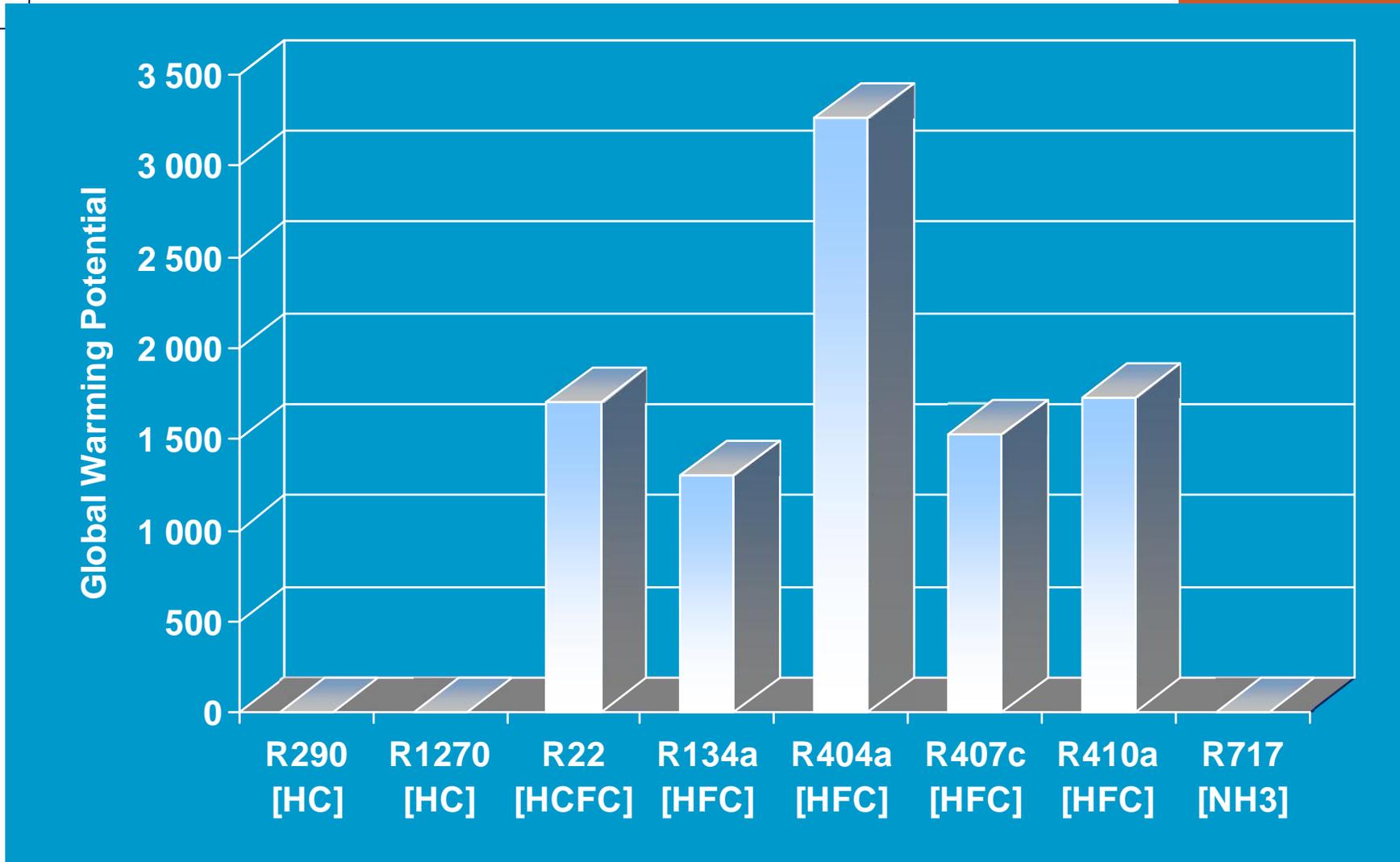
ODP - Ozone Depletion Potential:

Parâmetro que mede o potencial de um produto de destruir a camada de Ozônio.

GWP - Global Warming Potential:

Parâmetro que mede o potencial de aquecimento do globo provocado pelos gases presentes na atmosfera ($\text{CO}_2=1$).

Environmental qualities



Ammonia (R-717) and Hydrocarbons (R-290 e R- 1270) have:
ODP = 0 (Ozone Depletion Potential)
GWP (Global Warming Potential) < 3 * (* 100 years horizon)

Sistemas com carga de amônia reduzida



As altas cargas de refrigerante estão onerando os proprietários de sistemas de refrigeração que utilizam amônia devido aos atuais **requisitos legais**.

Nos EUA, instalações contendo 500 lb (227 kg) de amônia ou mais devem ser reportadas ao comitê de planejamento de emergência local.

Instalações que contenham mais de uma quantidade limite (TQ - threshold quantity) de amônia devem, também, apresentar um plano de gestão de riscos para a Agência de Proteção Ambiental dos EUA – EPA.

Califórnia: 500 lb (227 kg). Geral: 10.000 lb (4536 kg). **Europa: 6.600 lb (3000kg)**

Para todos os sistemas de refrigeração com amônia, independentemente da carga, **perdas** de mais de 100 lb (45 kg) devem ser comunicadas ao Centro de Resposta Nacional dentro de 15 minutos a contar do momento em que a pessoa no comando da instalação tomar conhecimento da perda.

A amônia não é o único refrigerante sob pressão legal.

Sistemas de Refrigeração com carga de refrigerante reduzida



O que motiva a busca por soluções de baixas cargas de amônia?

O aumento dos requisitos de segurança (**regulamentação**) em plantas de refrigeração com amônia vem colocando enorme pressão sobre os proprietários devido ao aumento do custo da conformidade (**compliance**).

Em todo o mundo, proprietários de instalações frigoríficas estão à procura de soluções de refrigeração com baixa carga de amônia.

Resultados:

Elimina / reduz o plano de gestão de risco EPA (RMP) e os requisitos de processo de gestão de segurança OSHA (PSM) para instalações de amônia.

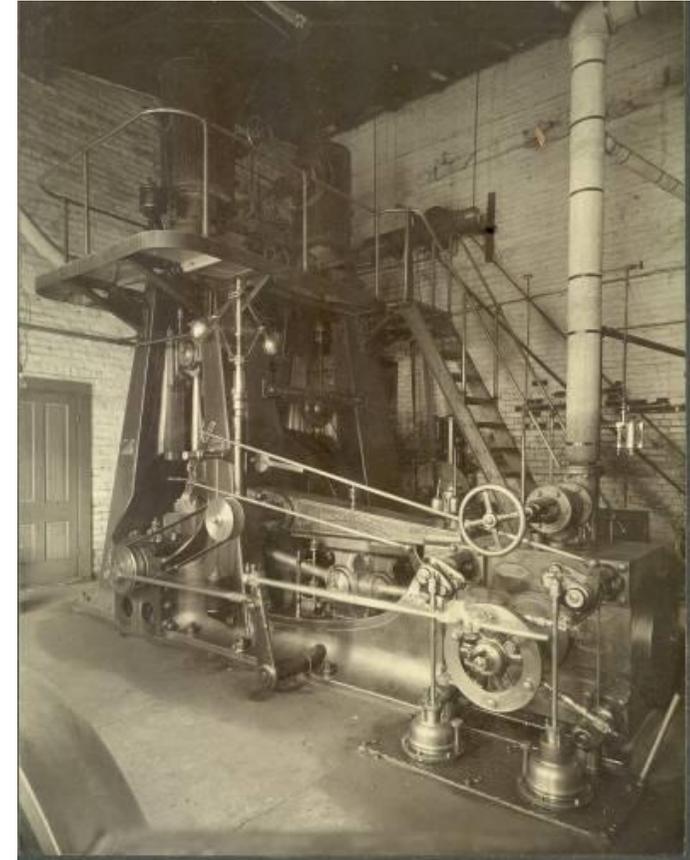
Amônia – R 717



- Refrigerante natural usado há + 150 anos
- Não agride a camada de ozônio
- Não provoca efeito estufa
- Alta eficiência termodinâmica
- Preço bastante reduzido
- Substância natural biodegradável
- Auto alarme: Detectável a partir de 5 ppm
- Não é acumulativa no corpo humano
- Não poluidora

Chillers com Amônia:

**Investimento
de longo prazo!**



Frick ammonia compressor built in 1886. Installed at Gipp's Brewery, Peoria, IL. Operated until 1946.

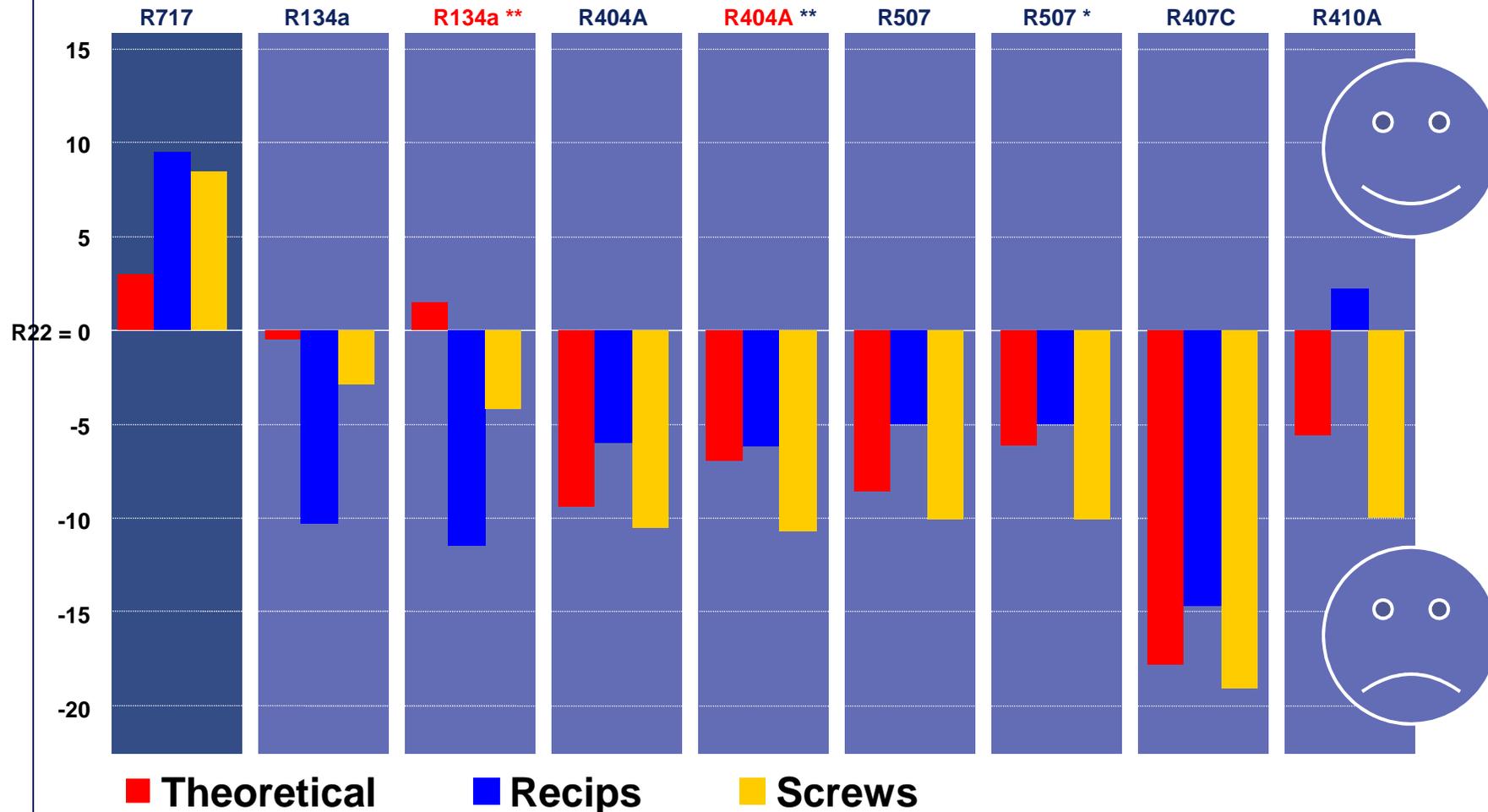
Ammonia



- Ammonia is produced in natural, biological processes
- Industrially produced ammonia is about 3% of the total amount present in nature
- Only a few per cent is used as refrigerant
 - More than 80% is used as fertilizers and the rest in various industrial processes
- The refrigerant number is R717
 - The 700-group identifies inorganic compounds also including R718 (water) and R744 (CO₂)

