



Norwegian University of
Science and Technology



An overview of current CO₂ compressors

Engin Söylemez

12.09.2022

Introduction

- The objectives:
 - Status of CO₂ compressors
 - Commercially-available the largest CO₂ compressors for subcritical and transcritical applications
- The CO₂ compressors of five brands:
 - **Mayekawa MYCOM:** J series
 - **Johnson Controls SABROE:** HPO/HPC/HPX series
 - **DORIN:** CD series for transcritical and CDS series for subcritical applications
 - **GEA BOCK:** HG series for subcritical and transcritical applications
 - **BITZER:** Octagon SL for subcritical and Ecoline for transcritical applications

CO₂ compressors: status

Overview of the development and status of carbon dioxide (R-744) refrigeration systems onboard fishing vessels

- Limited scientific work by academia
- The efforts for the CO₂ compressor developments by manufacturers
 - higher isentropic and volumetric efficiencies
 - higher cooling capacities
 - fewer operating costs
 - Lower noise levels
 - less vibration
 - improved oil management
- Availability of CO₂ compressors for different commercial and industrial applications
 - However, the compressors with higher cooling capacities and high resistance to dynamic loads are needed for marine/fishing vessels
- Semi-hermetic reciprocating CO₂ compressor: the dominant compressor type
- Higher capacities and displacements with open type screw and reciprocating compressors

MYCOM compressors

J series screw compressors



- Open type screw compressors for subcritical applications
- 9 different models
- Cooling capacity of around **3800 kW** (-50/-10 °C)
- Displacement from **390 to 3839 m³/h**

MYCOM compressors

J series screw compressors

Item		Model (N/C/P/F) ¹		170J			220J			280J		
		S-V	M-V	L-V	S-V	M-V	L-V	S-V	M-V	L-V		
Refrigerant		Ammonia / CO ₂ / Propane, Propylene / HFCs										
Theoretical displacement	2950rpm	m ³ /h	390	507	659	856	1114	1447	1886	2451	3190	
	3550rpm	m ³ /h	469	610	793	1030	1340	1741	2269	2949	3839	
Minimum rotation speed		rpm	1450 ^{±2}									
Maximum rotation speed		rpm	4500 ^{±2}									

Model	Weight (kg)
170JS-V ^{*1}	875
170JM-V ^{*1}	905
170JL-V ^{*1}	950
220JS-V ^{*1}	1500
220JM-V ^{*1}	1560
220JL-V ^{*1}	1630
280JS-V ^{*2}	2300
280JM-V ^{*2}	2450
280JL-V ^{*2}	2600

Refrigerant		Ammonia		CO ₂
		-40 / +35°C	-10 / +35°C	-50 / -10°C
Model	Temperature condition	Liquid Subcooling: 5°C Suction Superheat: 0°C Rotation speed: 2950rpm Economizer-type		Liquid Subcooling: 0°C Suction Superheat: 0°C Rotation speed: 50rpm
170JS-V	Cooling capacity (kW)	74.5	258.7	416.7
	Absorbed power (kW)	50.3	55.7	139.6
170JM-V	Cooling capacity (kW)	96.4	335.8	540.7
	Absorbed power (kW)	63.4	84.9	182.9
170JL-V	Cooling capacity (kW)	125.9	437.5	704.3
	Absorbed power (kW)	81.1	109.1	236.7
220JS-V	Cooling capacity (kW)	177.3	595.3	987.7
	Absorbed power (kW)	116.3	152.1	333.6
220JM-V	Cooling capacity (kW)	230.3	772.3	1280.8
	Absorbed power (kW)	147.2	192.6	424.9
220JL-V	Cooling capacity (kW)	301.4	1009.3	1673.1
	Absorbed power (kW)	189.5	246.5	544.3
280JS-V	Cooling capacity (kW)	419.5	1359.0	2237.4
	Absorbed power (kW)	254.2	330.1	725.4
280JM-V	Cooling capacity (kW)	544.1	1761.6	2900.3
	Absorbed power (kW)	317.1	413.6	918.7
280JL-V	Cooling capacity (kW)	709.0	2293.7	3776.2
	Absorbed power (kW)	397.3	519.4	1162.9

SABROE compressors



Sabroe HPO/HPC/HPX high-pressure reciprocating compressor units



HPC 108 single-stage reciprocating compressor unit (50 bar) with UniSAB systems controller

