

Semi-hermetic screw and Ammonia?

The clever way to cool sustainable

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Productmanger Chiller
GEA Refrigeration Germany GmbH

Schaffhausen, June 2019

euramm^on
refrigerants delivered by mother nature



Turnover (EUR)
4.674 Million



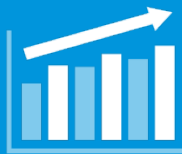
Employees (FTEs)
16.937



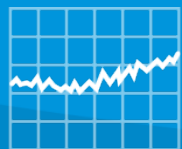
Operatives EBITDA (EUR)
566 Million



Operative EBITDA Margin
12,6 %



Profit (EUR)
4.491 Million



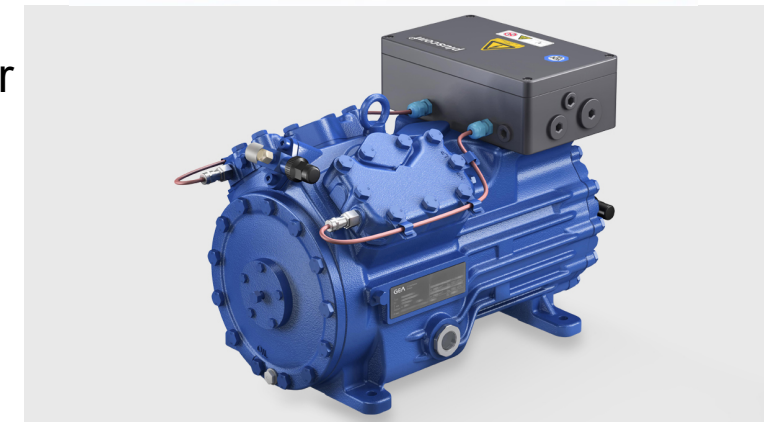
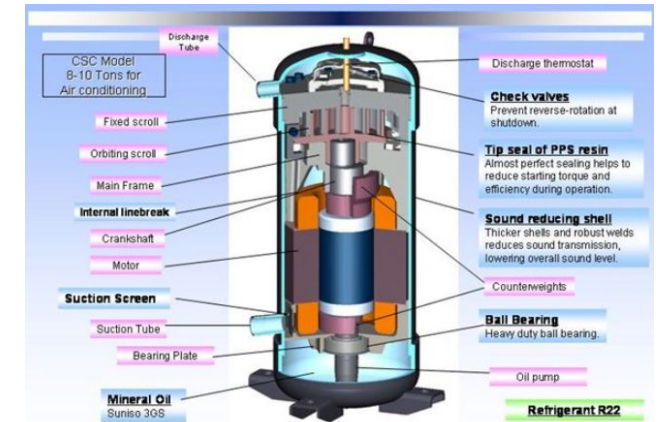
Bonus (EUR)
1,48

GEA – “engineering for a better world”

- GEA is a supplier of process technology mainly for the food industry but also for other industrial applications (Chemical / Pharma)
- International acting group with M-DAX listing and listed in selected sustainability MSCI indices
- Industrial and commercial Refrigeration important part of the portfolio

Compressor technologies used – commercial

- Hermetic compressors (F-Gases / HC)
 - Diverse designs and obvious variety of manufacturer
 - Mainly used in household (fridges) and commercial applications
 - Well approved simple and cheap design; normally no service
 - Advantage: Gas tight
 - Disadvantage: less efficient: not suited for industrial applications
- Semi Hermetic compressors (F-Gases / HC / CO₂)
 - Normally small piston compressors available from several supplier
 - Used in commercial applications up to a few hundred kW
 - Very common as Multi racks; limited services and lifespan
 - Advantage: compact and nearly gas tight; easy to package them
 - Disadvantage: limited efficiency: not in industrial applications



Compressor technologies used – industrial II

- Open type screw compressor (Ammonia)
 - Relatively young technology in connection with Ammonia
 - Limited number of manufacturer worldwide; sizes up to 15k m³/h
 - Very robust design with long lifetime (>25 y)
 - Advantage: very reliable; highest pressure differences possible
 - Disadvantage: limited part load efficiency; open shaft seal
- Open type reciprocating compressor (Ammonia)
 - First common technology in connection with Ammonia
 - Worldwide well known construction; capacities normally below screw
 - Preferred technology in the world wide food industry
 - Advantage: highest efficiency in full and part load conditions
 - Disadvantage: limited dP; relatively high service costs