Choose the right refrigerant

Comparison of refrigerants by COP*



COP vs. R22 at 0 °C / +35 °C

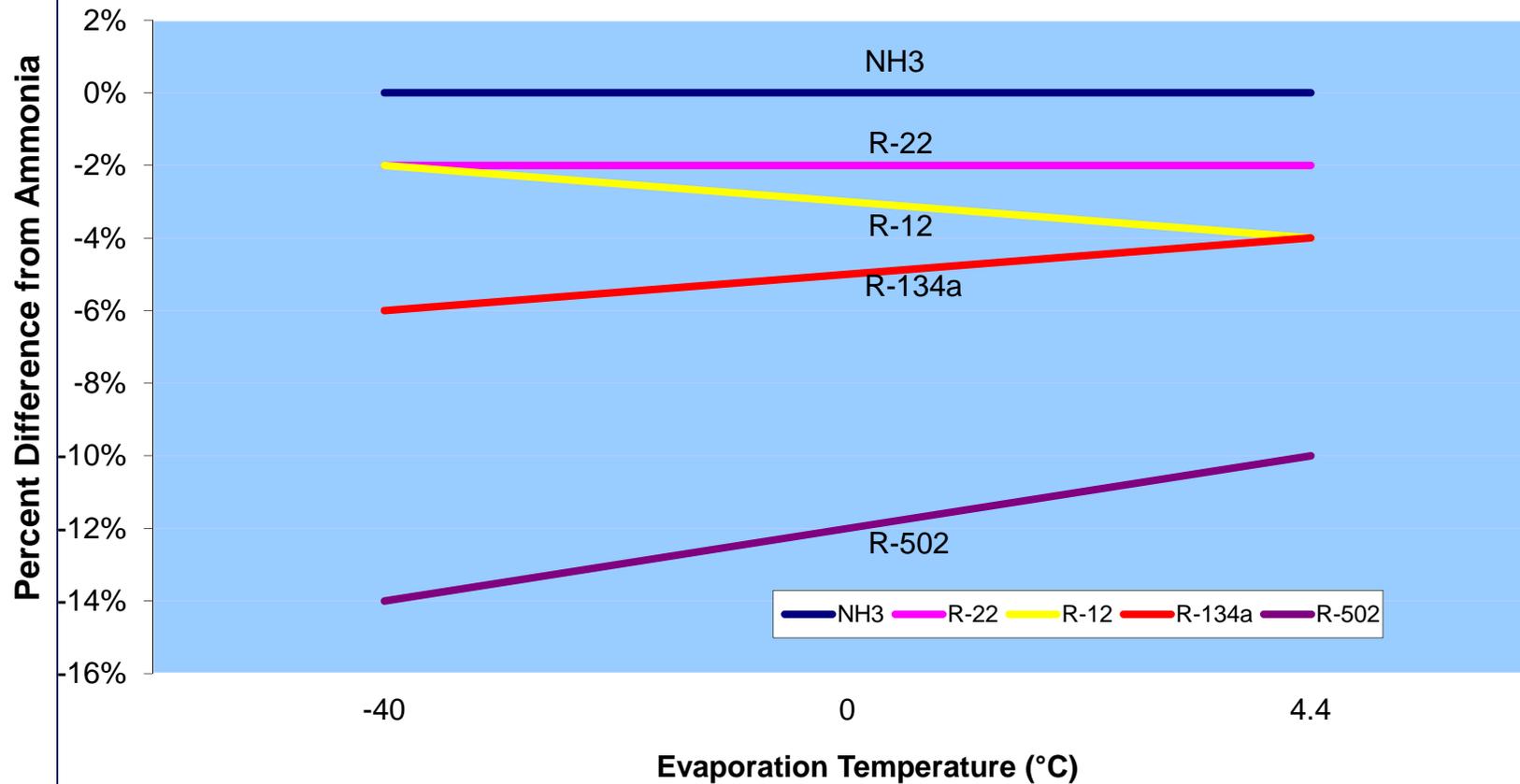
ET = 0°C, CT = +35°C (ET_{DEW} CT_{BUB}), SH = 0K, SC = 2K

** Note: with heat exchanger, SH = 20K, Pressure loss = 1K

Advantages of Ammonia



Coefficient of Performance for Refrigerants



Por que escolher a amônia?

Quais são as vantagens?



- Tecnologia conhecida
- Melhor eficiência (COP)
- Melhor coeficiente de transferência de calor
- Disponível e com baixo preço em todo o mundo
- Equipamentos de menor porte - mesma capacidade
- Ideal tanto para compressores alternativos quanto de parafuso
- Maior área de aplicação (de LT -50°C a HP +90°C)
- Simples e flexível para fazer extensão de planta ou em paralelo
- ODP = 0; GWP = 0

Vantagens da amônia



**A amônia ser um
refrigerante natural é
apenas uma pequena parte
da solução...**

**A eficiência do ciclo
da amônia é a real
resposta!**

Safety: Disadvantages of Ammonia



- Low concentrations ruled toxic
 - Short Term Exposure Limit 35 - 50 ppm
 - However self alarming at 5 ppm
 - 1500 ppm – instant reaction to flee
- Considered flammable
 - In narrow range of concentrations of 16-25% by volume of air in presence of open flames
 - To transport – non flammable fluid
- Ammonia is not compatible with copper
 - Special hermetic motors must be utilized
 - Either steel/aluminum piping is required
 - Advantages of enhanced heat transfer diminished

Sala de Máquinas



- Exigências básicas para qualquer refrigerante
 - Monitor de Refrigerante
 - Ventilação Mecânica
 - Tubulação das válvulas de segurança
 - Não pode ter internamente chama ou parede com mais de 427°C
 - Paredes, portas e tetos deverão ser resistentes a a fogo por mais de 1 hora
 - Equipamento de proteção individual

Aspectos de Segurança



Programa de Gestão de Riscos



Educação é a chave para Segurança!

Tendências no uso de Amônia



- Mercado Europeu de chillers é fortemente baseado em amônia
- + 90% dos chillers produzidos para o Mercado da região norte da Europa usam amônia
- Atualmente, ainda *poucos* chillers nos EUA usam amônia
Exceção: multinacionais europeias que empregam a sua política corporativa de refrigerante naturais.