- Open type reciprocating compressors for subcritical applications
- 13 different models
- Cooling capacity of **856 kW** (-50/-10 °C)
- Displacement/swept volume of between **100 and 1,100 m³/h**

SABROE compressors

Sabroe HPO/HPC/HPX high-pressure reciprocating compressor units

Technical data												
Model	Number of cylinders	Swept volume		Nominal capacities in kW at 1800 rpm				Unit dimensions in mm			Weight excluding motor	Sound pressure level at 1800 rpm
		1500 rpm	1800 rpm	Heating R717		Cooling R717 R744						
		m ³ /h	m ³ /h	+35/+73°C	+35/+90°C	0/+55°C	-50/-10°C	L	W	H		
HPO 24	4	97	116	332	N/A	83	116	1580-1930	835	985	510	77
HPO 26	6	146	175	497	N/A	125	174	1600-1950	940	985	550	78
HPO 28	8	194	233	663	N/A	167	232	1620-1970	940	985	580	80
HPC 104 S	4	226	271	786	N/A	198	214*	2261-2865	1305	1214	1340	83
HPC 106 S	6	339	407	1177	N/A	297	321*	2286-2890	1345	1260	1580	84
HPC 108 S	8	452	543	1569	N/A	396	428*	2311-2915	1486	1247	1660	85
HPC 112 S	12	679	814	2351	N/A	594	642*	3279-3687	1525	1448	2520	86
HPC 116 S	16	905	1086	3164**	N/A	792	856*	3329-3757	1525	1448	2600	87
HPX 704	4	111	133	380	356	95	133	2261-2865	1213	1214	1220	82
HPX 706	6	166	200	570	535	143	200	2286-2890	1267	1260	1440	84
HPX 708	8	222	266	760	713	190	266	2311-2915	1278	1260	1510	85
HPX 712	12	333	399	1140	1069	286	400	3279-3687	1345	1448	2430	86
HPX 716	16	443	532	1520	1426	381	533	3329-3737	1356	1445	2600	87

DORIN compressors



Transcritical
CD series

for industrial, civil, and commercial applications.

- Semi-hermetic reciprocating compressor
- Displacement from 1.12 to up to
 - **98.58 m³/h** (50 Hz, single stage)
 - **118.3 m³/h** (60 Hz, single stage)



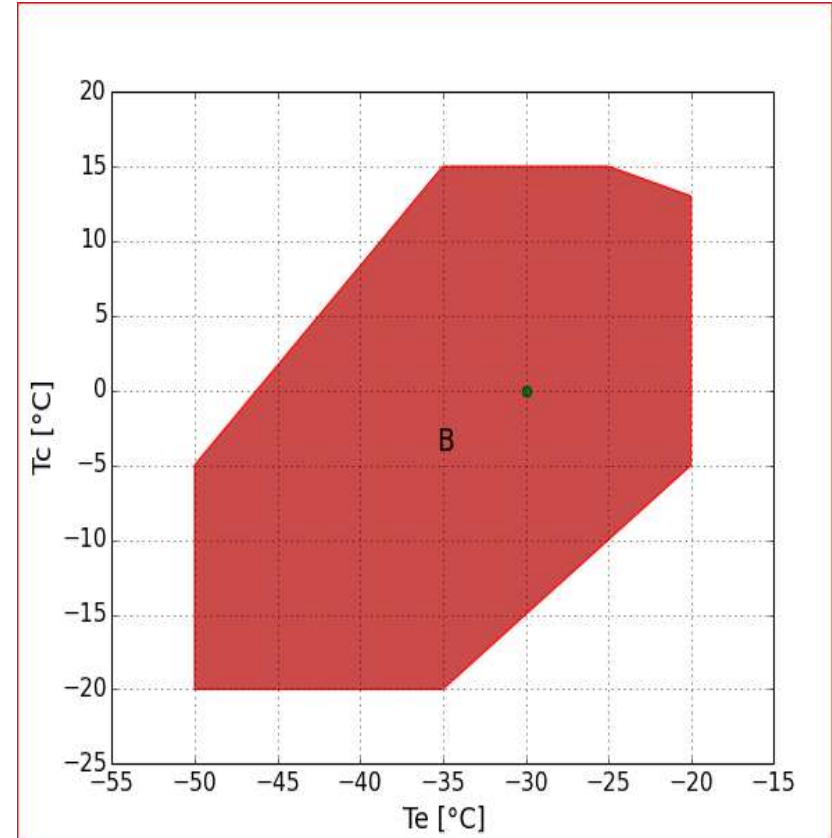
Subcritical
CDS Series

for typical cascade and booster installations.