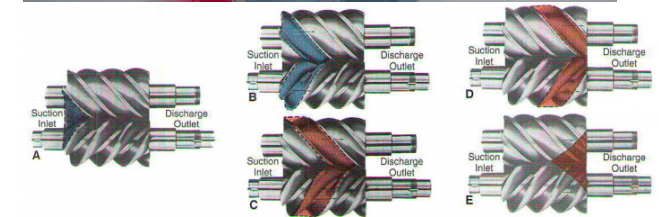
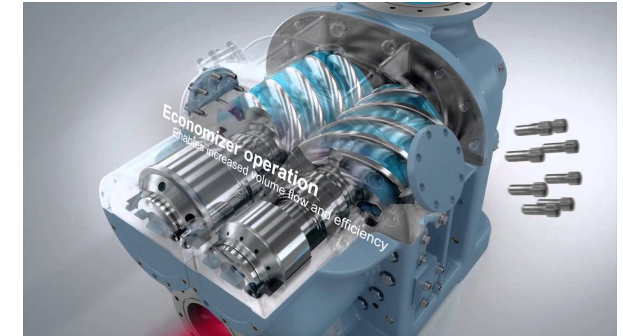


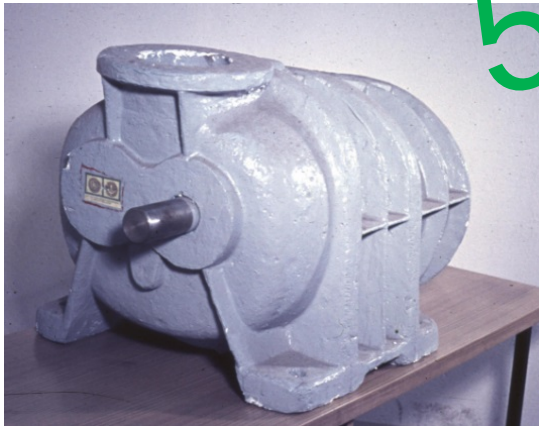
Figure 4-64. Basic operation of screw compressor. Revolving rotor compresses vapor. A—Compressor interlobe spaces being filled. B—Beginning of compression. C—Full compression of trapped vapor. D—Beginning of discharge of compressed vapor. E—Compressed vapor fully discharged from interlobe spaces. (Dunham-Bush, Inc.)



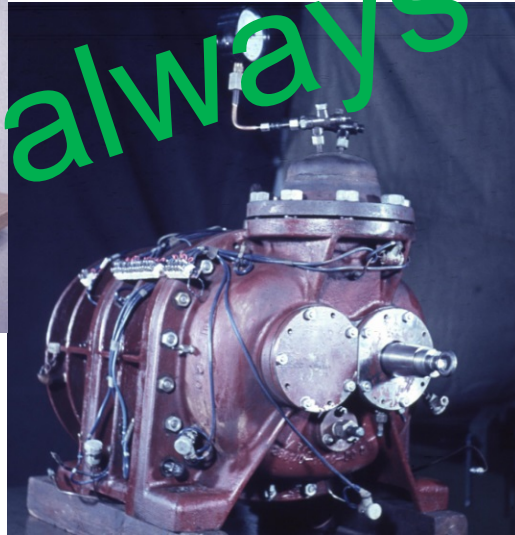
Industrial NH3 screw - something about the history....