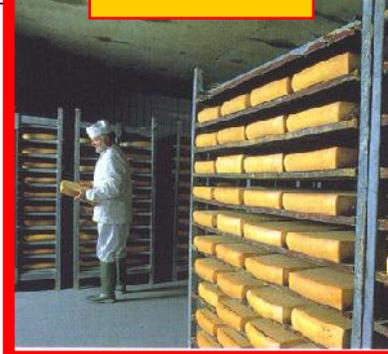
Áreas de Aplicação



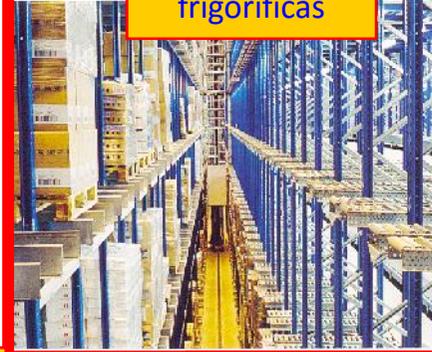
Resfriamento de concreto



Laticínios



Câmaras frigoríficas



Ar Condicionado



Resfriamento de solo



Pistas de gelo



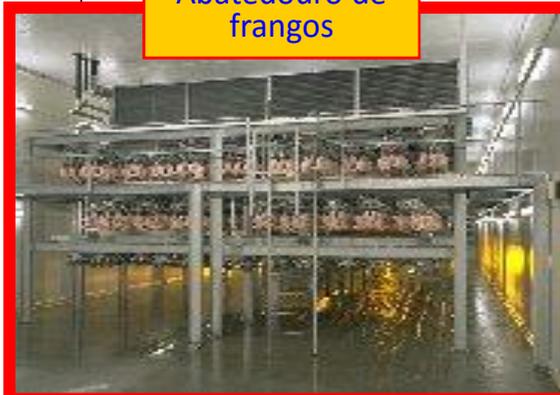
Frigoríficos



Cervejarias



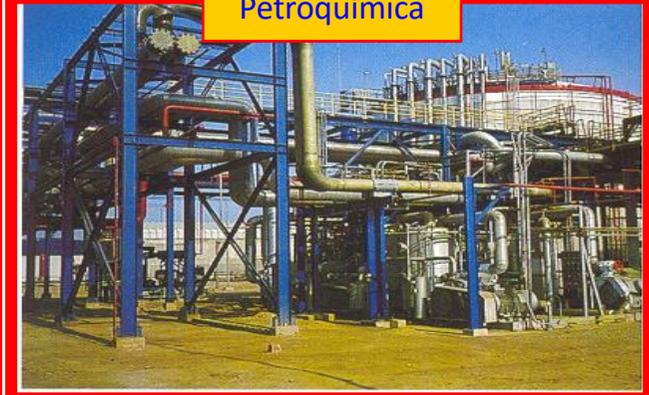
Abatedouro de frangos



Aplicações navais



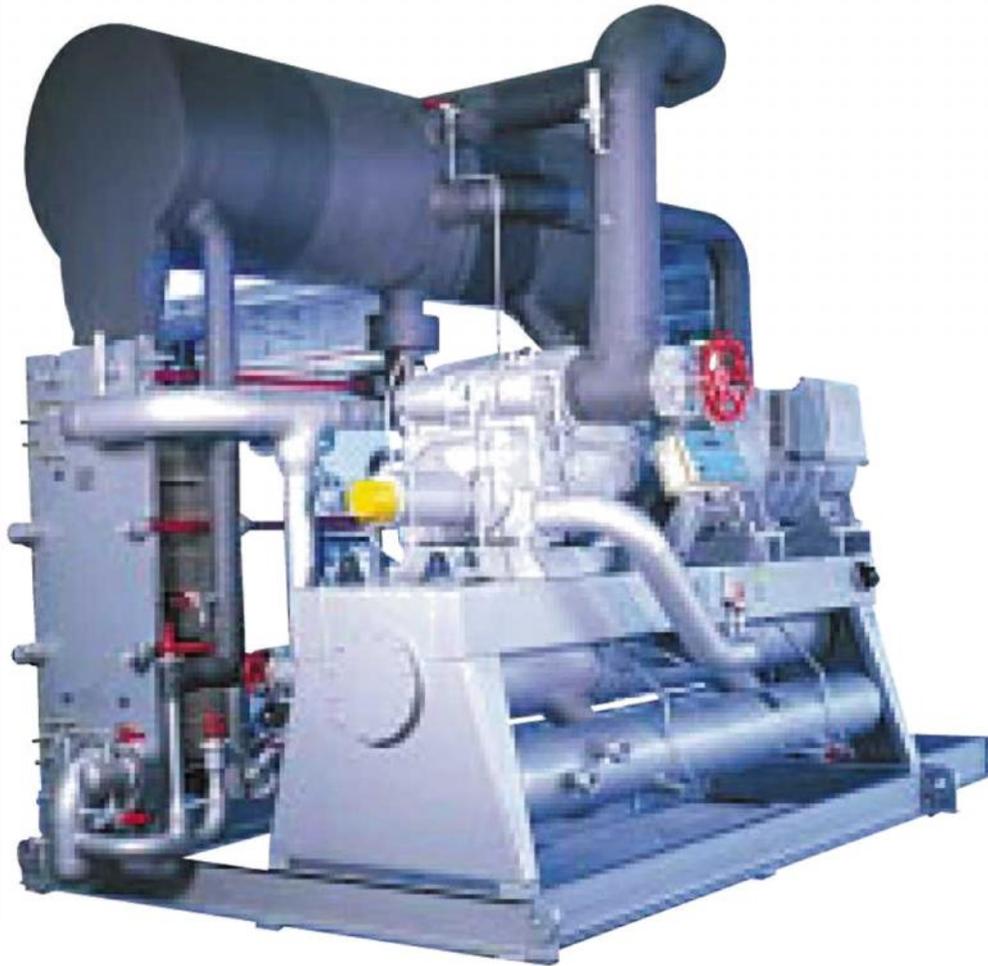
Química e Petroquímica



Chillers com trocadores de calor a placas

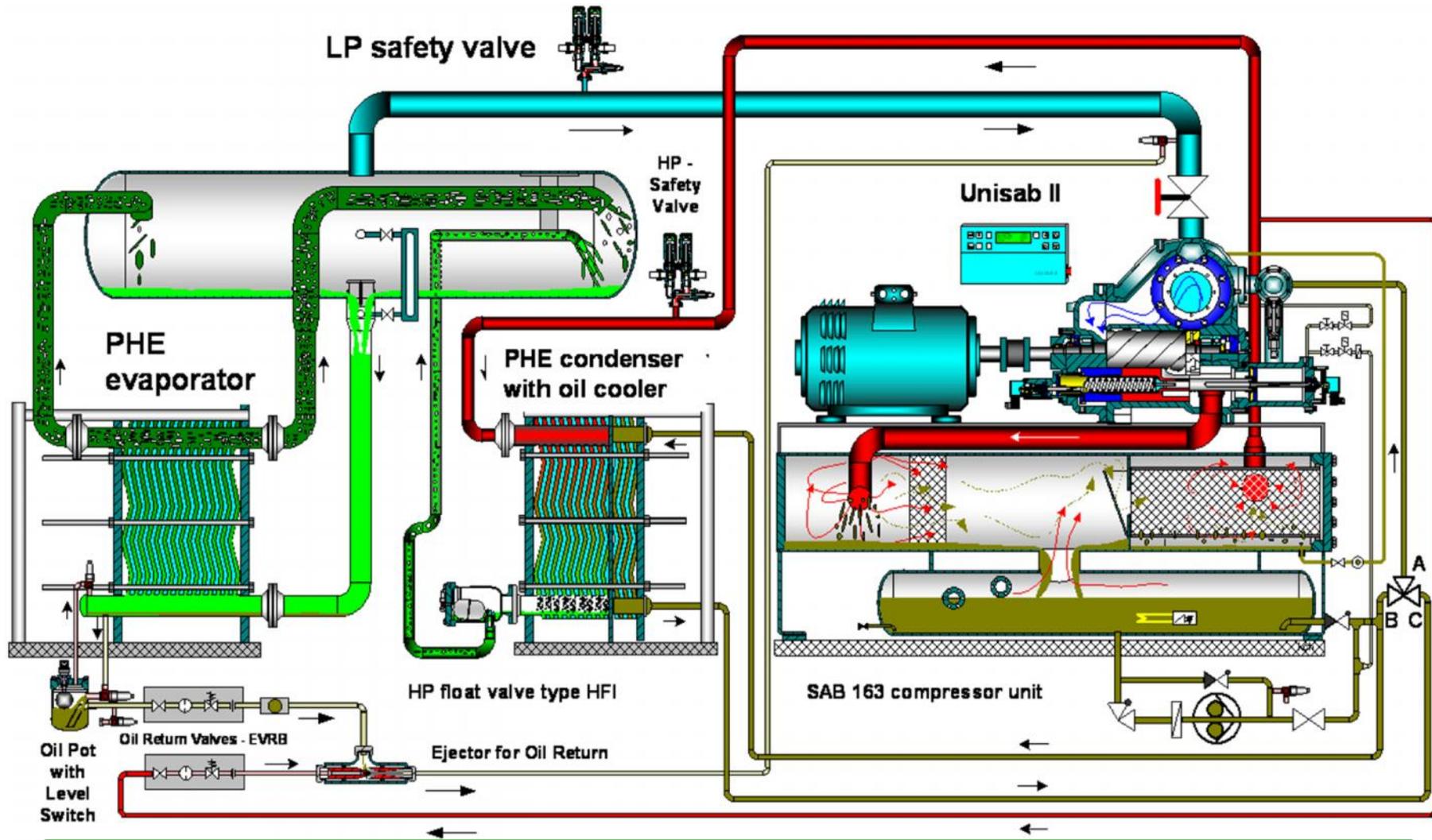


Associação de características de otimização:

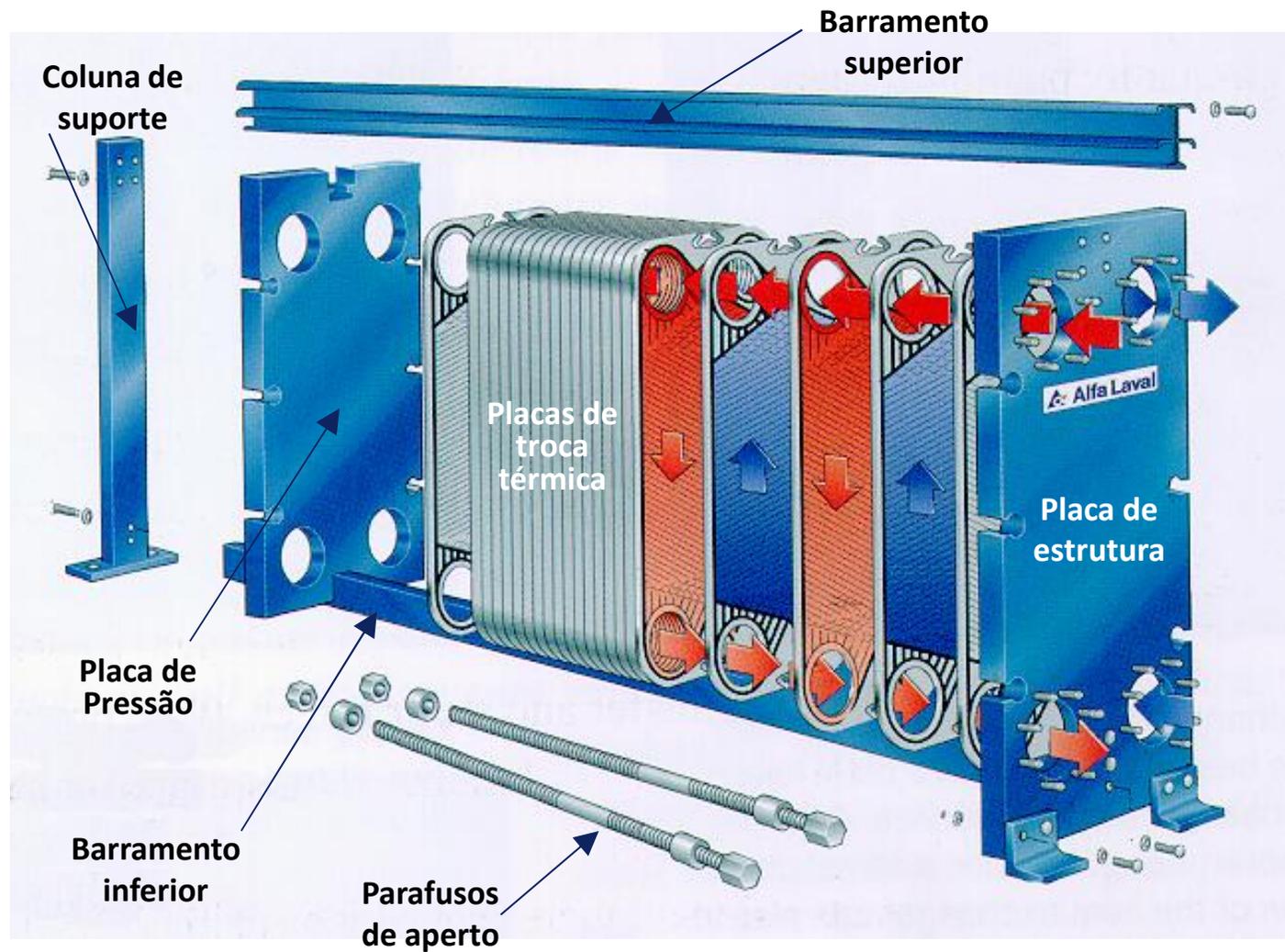


- R 717 como refrigerante:
carga reduzida
- Trocadores de calor a placas:
aço inoxidável ou titânio
 - Projeto compacto
- Não há conexões de R 717:
reduzido risco de vazamento
 - Manutenção simplificada
- Instalação: flexibilidade e rapidez
 - Alto COP

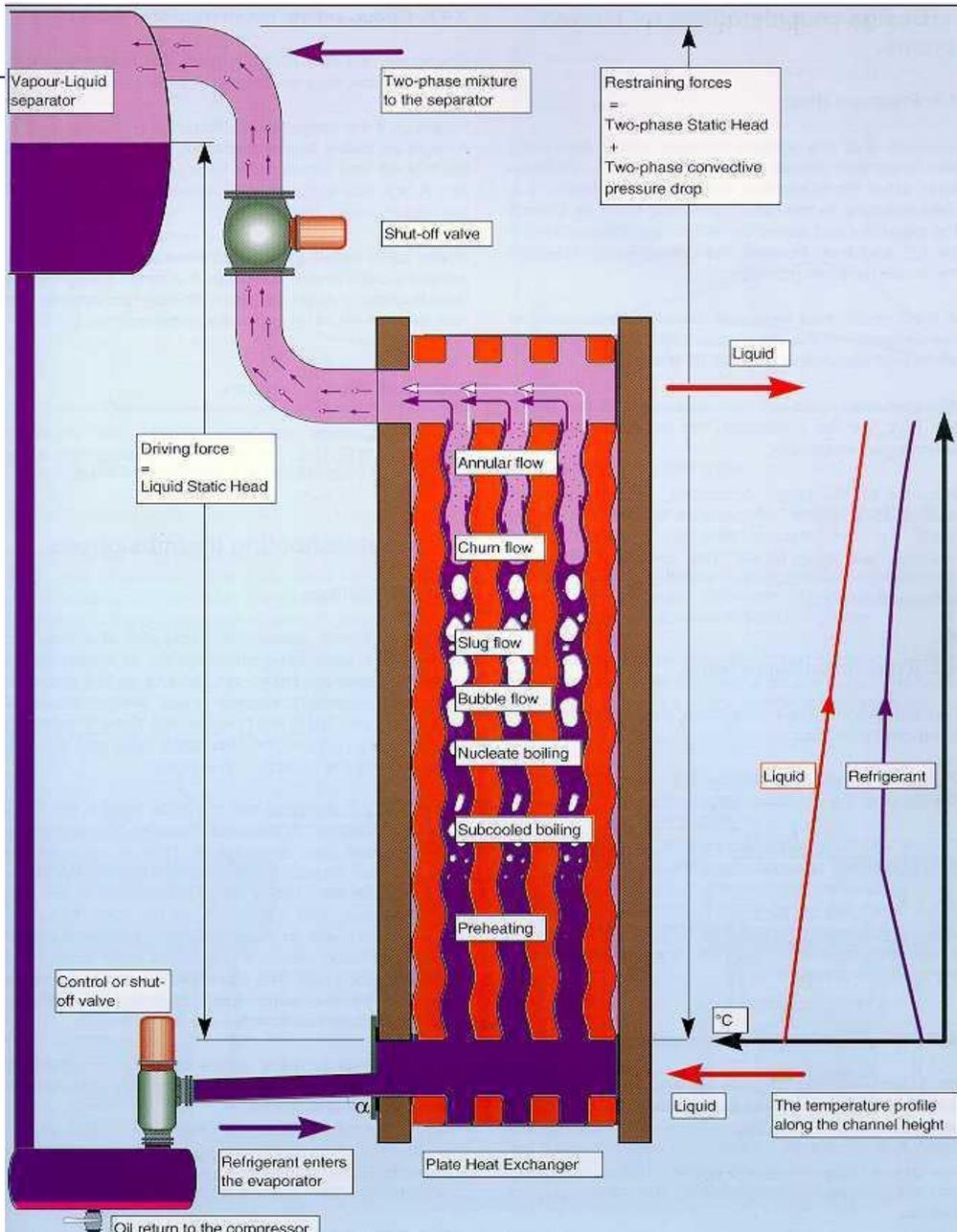
Chiller com PHE



PHE - Semi Soldado



Evaporador Inundado



- Sistema auto-circulante:

Dispensa bomba NH_3

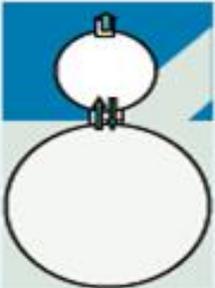
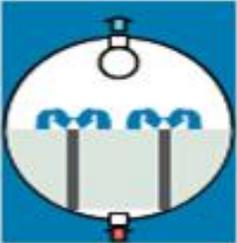
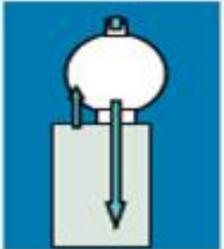
- Melhores coeficientes de

troca térmica:

Superfícies sempre molhadas

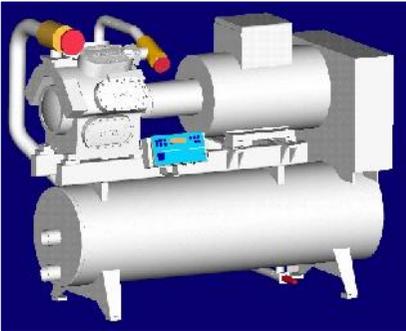
Comparativo entre trocadores de calor



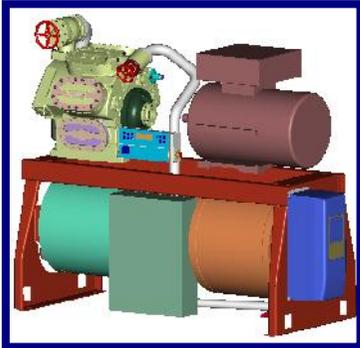
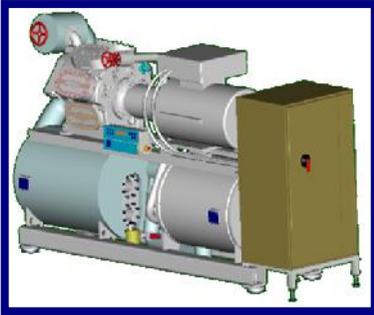
Modelo/Tipo do Evaporador	Carga de R-717 (100%)
 <p>EOSB 415004 Inundado (Shell & Tube)</p>	210 kg
 <p>ESSM 5040B3 Inundado (Shell & Tube)</p>	120 kg
 <p>EPHE 100 (M10) Inundado (PHE)</p>	45 kg
 <p>ESRA 70 Inundado (Shell & Plate)</p>	20 kg