- Semi-hermetic reciprocating compressor
- Displacement from 1.9 to
 - **91 m³/h** (50 Hz)
 - **109.2 m³/h** (60 Hz)

DORIN: subcritical (CDS series)

RANGE	MODEL MODELLO	DISPLACEMENT Spostamento volumetrico		CYLINDERS CILINDRI	OIL CHARGE CARICA OLIO	SUCTION ASPIRAZIONE	DISCHARGE SCARICO	NET WEIGHT PESO NETTO
		50 Hz [m³/h]	60 Hz [m³/h]					
CDS11	CDS101B	1,90	2,28	2	1,0	16s	14s	42
	CDS151B	2,53	3,04	2	1,0	16s	14s	43
	CDS181B	3,48	4,18	2	1,0	16s	14s	44
	CDS301B	4,34	5,21	2	1,0	16s	14s	46
	CDS351B	5,53	6,64	2	1,0	16s	14s	48
	CDS381B	6,75	8,10	2	1,0	16s	16s	49
	CDS401B	8,20	9,84	2	1,0	16s	16s	49
CDS35	CDS501B	10,61	12,73	4	2,0	22s	18s	99
	CDS701B	13,50	16,20	4	2,0	22s	18s	99
	CDS751B	16,19	19,43	4	2,0	22s	18s	99
	CDS901B	19,13	22,96	4	2,0	28s	22s	109
	CDS1201B	22,32	26,78	4	2,0	28s	22s	110
CDS41	CDS1501B	29,49	35,39	4	2,5	35s	28s	138
	CDS2001B	33,63	40,36	4	2,5	42s	28s	144
	CDS2401B	42,81	51,37	4	2,5	42s	28s	141
	CDS2501B	48,82	58,58	4	2,5	42s	28s	146
	CDS3001B	48,82	58,58	4	2,5	42s	28s	160
CDS7	CDS6001B	91,00	109,20	8	8,5	66s	54s	346



DORIN: transcritical (CD series)

Model	Displacement (m ³ /h)		Weight (kg)	Model	Displacement (m ³ /h)		Weight (kg)
	50	60			50	60	
CD6 501-40B	39.85	47.82	415	CD6 801-53M	53.21	63.85	460
CD6 601-40M	39.85	47.82	425	CD6 901-53H	53.21	63.85	445
CD6 701-40H	39.85	47.82	448	CD6 601-59B	59.53	71.44	428
CD6 501-45B	45.34	54.41	422	CD6 901-59M	59.53	71.44	452
CD6 701-45M	45.34	54.41	448	CD6 701-65B	64.49	77.39	444
CD6 801-45H	45.34	54.41	460	CD6 801-82B	81.95	98.34	456
CD6 501-53B	53.21	63.85	422	CD6 801-99B	98.58	118.3	476

BOCK compressors



HG CO2 T compressors transcritical



HG CO2 T compressors subcritical

for supermarkets, commercial, industrial refrigeration and heat pumps.

- Gas-cooled semi-hermetic reciprocating compressor
- Displacement from 4.8 to 39.5 m³/h (50 Hz)
- Higher efficiency with LSPM (Line Start Permanent Magnet) : EER/COP of 2.04 (50 Hz [1500 rpm], evaporating -10°C, gas cooler outlet 35°C/90 bar, superheat 10 K)

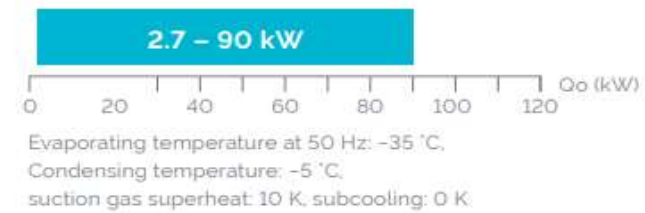
cascade and booster systems in supermarket, commercial and industrial cooling applications.