1968

First model of a German Industrial screw compressor - S-800



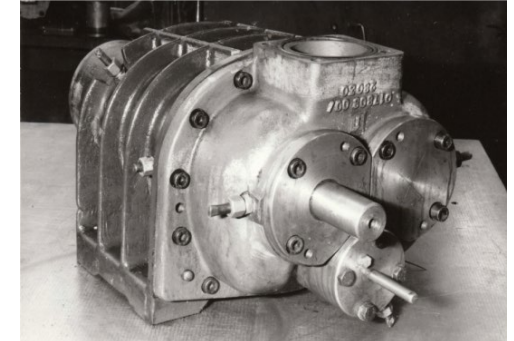
50 years but always industrial



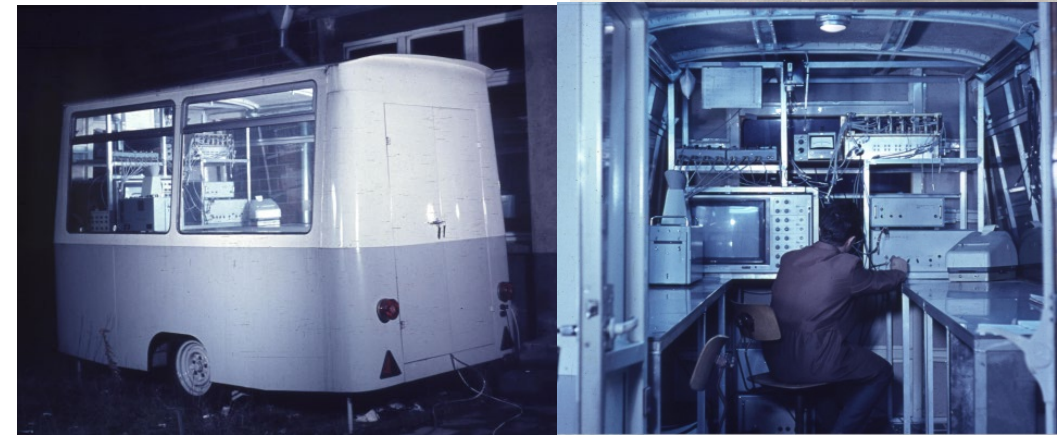
A S 800 ready for test ...

1974

The type S 450 – the first one with radial slide bearings



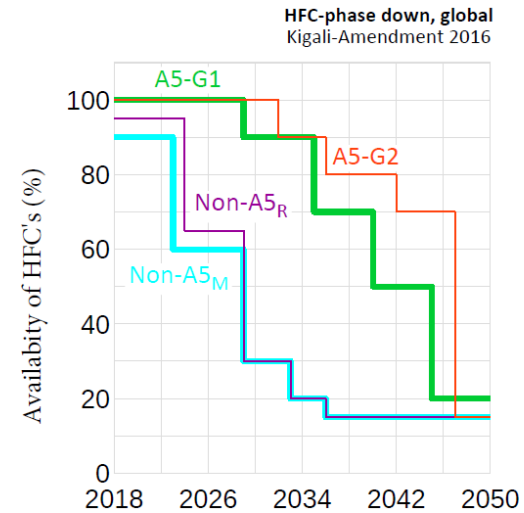
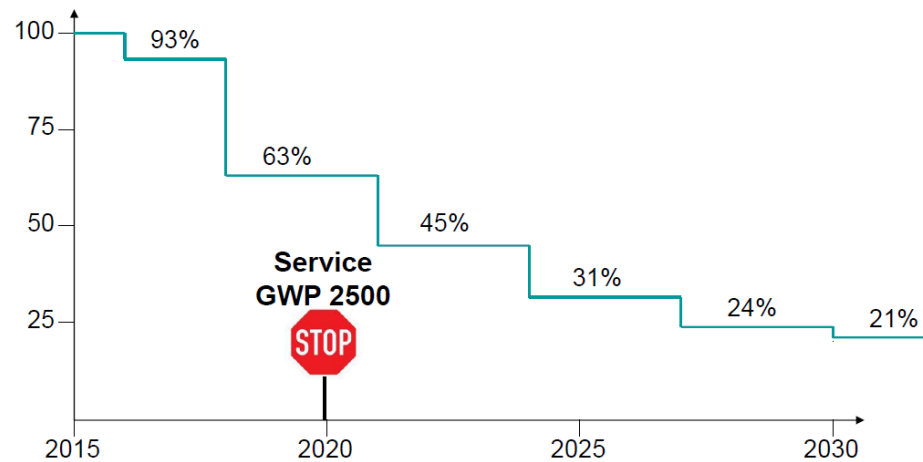
The first test lab



F-gases as refrigerants – a world under pressure!