Ref. Carga: capacidade = 500 kW

ChilIPAC



Product development process



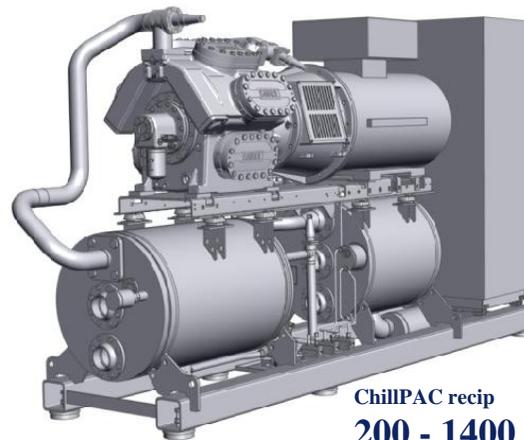
Sabroe chillers – a clear product profile



PAC recip
100 - 1400 kW

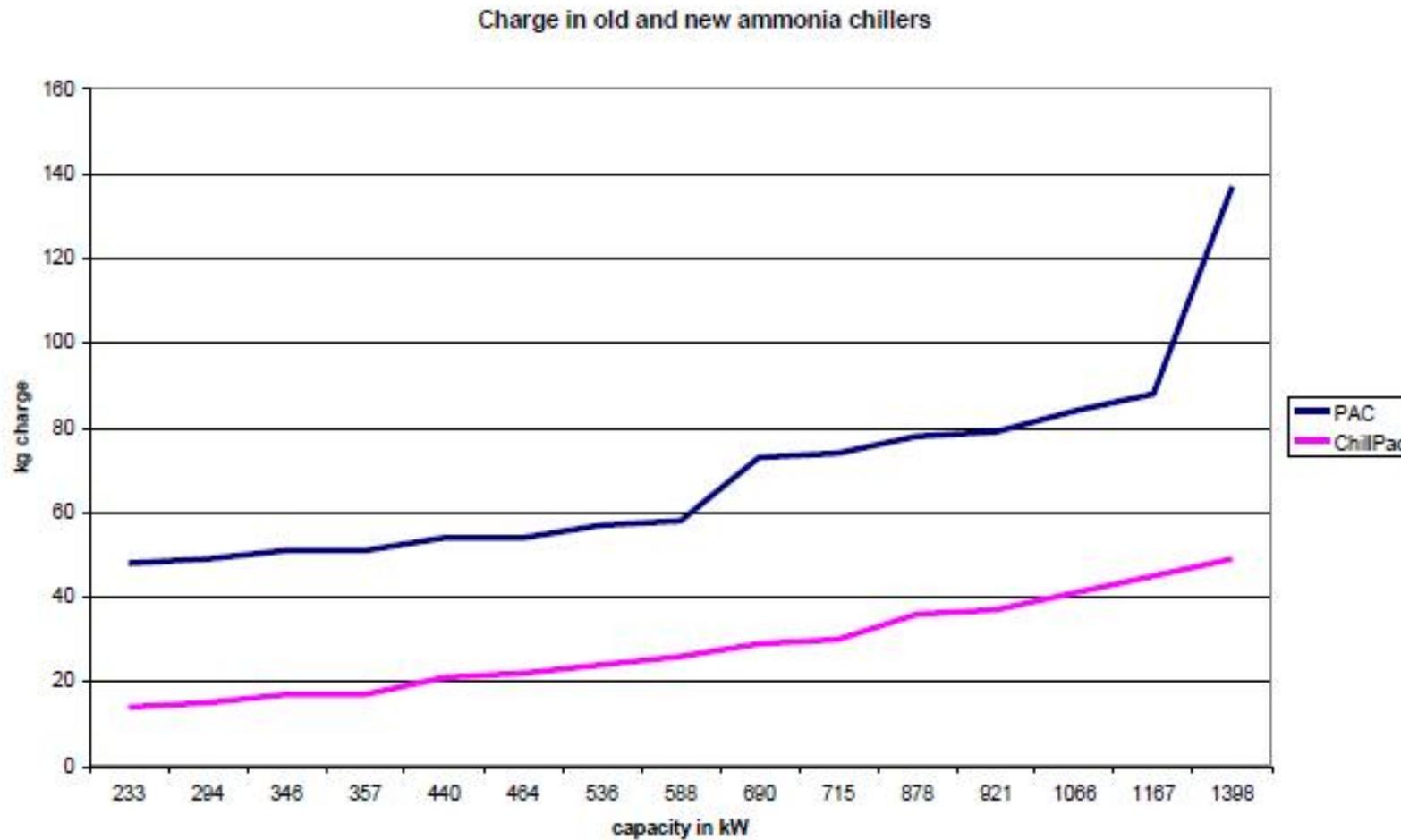


PAC screw
200 - 8000 kW



ChillPAC recip
200 - 1400 kW

Comparação entre chillers

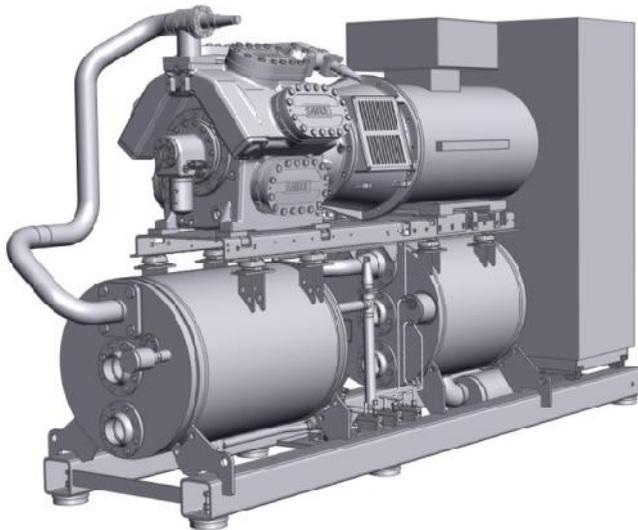


ChillPAC

Important features demanded by the market



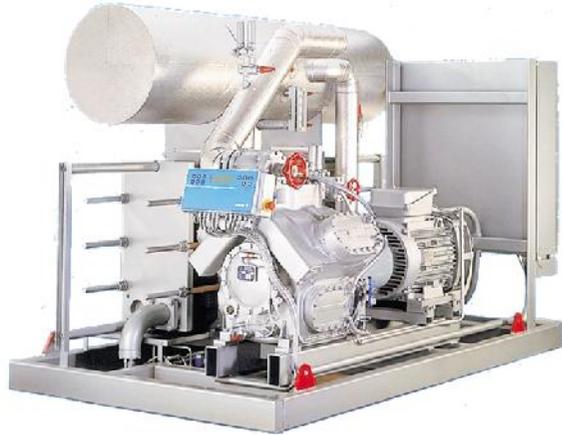
- Future-safe refrigerant (ammonia)
- High COP even at part load (flooded evaporation)
- **Lowest possible refrigerant charge** (plate heat exchanger technology)
- Compactness (door size)



- Application:
- process water cooling
 - air conditioning
 - Retrofit in old R-22 installations

PAC x ChiIPAC

Features



Conventional chiller

- **Semi-welded plate heat exchangers**
- **Traditional design of plates/cassettes**
- **External liquid separator**
- **External oil separator**
- **External high-pressure float valve**

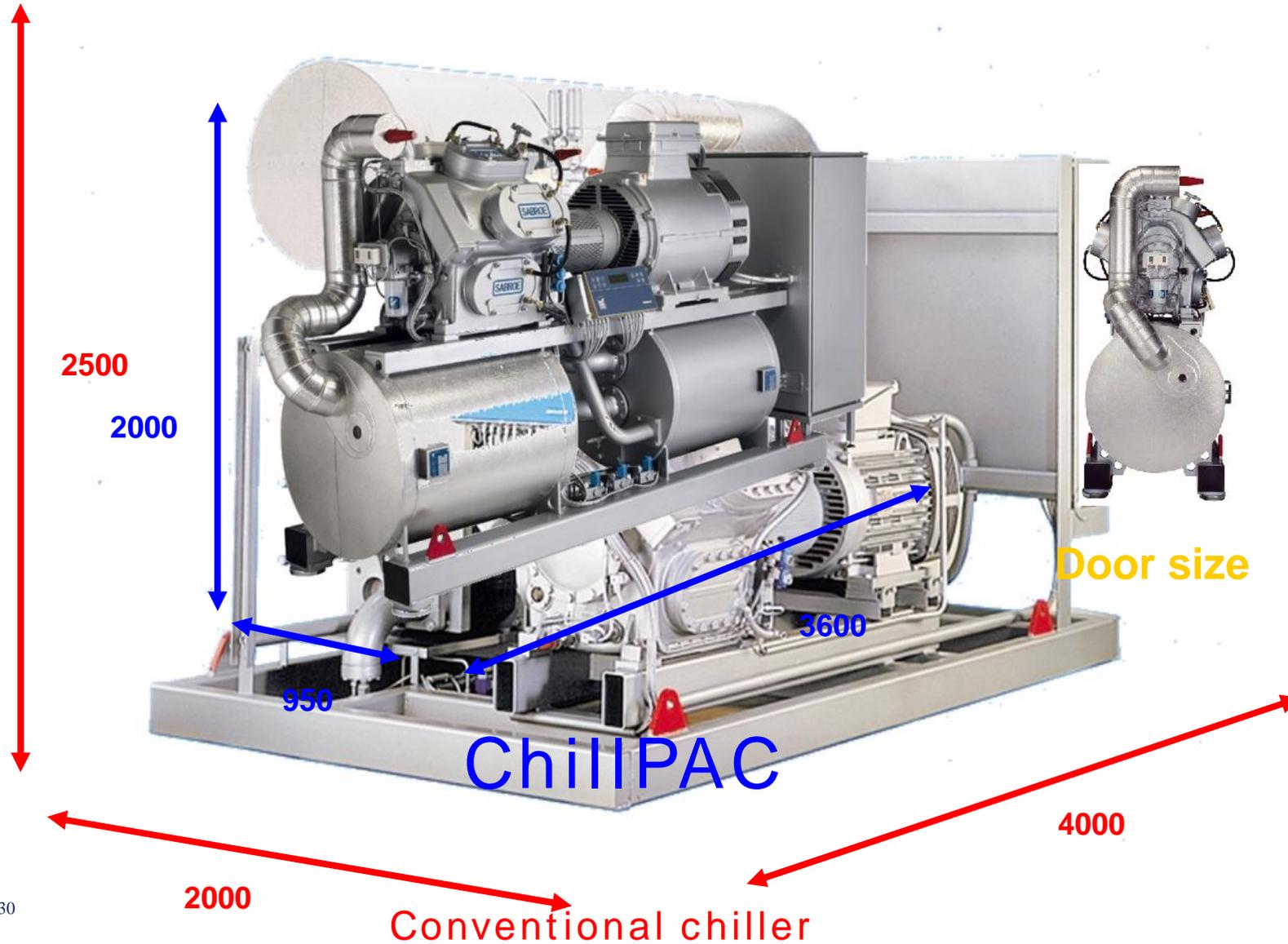


ChiIPAC

- **Fully welded plate heat exchangers**
- **New patented plate/cassette design**
- **Built-in liquid separator (into evaporator)**
- **Built-in oil separator (into condenser)**
- **Built-in high pressure float valve (into condenser)**

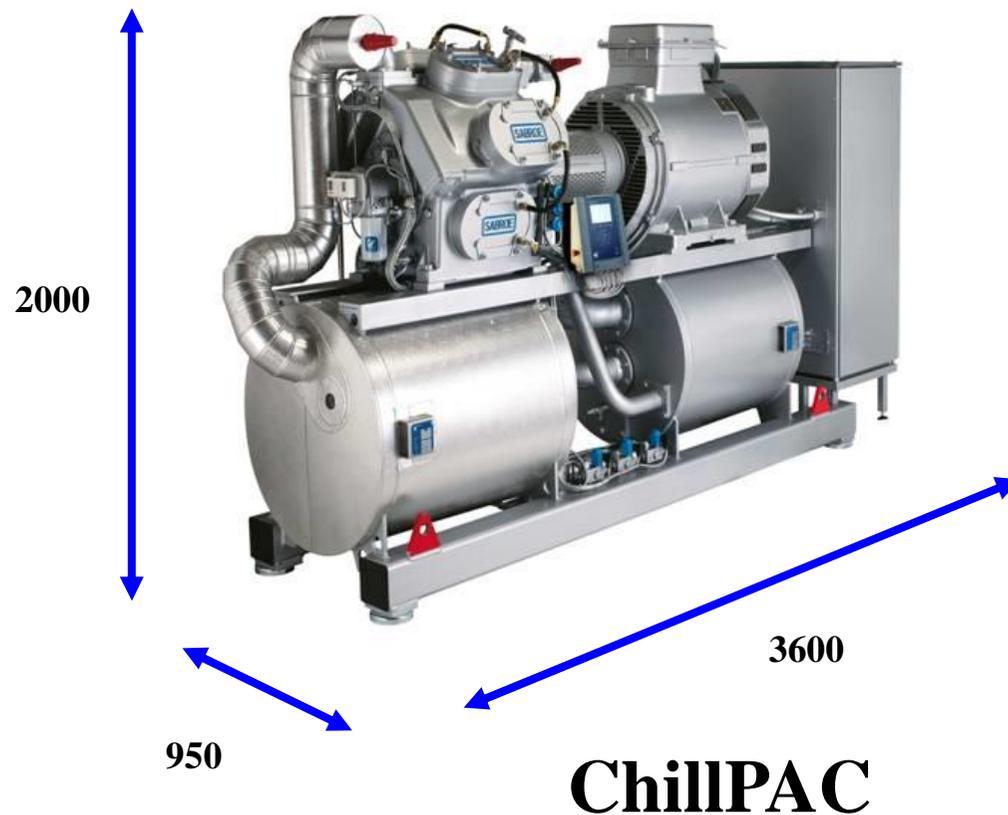
ChilPAC

Very compact ammonia chiller



ChillPAC

Compact, low weight and small refrigerant charge



Sabroe type:
ChillPAC 108 E-A

Cooling capacity: 700 kW

Conditions water:
+12/+7°C and +30/+35°C

Drive system: 132 kW Y/D or VSD
(Data from brochure)