- Gas-cooled semi-hermetic reciprocating compressor
- Displacement from 1.6 to 49.2 m³/h (50 Hz)
- Designed for subcritical CO₂:
High efficiency at low temperature applications ($t_o < -15$ °C)

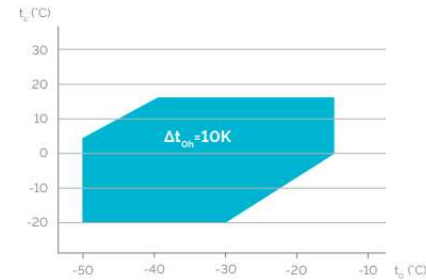
BOCK: subcritical

Model	Displacement (m ³ /h)	Weight (kg)
HGX44e-565-4-S	49.2	201
HGX44e-475-4-S	41.3	200
HGX44e-390-4-S	34.2	203
HGX44e-320-4-S	27.7	197
HGX34e-255-4-S	22.3	104
HGX34e-210-4-S	18.4	102

Cooling capacity

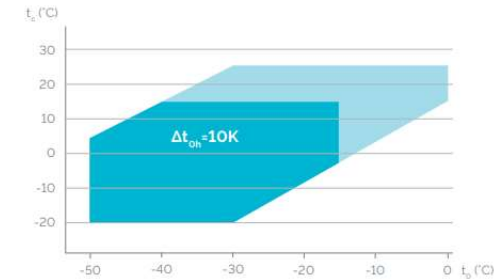


Operating limits HG CO₂ (subcritical)



Max. permissible operating pressure (LP/HP):
40/55 bar HGX12e CO₂, HGX22e CO₂ & HGX34e CO₂
resp. 30/55 bar HGX44e CO₂

Operating limits HG CO₂ LT



Max. permissible operating pressure (LP/HP): 100/100 bar
● compressor version ML ○ compressor version S

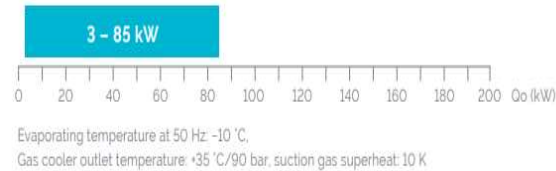
* For higher capacities in low temperature applications with standstill pressures up to LP 100 bar, the HGX34 CO₂ T and HGX46 CO₂ T are available in the ML version with 12 displacement stages.

BOCK: transcritical

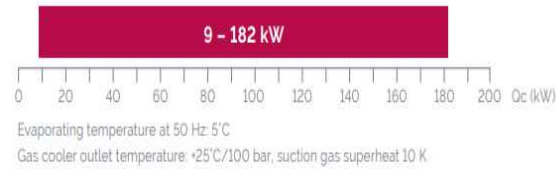
Model	Displacement (m ³ /h) 50/60 Hz		Weight (kg)
HGX46/440-4 ML	38.2	45.8	242
HGX46/345-4 S/SH/ML	30.2	36.2	242
HGX46/310-4 S/SH/ML	27.2	32.6	240
HGX46/290-4 S/SH/ML	25.5	30.6	218
HGX46/280-4 S/SH/ML	24.4	29.3	240
HGX34/280-4 S/SH/ML	20.1	24.1	213