- F-gases worldwide under pressure!
- Terms used
 - ODP – Ozone depletion potential (HCFC)
 - GWP – global warming potential (HFC)

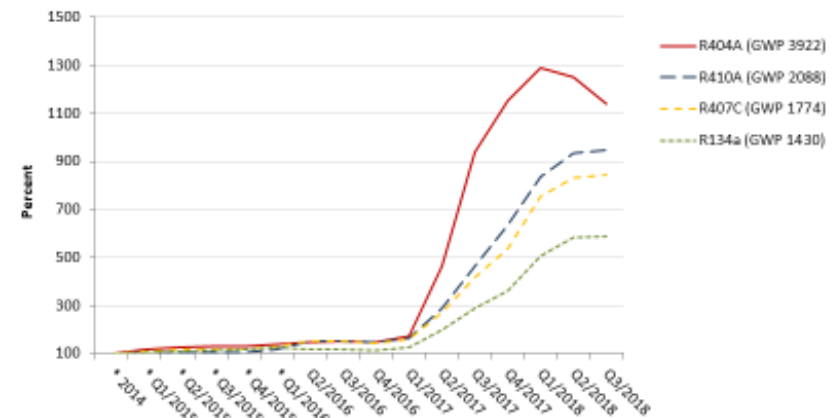
CO₂ Äquivalentes Phase Down (Art.15 + Annex V)
 Serviceverbpt GWP >2500 ab 2020 (Art.11 (1)+ Annex III(12))



Phase down commitment 2019 – 2047

- **Article-5-G2:** Bahrain, Indien, Iran, Kuwait, Oman, Pakistan, Katar, Saudi Arabien, Vereinigte Arabische Emirate
- **Article-5-G1:** all developing countries
- **Non-Article-5_R:** Belarus, Russia, Kasakstan, Non-A5_R, Tadschikistan, Usbekistan
- **Non-Article-5_M:** all other UN-countries (w/o EU)

Development of purchase prices for various HFC refrigerants at service company level (price index, 2014 = 100 %)



EU Ecodesign – well known or not known?

- Efficiency requirements defined for electrical energy consuming products
- Valid for medium / low / high temperature process chiller already from 01/2017//01/2018
- Not permitted to sell chiller which not complies to EcoDesign!
- Low efficient chiller (~70% of existing products!) do not reach the Ecodesign-requirements!

Letter of compliance - ECO-design
Requirements acc. Directive 2009/125/EC

Manufacturer: GEA Refrigeration Germany GmbH
Höhlhäuser Str. 155, 13509 Berlin, Germany
Phone +49 30 43 592 6

We hereby declare that our Process-Chiller are within the scope of eco-design requirements, implemented according to EU-commission regulation 2015/1095 for low (-25°C) and medium (-8°C) temperatures and EU-commission regulation 2016/2281 for high (7°C) temperatures. If applicable the harmonized standards EN 14511 series and EN 14825 have been considered. Value tolerances for selection tools comply with EN 12500.

Pre-conditions:

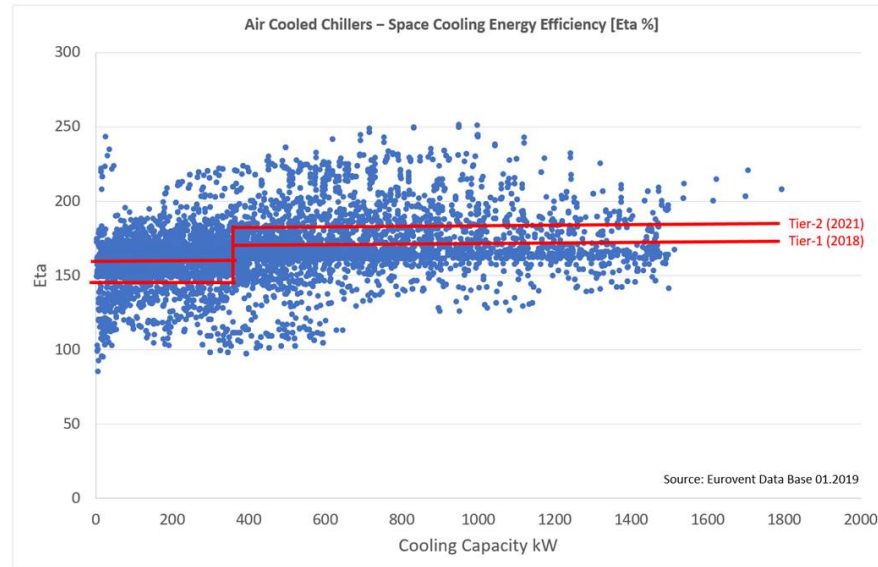
1. EER calculations are on base of our RT select calculation/sales tool - currently valid version.
2. SEPR calculations are made in a spreadsheet tool, version 1.5.3, dated 2013-09-01. Results are opposed to the limits specified in commission regulation 2015/1095 Annex VII and 2016/2281 Annex II. See data and calculation on following pages.
3. Screw compressors without performance-increasing system (economizer).
4. Secondary refrigerant: Ethylene glycol for (-8°C) and (-25°C) and water (7°C).
5. Suction and discharge pressure drops included.
6. Brine/water pump power (NPT) included; (not part of scope of supply)
7. Electric motor efficiency considered and included
8. Chiller includes evaporator (brine/water) and condenser (water or air).