Refrigerant charge: 35 kg

ChilIPAC

Low weight and very low charge



ChilIPAC 108 E-A

Cooling capacity: 700 kW, E-water +12/+7°C, C-water +25/+30°C & E-motor 132 kW



Conventional chiller



Approx. unit weight: 4300 kg

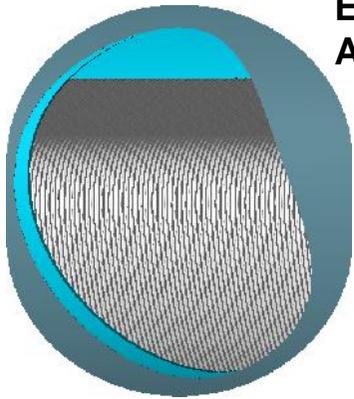
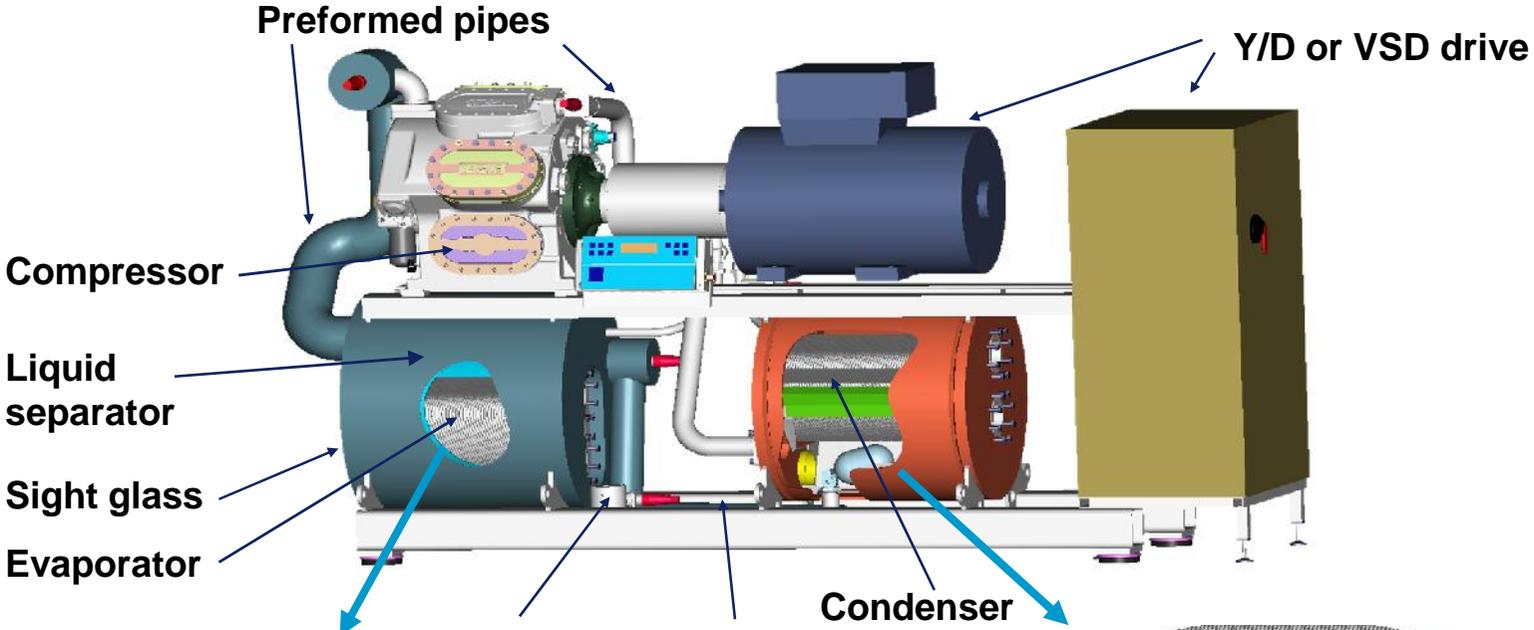


ChilIPAC

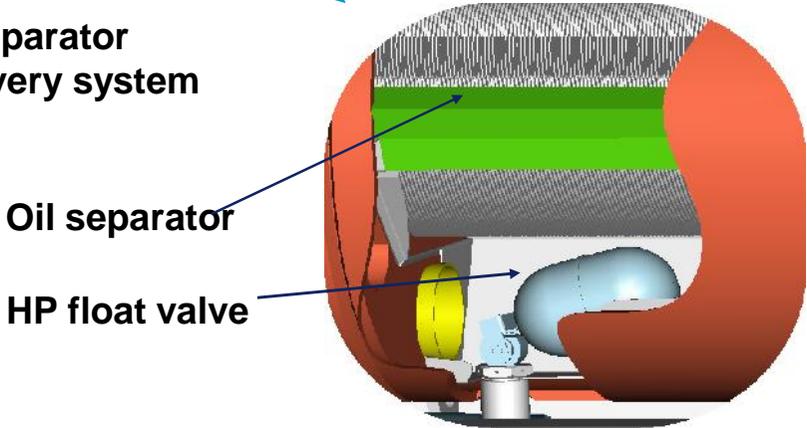


Approx. unit weight: 3500 kg

ChillPAC integrated design in detail



Evaporator & oil separator
Automatic oil recovery system



ChillPAC plate stack

Plate heat exchanger for compact ammonia chiller



Half pipe plate stack
32 – 125 cassettes

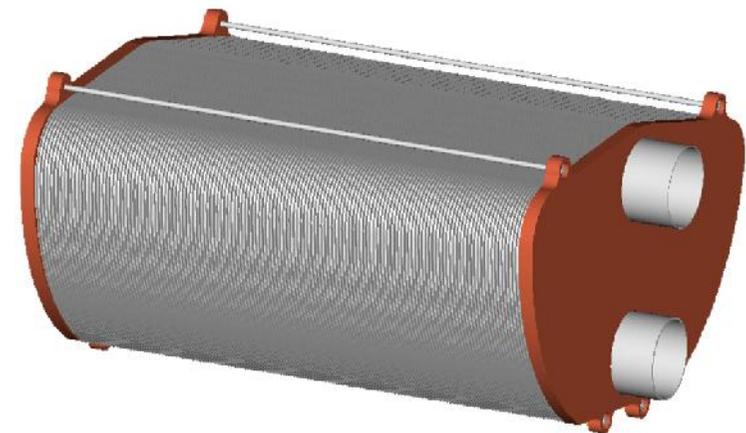
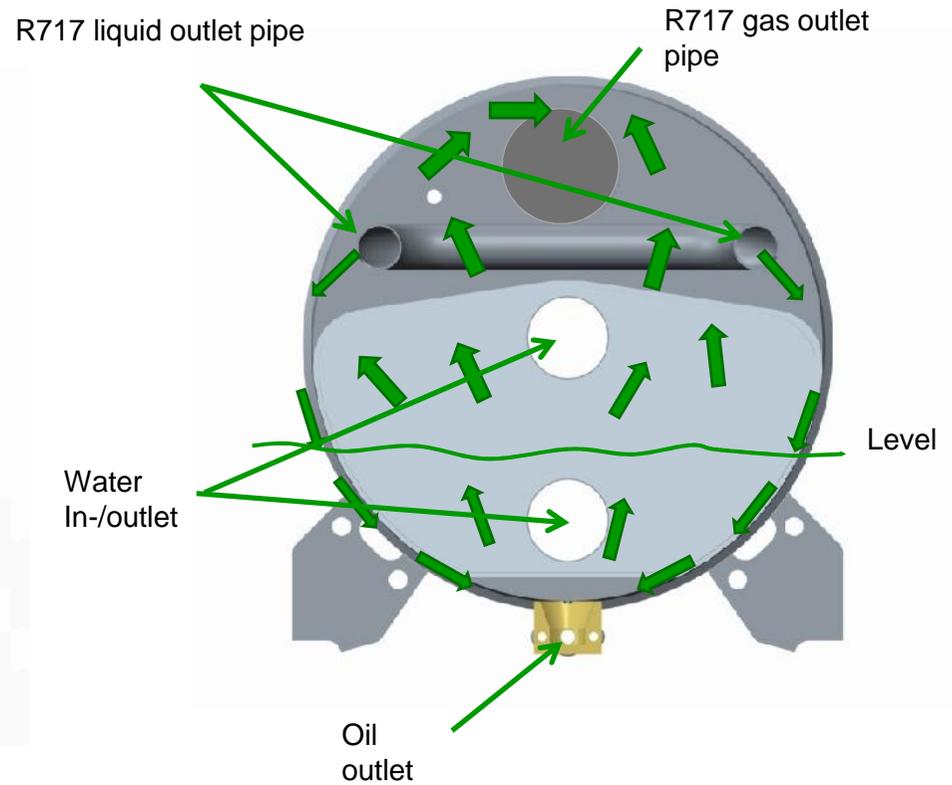
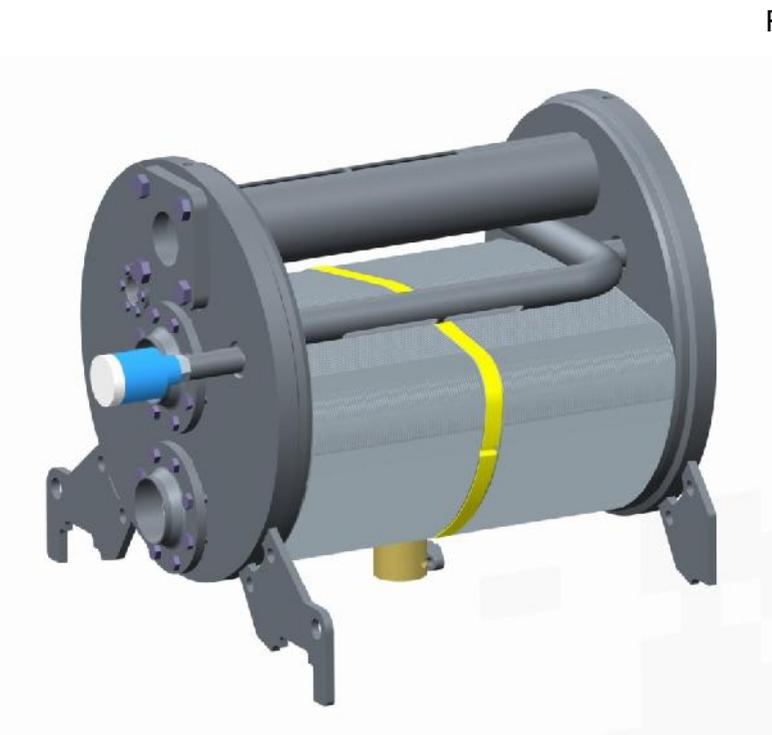