With LSPM motors

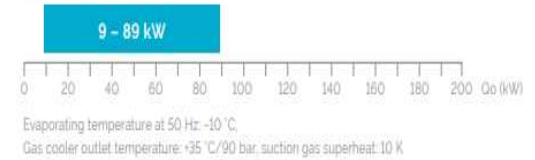
Cooling capacity



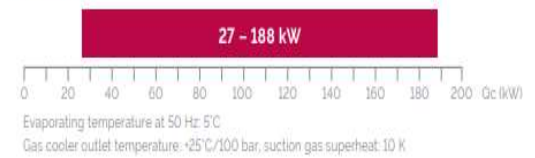
Heating capacity



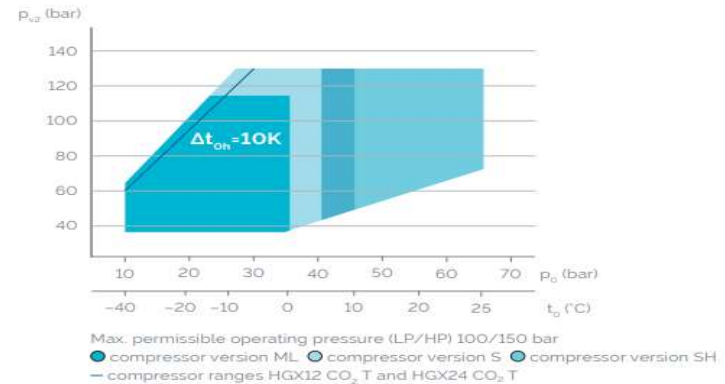
Cooling capacity



Heating capacity

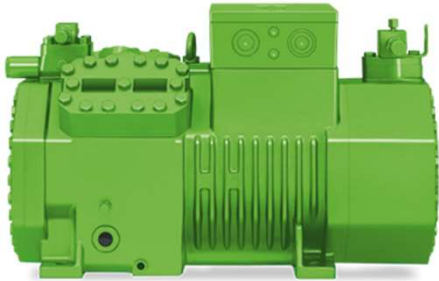


Operating limits



BITZER compressors

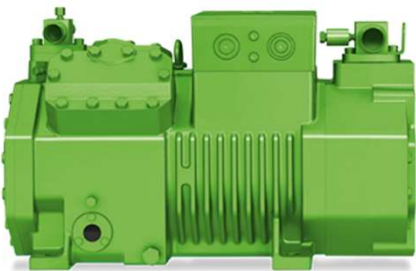
Transcritical



applications for supermarkets, commercial, industrial refrigeration and heat pumps.

- Gas-cooled semi-hermetic reciprocating compressor
- Displacement from 3.3 to 38.2 m³/h (50 Hz)
- Higher efficiency with LSPM (Line Start Permanent Magnet)

Subcritical



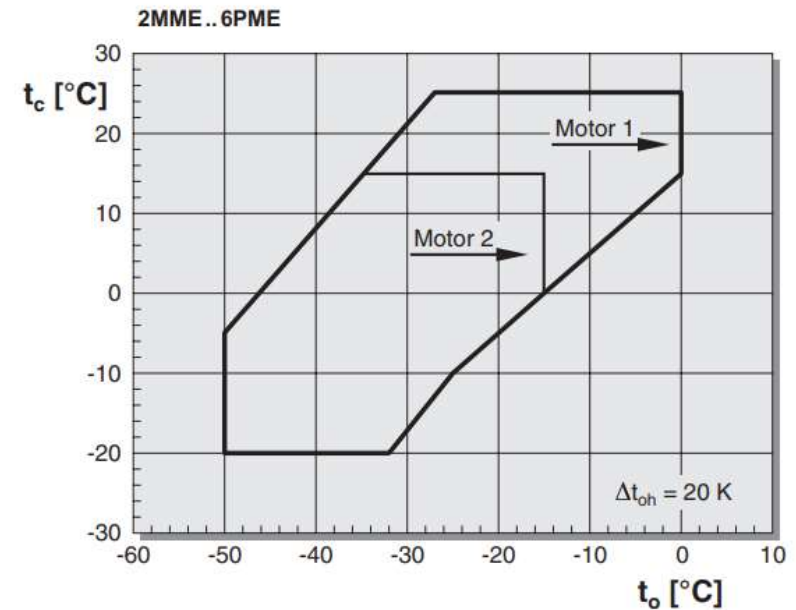
New ME series with high standstill pressure based on SL-series

- Gas-cooled semi-hermetic reciprocating compressor
- Displacement from 1.33 to 64.9 m³/h (50 Hz)