legal limits of 2015/1095 - minimum SEPR (TIER1)
refrigerant: Ammonia (GWP < 150)

	medium temperature (-8°C)		low temperature (-25°C)	
	< 300 kW	> 300 kW	< 200 kW	> 200 kW
water cooled	2,57	3,42	1,64	1,88
air cooled	2,02	2,52	1,33	1,44

legal limits of 2016/2281 - minimum SEPR (TIER1)
refrigerant: Ammonia (GWP < 150)
capacity control: variable
de-gradation: 0,9

	high temperature (7°C)		
	< 400 kW	> 400 kW < 1500 kW	> 1500 kW
water cooled	6,50	7,50	8,00
air cooled	4,50	5,00	



ENTR Lot 1 Professional Storage Cabinets, Blast Cabinets, Condensing Units and MT/LT Process Chillers

ENER Lot 21 Air Heating Products (incl. "Air" HP), Cooling Products (incl. A/C Chillers) and High Temp Process Chillers

Commissions Energy (ENER) and Enterprise (ENTR)

ENER Lot .			ENTR Lot .	
1. Boilers	10. Air con < 12 kW <input checked="" type="checkbox"/> - under revision	20. Local room heating	1. Refrigeration <input checked="" type="checkbox"/>	
2. Water heaters	11. Motors, fans, ... <input checked="" type="checkbox"/> - under revision	21. Central heating, cooling products	2. Transformers	
3. PC	12. Com. Refrigerators	.....	3. Multime	
4. Copiers	.....	.....	4. Industr. ces	
5. TV, ...	.....	3. Motors / Drives <input checked="" type="checkbox"/>	5. Machin	
6. Stand-by losses	15. Fan coil units	.....	.....
7. Battery charger	.....	.....	.....
8. Office lights	.....	.....	.....
9. Street lights	.....	.....	.....
	19. Domestic lighting		.....

Current main work items for RACHP

- Axial fans with motor
- HT Process Chillers
- Comfort A/C Chillers
- Air Heating Heat Pumps
- Condensing Units
- MT & LT Process Chillers

GEA semi-hermetic Ammonia – a short history



1991 – 2008

FKA reciprocating compressors and packages of Ilka Mafa (GEA); Aluminium wound motors



1991 – 2008

FKA Chiller series with one or even two circuits based on the semi-hermetic compressors



1991 – 2008

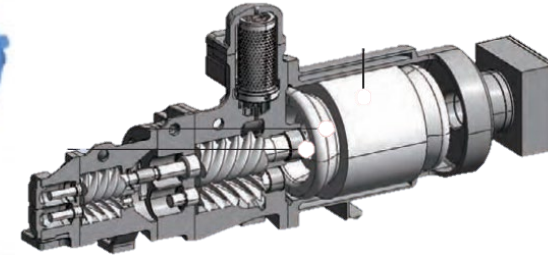
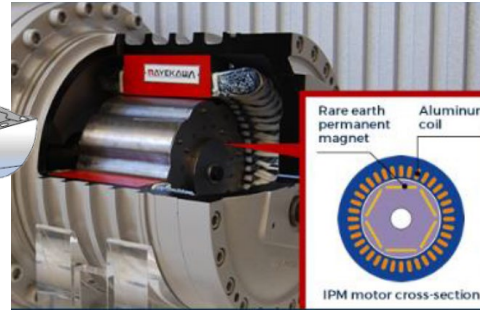
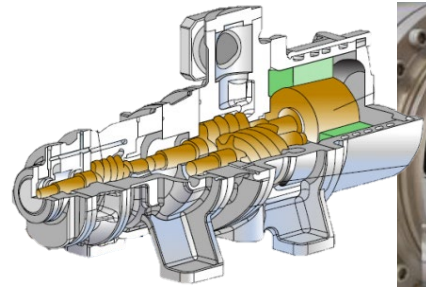
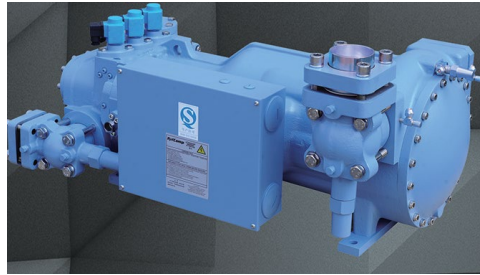
FKA series also made for outdoor erection