Plate design by Alfa Laval

ChillPAC flooded evaporator with integrated liquid separator



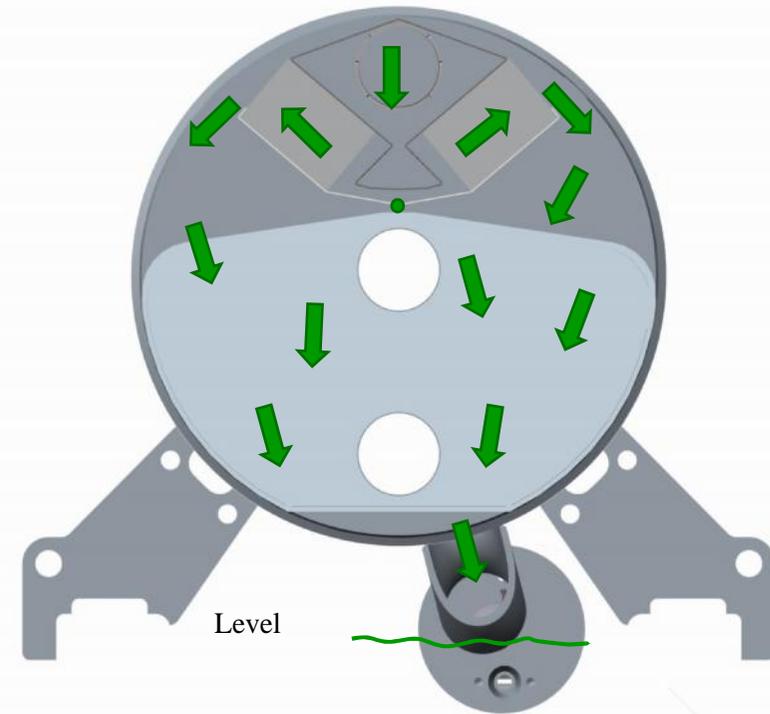
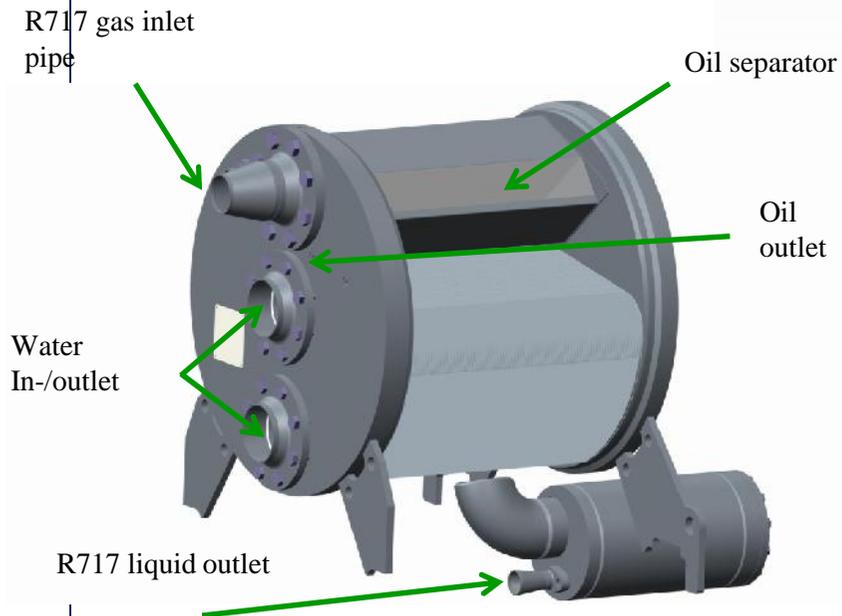
ChillPAC condenser

with integrated oil separator, receiver and expansion valve

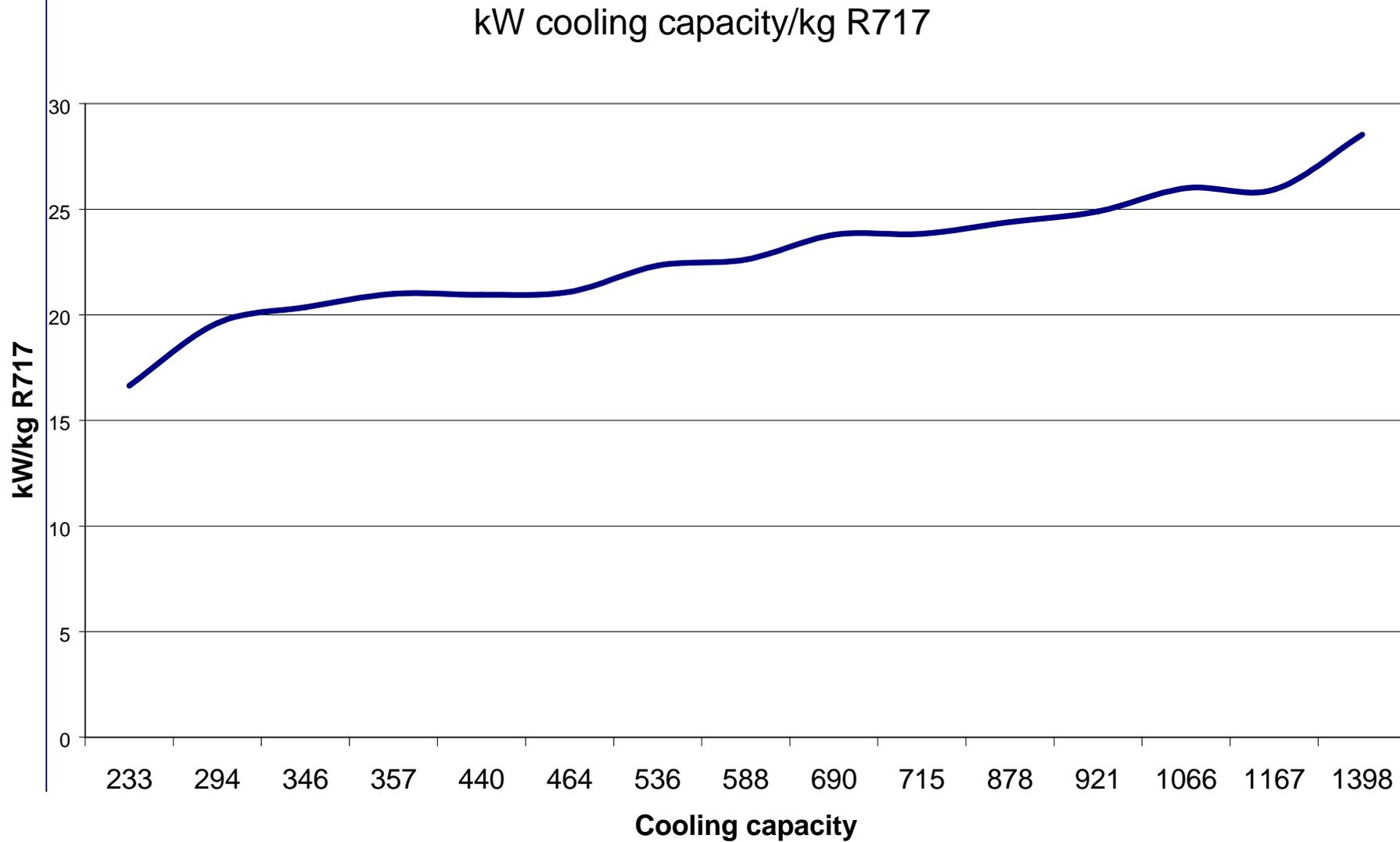


Condenser

- Compact design
- Very low refrigerant charge
- 150 -1600 kW



How low charge can be achieved?



ChillPAC - water

Using Sabroe SMC 100 reciprocating compressors



Selection guide - ChillPAC

Water chillers (Water: inlet 12°C, outlet 7°C)								
Type	Cooling capacity kW	E-motor kW	R717 charge kg	Dry weight kg	Dimensions			Sound level *) dB(A)
					L mm	W mm	H mm	
CPAC 104S-A	233	45	14	2301	2900	1000	2000	78
CPAC 104L-A	294	55	15	2410	2900	1000	2000	79
CPAC 106S-A	346	75	17	2727	2900	1000	2000	79
CPAC 104E-A	357	75	17	2652	2900	1000	2000	79
CPAC 106L-A	440	90	21	2950	2900	1000	2000	80
CPAC 108S-A	464	90	22	3060	2900	1000	2000	80
CPAC 106E-A	536	110	24	3225	3100	1000	2000	81
CPAC 108L-A	588	110	26	3526	3100	1000	2000	82
CPAC 112S-A	690	132	29	4315	4000	1000	2200	82
CPAC 108E-A	715	132	30	3880	3300	1000	2000	82
CPAC 112L-A	878	160	36	4738	4500	1000	2200	83
CPAC 116S-A	921	200	37	5044	4500	1000	2200	83
CPAC 112E-A	1066	200	41	5196	4600	1000	2200	83
CPAC 116L-A	1167	250	45	5556	4700	1000	2200	83
CPAC 116E-A	1398	315	49	5878	5000	1000	2200	84

Condenser: Water inlet 30°C, outlet 35°C Motor: 3 x 400V, 50Hz, 1460 rpm

ChillPAC - water

Using Sabroe SMC 100 reciprocating compressors



Selection guide - ChillPAC

Brine chillers (Ethylene glycol 30%: inlet -4°C, outlet -8°C)

Type	Cooling capacity	E-motor	R717 charge	Dry weight	Dimensions			Sound level *) dB(A)
	kW	kW	kg	kg	L mm	W mm	H mm	
CPAC 104S-C	116	37	13	2253	2700	1000	2000	78
CPAC 104L-C	150	55	15	2378	2900	1000	2000	79
CPAC 106S-C	172	55	15	2505	2900	1000	2000	79
CPAC 104E-C	185	75	17	2586	2900	1000	2000	79
CPAC 106L-C	222	75	18	2701	2900	1000	2000	80
CPAC 108S-C	227	75	18	2766	2900	1000	2000	80
CPAC 106E-C	272	90	20	2866	2900	1000	2000	80
CPAC 108L-C	295	110	22	3091	3100	1000	2000	82
CPAC 112S-C	339	110	24	3696	3800	1000	2200	82
CPAC 108E-C	363	132	25	3523	3300	1000	2000	82
CPAC 112L-C	440	160	29	4290	4200	1000	2200	83
CPAC 116S-C	450	160	29	4390	4200	1000	2200	83
CPAC 112E-C	544	200	35	4733	4300	1000	2200	83
CPAC 116L-C	586	200	37	4898	4300	1000	2200	83
CPAC 116E-C	718	250	43	5322	4300	1000	2200	83

Condenser: Water inlet 30°C, outlet 35°C Motor: 3 x 400V, 50Hz, 1460 rpm

ChillPAC

Compared with a conventional chiller



- Highly efficient solution
- 60% smaller footprint
- Max. width is 1.0 m, max. height is 2.15 m
- 20% lower weight
- 60% lower refrigerant charge
- Dimensions as HCFC/HFC chillers
- Fully welded plate heat exchangers
- Built-in functions to reduce size and improve reliability and safety

ChillPAC competitiveness



- Simple and VERY compact construction
- Very high COP and future safe refrigerants
- VERY low refrigerant charge
- Reliable and stable operation
- Only high-quality components
- R717 chiller benchmarking
- Test run facilities

Heat Pumps

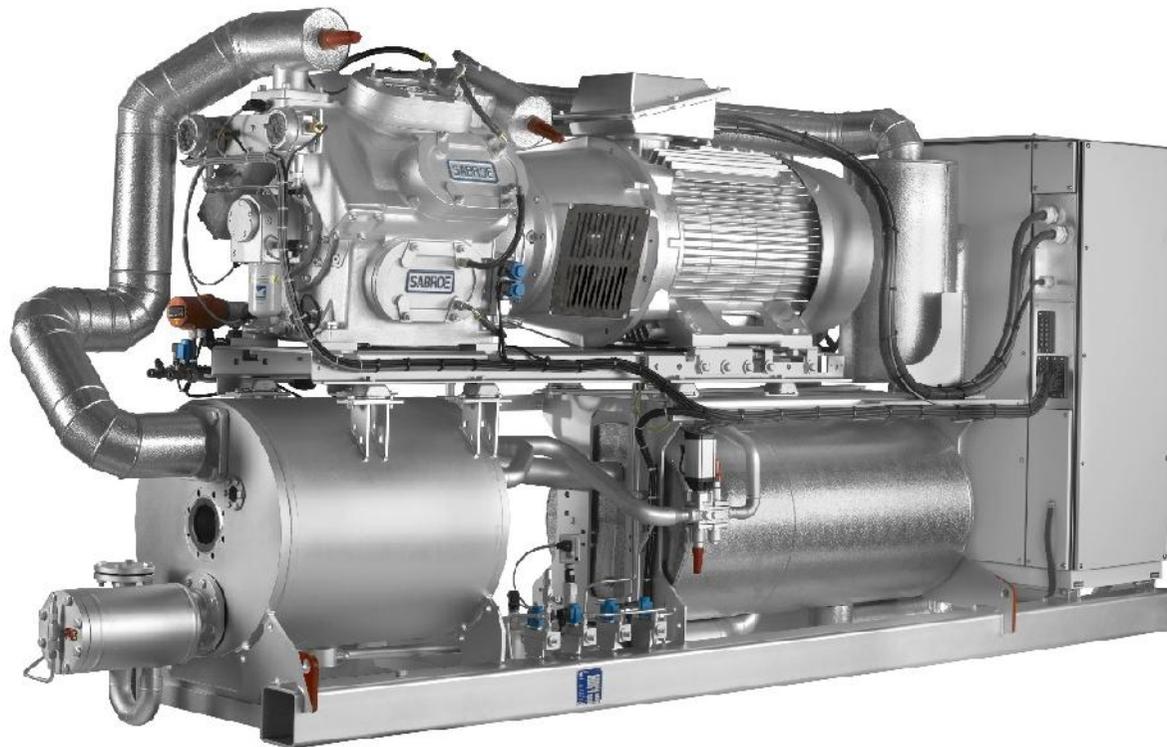


Heat exchangers systems

Combined Subcooler-condenser-desuperheater



- Dimensioning of heat exchangers for heat pumps
- Combined subcooler-condenser-desuperheater unit