BITZER: largest subcritical

Model	Displacement (m ³ /h)	Weight (kg)
6PME-40K	64.94	237
6TME-35K	54.57	232

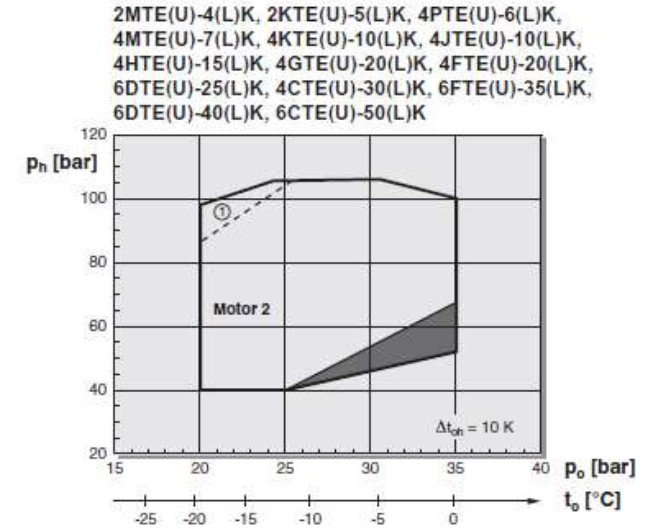
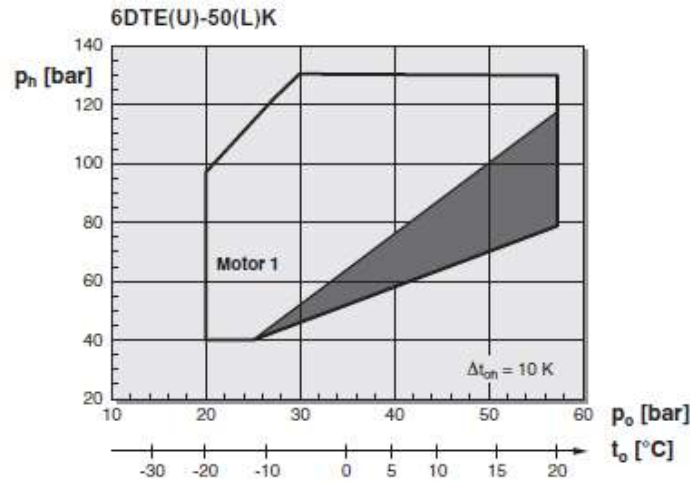
- Bitzer is working on a new eight-cylinder compressor with a displacement of 200 m³/h.
- It will be equipped with internal capacity control with internal bypassing.



t_o Evaporating temperature (°C)
 t_c Condensing temperature (°C)
 Δt_{oh} Suction superheat (K)

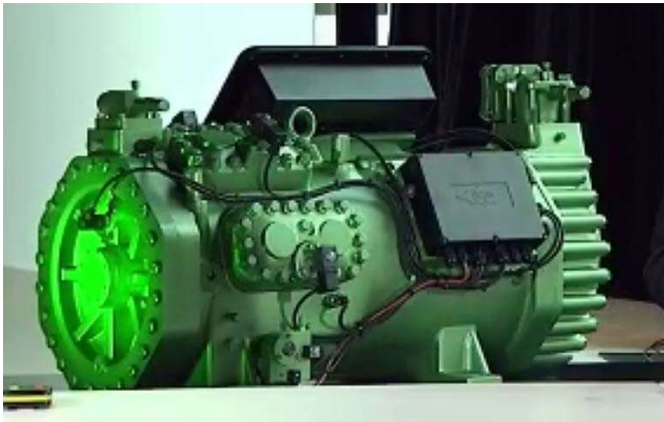
BITZER: transcritical

Model	Displacement (m ³ /h)	Weight (kg)
6CTE-50K	38.2	241
6DTE-50K	30.3	242
6DTE-40K	30.3	238
6FTE-50K	26.1	243
6FTE-35K	26.1	233



- t_o Evaporating temperature (°C)
- Δt_{oh} Suction superheat (K)
- p_o Suction pressure abs. (bar)
- p_h High pressure abs. (bar)
- ① Range with limitations for the compressors 4PTEU

BITZER : largest transcritical



- [Bitzer](#) is working on a new eight-cylinder compressor with a displacement of 99.2 m³/h.
- Released date: July/August 2023

- [Bitzer CKHE7](#) with a 140hp eight-cylinder compressor has a displacement of 99.2m³/hr, which is around 2.5x larger than currently available models.
- Announced at the Chillventa eSpecial online exhibition
- Designed for large commercial and light industrial applications, as well as heat pumps, the compressor is equipped with mechanical capacity unloading and offers a wide speed range for inverter drives

Summary

RP: reciprocating
SHRP: semi-hermetic reciprocating
S: subcritical
T: transcritical

Brand	Operating condition	Type	Displacement [m ³ /h] 50/60 Hz		Weight (kg)	Max cooling capacity [kW]
MYCOM	S	Open Screw	3190	3839	2600	3776.2 (-50/-10 °C)
SABROE	S	Open RP	905	1086	2600 (exc motor)	856 (-50/-10 °C)
DORIN	T	SHRP	98.58	118.3	476	-
	S	SHRP	91	109.2	346	-
BOCK	T	SHRP	38.2		242	89
	S	SHRP	49		201	90
BITZER	T	SHRP	99.2		-	-
	S	SHRP	64.94		237	122 (-35/-5 °C)

Questions