Ammonia semi-hermetic piston – a short life only

Device	Technical detail	Advantage / Disadvantage
Semi-hermetic reciprocating compressor	Based on the current open design; water-cooled cylinder heads	Relatively compact with good efficiency and reliability / limited range
Suction gas cooled electric motor	Aluminium wound motor from a German supplier; Ammonia suction gas cooled	Compact and tight Ammonia compressor package / poor motor efficiency; small number sold
Chiller based on semi-hermetic Ammonia piston compressor	Simple and tight construction for in- and outdoor use; several heat exchanger arrangements; smaller capacities (< 500 kW)	Perfect solution to substitute F-Gas chiller / limited acceptance of Ammonia systems at this time outside of industrial applications



Ammonia semi-hermetic screw compressor – a return of an idea

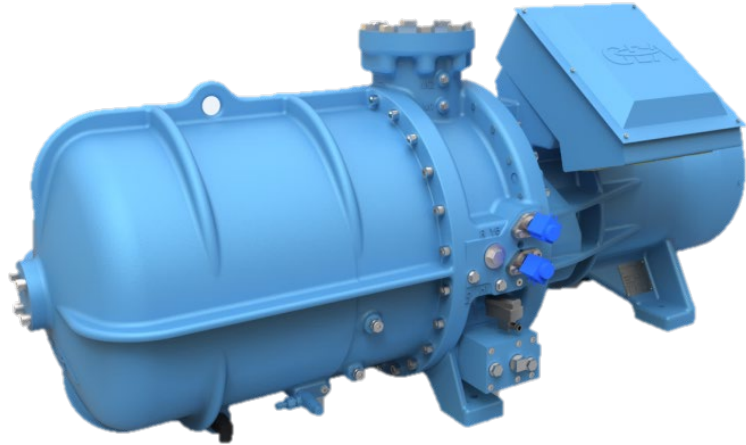


- MYCOM
 - Cascade (NH₃/CO₂) solution based on semi-hermetic driveline – very successful!
 - Compressor directly connected with motor (Aluminium coil – IPM motor)
 - Not really suction gas cooled motor; smaller cooling capacities @ lowest suction pressure
- SNOWKEY /SRM
 - Several sizes of semi-hermetic Ammonia screw; huge experiences in semi-hermitic technology (F-Gas)
 - Based on suction gas cooled motor with IPM and Aluminum winding
 - Small Chiller already shown (appr. 100 kW capacity)
- Other industrial screw manufacturer
 - Developments started, results pending

GEA CompaX – the modern definition of semi-hermetic with Ammonia

Electric motor

- Suction gas cooled motor with GEA special winding



Oil separator

- 2 stage separation

Screw compressor

- Automatic and extended Vi by default
- Oil filter direct mounted

Safety



- Very limited external connections
- No shaft seal!