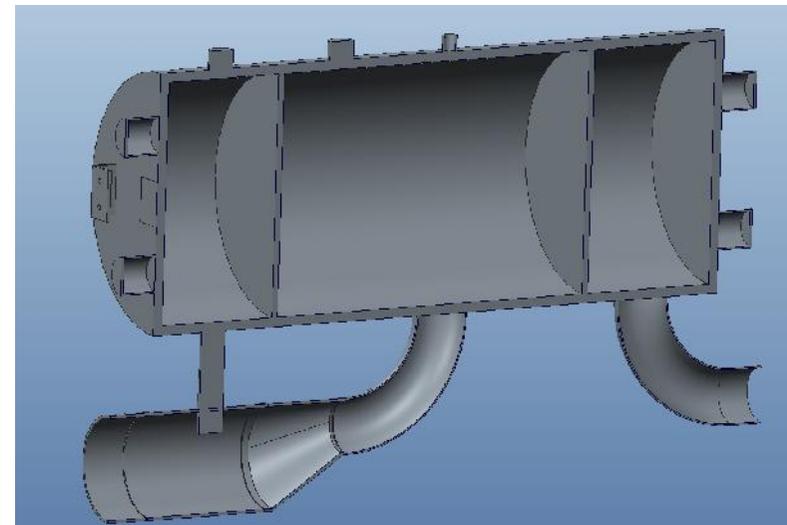
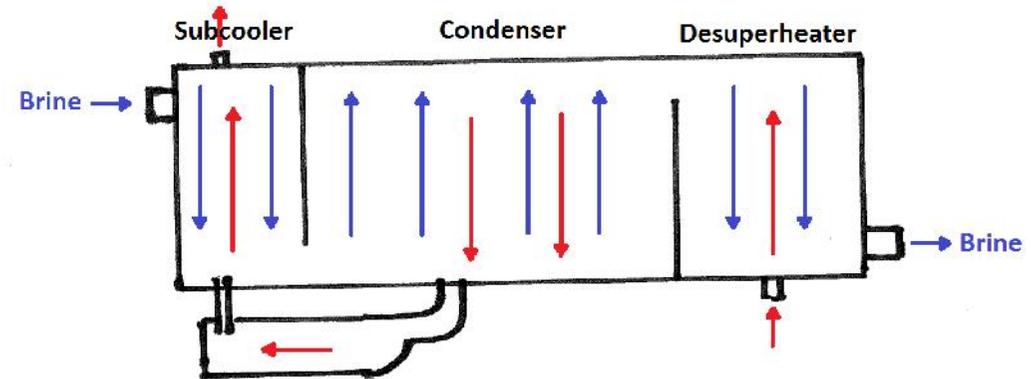


Heat exchangers systems

Combined Subcooler-condenser-desuperheater

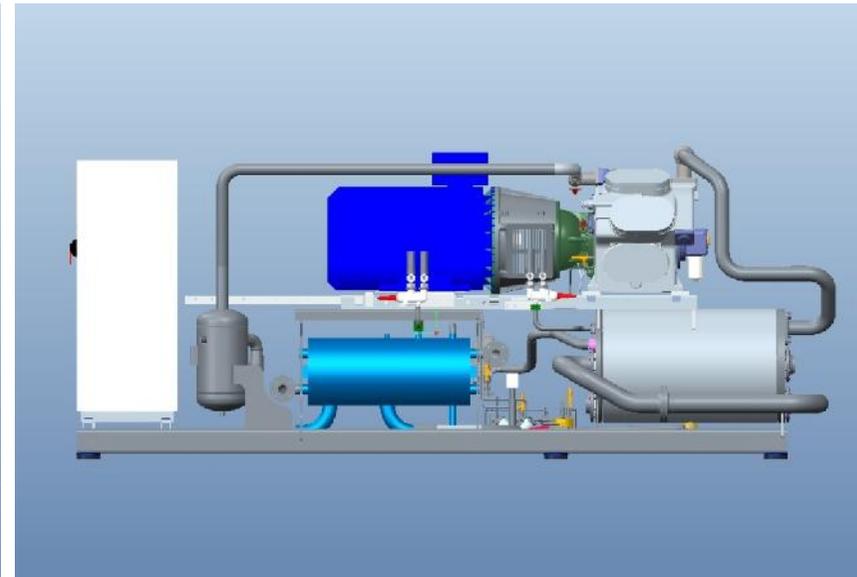
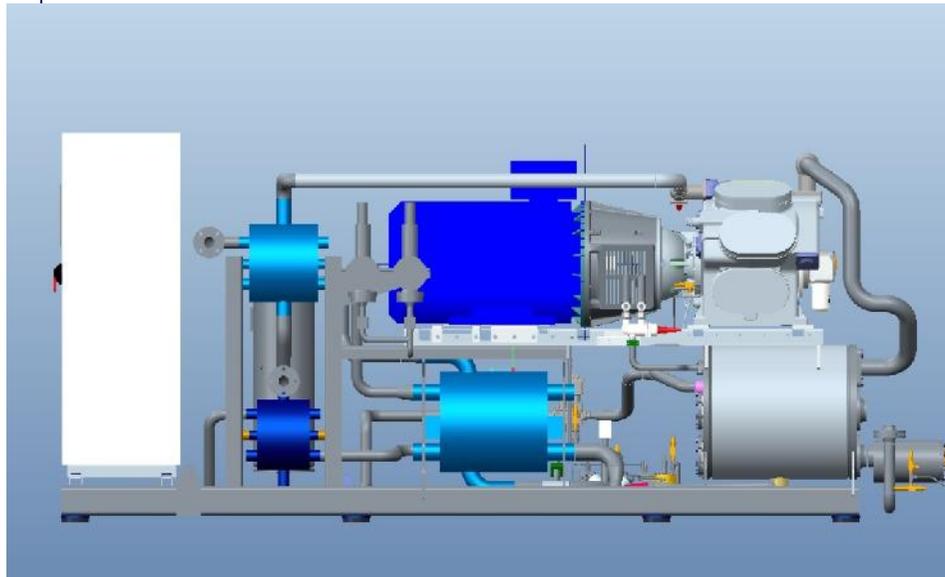


- Combined subcooler-condenser-desuperheater unit
- Patent pending
- Collaboration with Vatherus
- High pressure 60 bar
- Exclusive JCI product
- From 350 mm
- 1MW @ 90°C



Heat exchangers systems

Combined Subcooler-condenser-desuperheater



Compact



Very compact

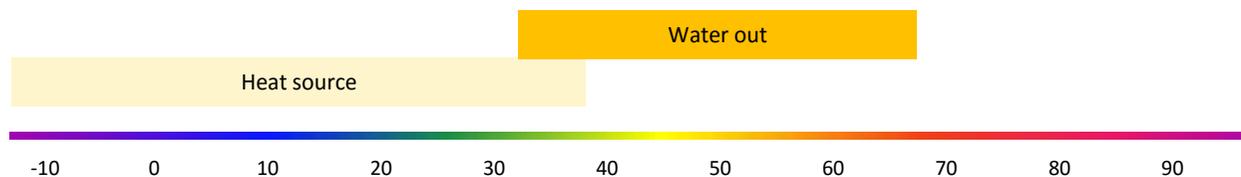
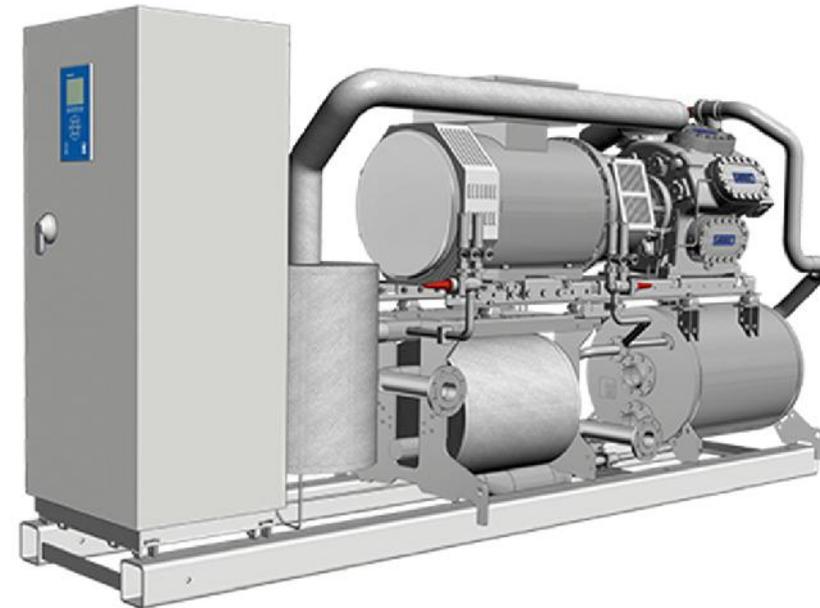
HeatPAC 100 series

... for 70°C applications



Standard NH₃ industrial heat pump unit

- Range consists of 6 models: 240 kW up to 1150 kW
- Max. outgoing water temperature: 70°C
- Small refrigerant charge: ~50 kg for largest unit
- Max. heating capacity: 1150 kW (40°C /70°C)
 - Cooling capacity: 965 kW
 - Power consumption: 186 kW
 - COP heat pump = 6.2
- One-stage compression only **limited lift**
- Cascade evaporator version available
- Application: Brewery, dairy, abattoir, fish processing etc.



New HeatPAC 70 series for 90°C applications



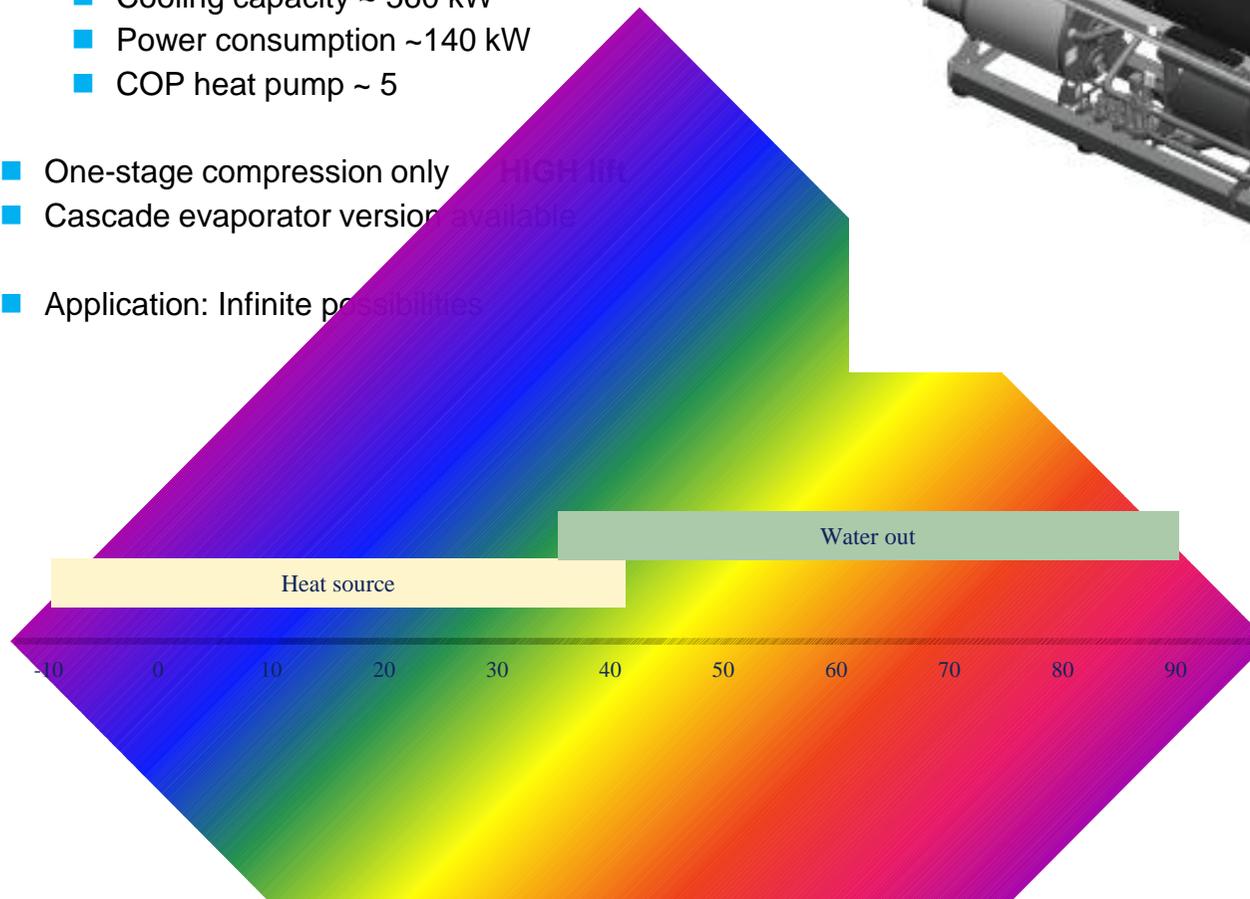
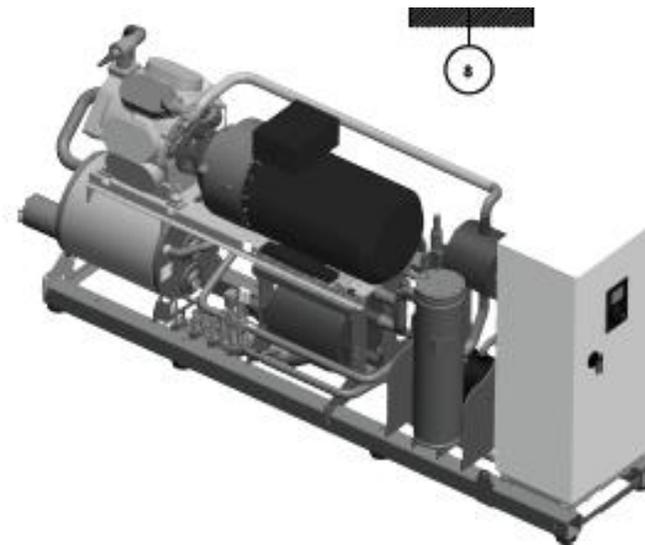
Standard NH₃ industrial heat pump unit