Efficiency



- Good efficiency through the whole speed limits (1200 – 5200 rpm)
→ perfect match also in part load

Reliability



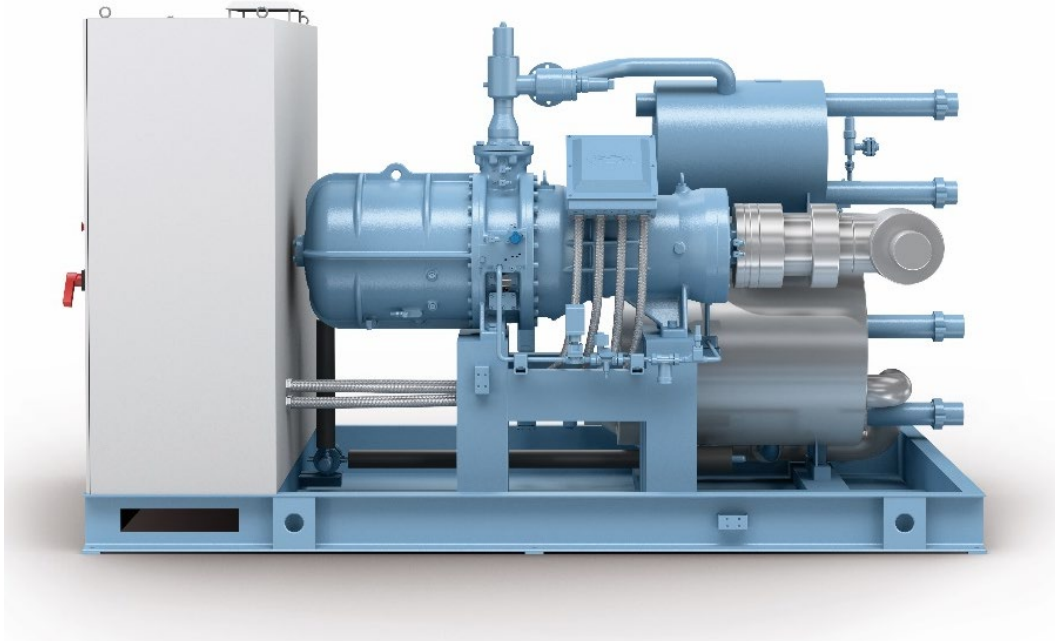
- Based on 50 years experiences with manufacturing screw compressors; experiences in semi-hermetic Ammonia technology

Compact



- Compact design
- Perfect for use with a chiller

GEA BluQ chiller – A/C by using Ammonia – yes!



Safety

- No shaft seal; oil cooling by ref. injection
- Fully welded plate+shell HX!
- Base tub as drip tray



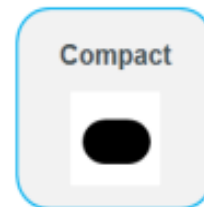
Efficiency

- VSD by default, no capacity slide
- Extended Vi (14-27/18-50)
→ perfect match at all part load conditions



Reliability

- Extended experiences with chiller
- More than 2000 chillers in the field
- “no service” chiller



Compact

- Compact design based on Blu-Chiller
- Perfect for substitutions of F-Gas units; Lowest Ammonia content (<50g/kW)

Model	Cooling capacity (kW) R717 | +12/+7 °C	EER	$\eta_{s,c}$ ^{*)} acc. EcoDesign 2016/2281		Compressor	Max. speed (rpm)	Dimensions (mm)		
			≤1500 kW	>1500 kW			L	W	H
GEA BluQ 120	1,150	5.0	•	--	GEA CompaX 700	4,500	3,800	2,400	2,400
GEA BluQ 140	1,350	5.0	•	--	GEA CompaX 700	5,200			
GEA BluQ 150	1,440	5.1	•	--	GEA CompaX 900	4,500			
GEA BluQ 170	1,650	5.1	--	•	GEA CompaX 900	5,200			

^{*)} η = Seasonal Space Cooling Energy Efficiency at +12/+7 °C

• Strengths

- Alternative to conventional open Ammonia systems – tight by design
- No limit in operating conditions
- Lowest refrigerant content
- Long life industrial quality

• Weaknesses

- Small number of references up to now
- No „discount“ from EN 378 if semi-hermetic
- Still based on steel and stainless-steel – higher CAPEX

• Opportunities

- Natural refrigerants in an up wind – political safe and always available
- More sizes and alternatives (supplier) available soon
- Increasing demand in A/C combined with heat pumps

• Threats

- F- gases still dominating in A/C
- Low GWP F-gases / F-gas Lobby
- Big variety of existing F-Gas chiller
- Limited technical knowledge of contractors if Ammonia



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refrigerants delivered by mother nature