- Range consists of 3 models: 230 to >700 kW
- Max. outgoing water temperature: 90°C
- Small refrigerant charge: ~45 kg for largest unit

- Max. heating capacity: > 700 kW (40°C /90°C)
 - Cooling capacity ~ 560 kW
 - Power consumption ~140 kW
 - COP heat pump ~ 5

- One-stage compression only
- Cascade evaporator version available

- Application: Infinite possibilities



Low Charge Heat Pumps



HPAC	Heating cap [kW]	Charge [kg]	kg/kW heat
20-W	240	20	0.083
26-W	359	23	0.064
28-W	484	25	0.052
104-W	570	28	0.049
106-W	852	37	0.043
108-W	1149	48	0.042

ChillPAC family (products based on halfpipe)



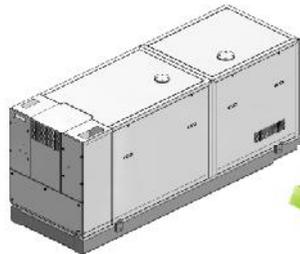
ChillPAC screw



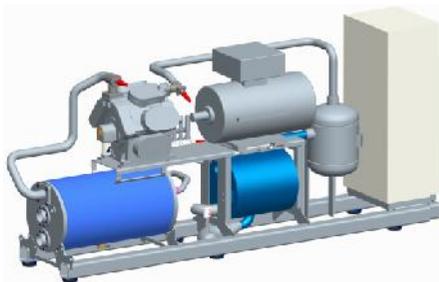
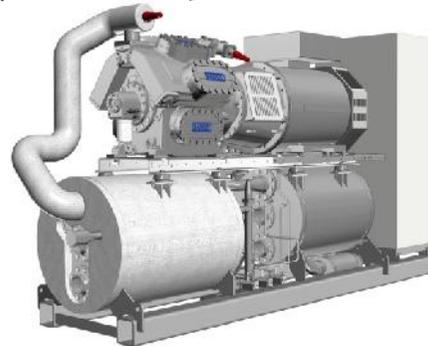
MiniPAC (CMO compr.)



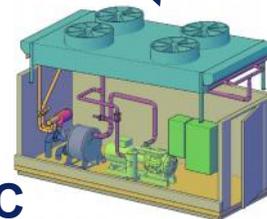
**ChillPAC LP
(Remote condenser)**



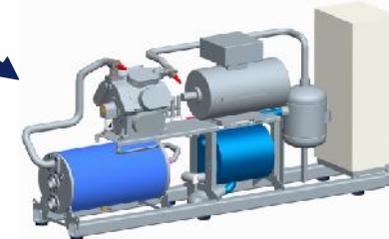
ChillPAC SABCube



HeatPAC (Heat pump)



**AirPAC
(Air cooled condenser)**



**ChillPAC super charger
(with cascade cooler)**

Exemplos de aplicação

Heathrow airport – London – Terminal 5



4 unidades – total de 25 000kW



One out of four chillers is in place. London Heathrow Intl. Airport

Exemplos de aplicação

Scandinavian Congress Center



Scandinavian Congress Center in the center of Aarhus uses Ammonia systems with a total cooling capacity of 1,200 kW.

Desde 1995.



$Q = 3 \times 4200 \text{ kW}$
 $T_s = 1.0^\circ\text{C} - \text{água}$

APLICAÇÃO: AR CONDICIONADO

Refrigeração de mina subterrânea - produção de Cloreto de Potássio a partir de rocha de Cloreto de Sódio (30% KCl; 65% NaCl)

APLICAÇÃO: AR CONDICIONADO

Micro-
processador

Válvulas
reversoras
de fluxo

R-717:

EPHE: 160 kg

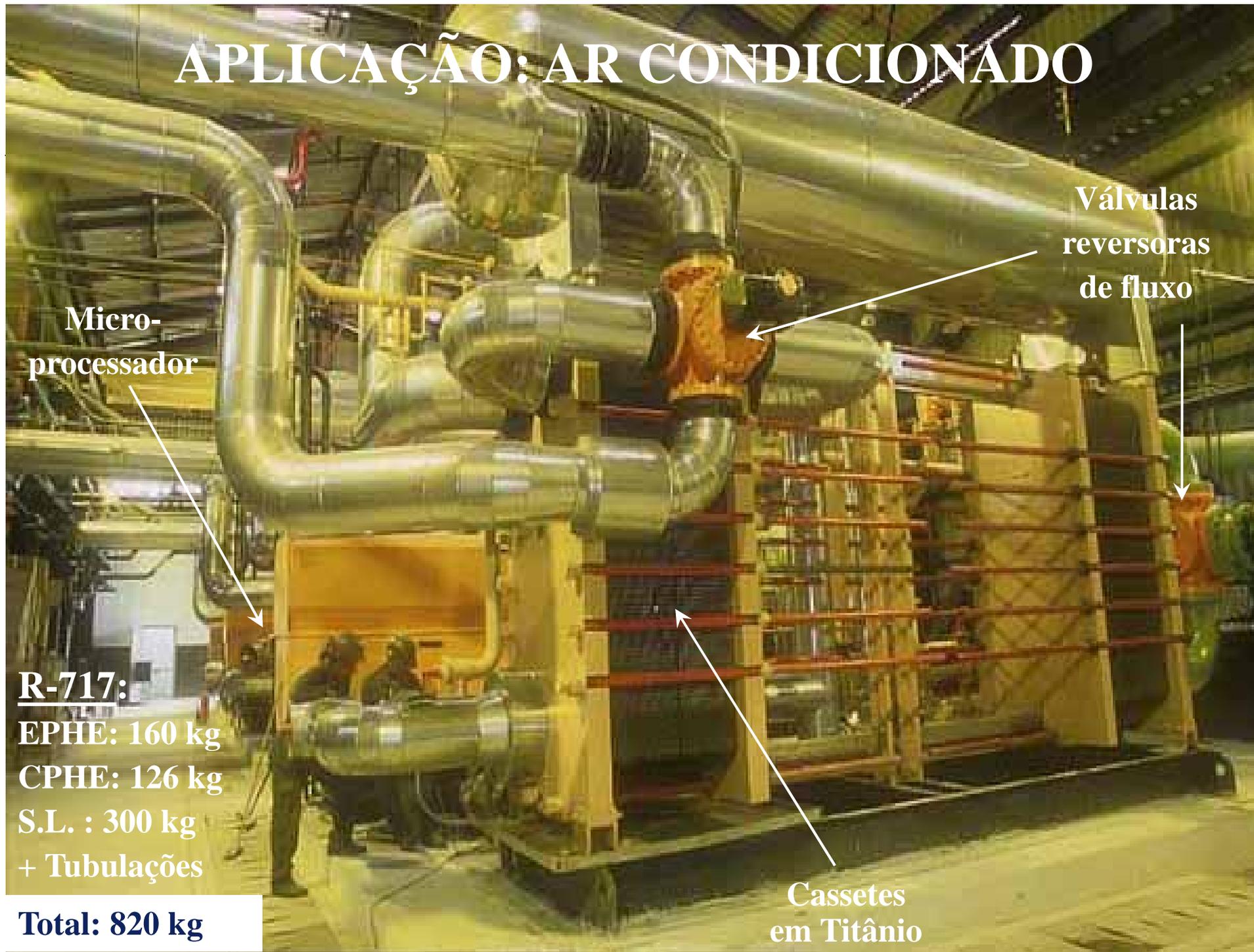
CPHE: 126 kg

S.L. : 300 kg

+ Tubulações

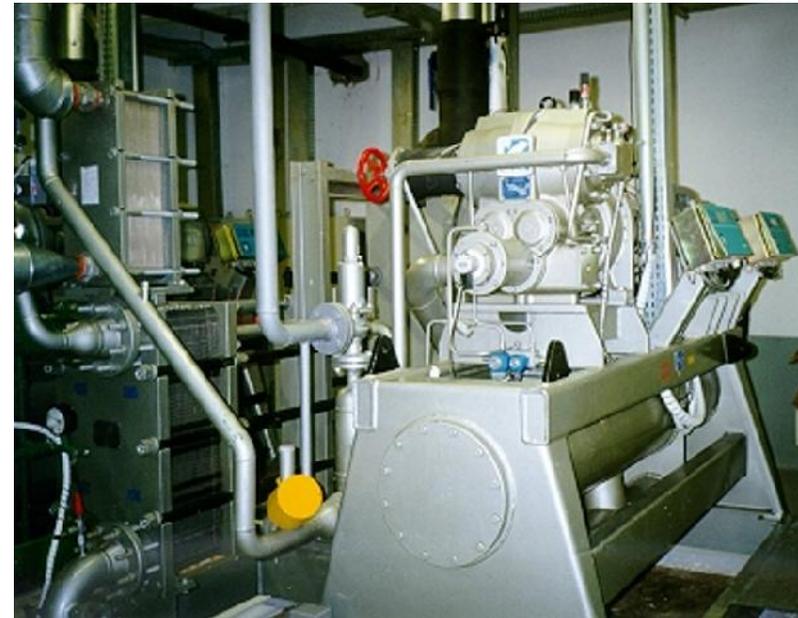
Total: 820 kg

Cassetes
em Titânio



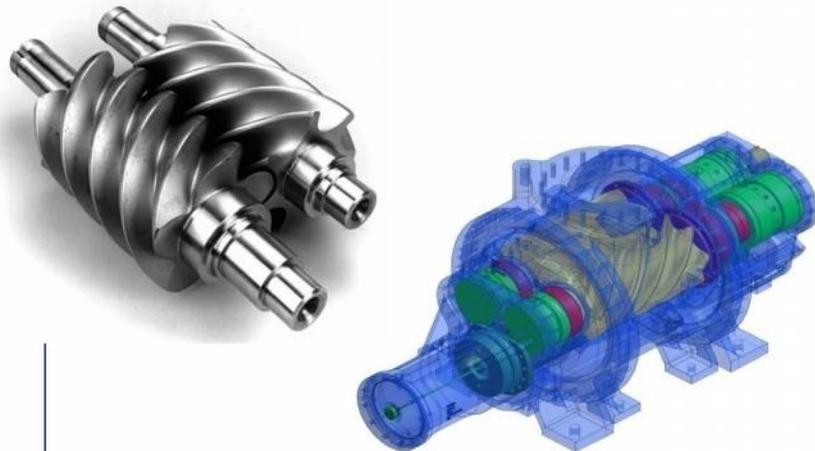
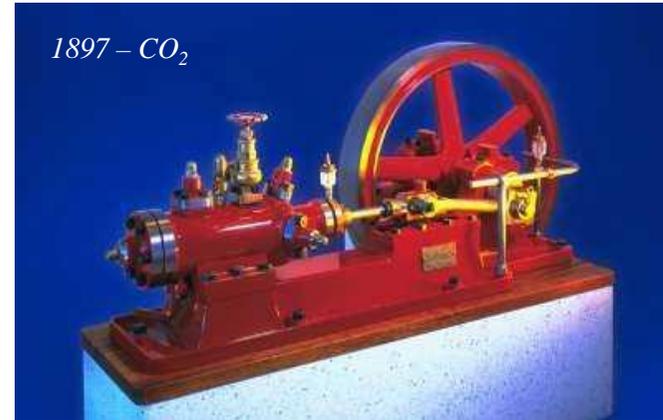
Exemplos de aplicação

Supermercado Zaffari – Rio Grande do Sul



- **Área da loja: 10.000 m²**
- **Resfriados: 2 x 190.000 kcal/h; Ts=-2.0°C; Propileno Glicol (20%)**
- **Congelados: 2 x 60.000 kcal/h; Ts=-27.0°C; Tyfoxit (80%)**
- **Ar Condicionado: 3 x 330 TR + tanque de 1100 m³; Ts=6.0°C**

Muito obrigada pela atenção!



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SISTEMAS DE ÁGUA GELADA



PROGRAMA
BRASILEIRO DE
ELIMINAÇÃO DOS
HCFCs
Projeto para o Gerenciamento de CFCs

Apoio Institucional:



Execução



Implementação



Empoderando vidas.
Fortalecendo nações.

Realização

Ministério do
Meio Ambiente

