



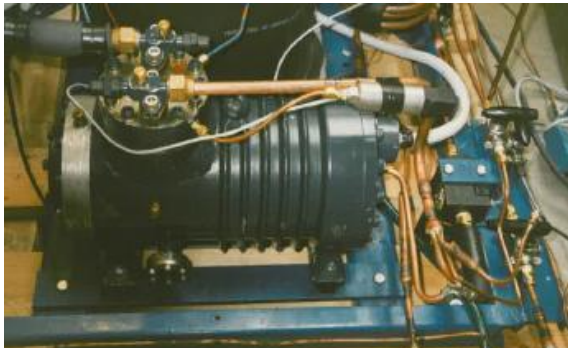
ATMO
sphere
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natural refrigerants

**CO₂ DOUBLE STAGE
TRANS-CRITICAL COMPRESSORS:
MAKING CO₂ EQUIPMENTS
RELIABLE, AFFORDABLE AND MORE
EFFICIENT**

SUMMARY

1. **CO₂ COMPRESSORS: STATE OF THE ART**
2. **DOUBLE STAGE CO₂ COMPRESSORS**
3. **APPLICATIONS & BENEFIT**
4. **SYSTEMS EXAMPLES**
5. **CONCLUSIONS**

1. CO₂ COMPRESSORS: STATE OF THE ART



1996

1ST CO₂ TRANS-CRITICAL COMPRESSORS TO SINTEF, NORWAY

➔ OBJECTIVE: VALIDATE BEHAVIOUR OF FLOATING HEAD PRESSURE

2013

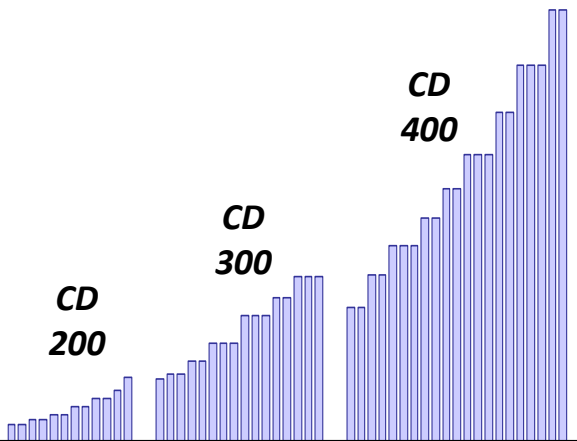
➔ LARGEST CO₂ TRANS-CRITICAL COMPRESSOR RANGE AVAILABLE

➔ DISPLACEMENT FROM 1.30 m³/h TO 36.6 m³/h (@ 60Hz)

➔ NOMINAL MOTOR POWER FROM 1.8 hp TO 60 hp

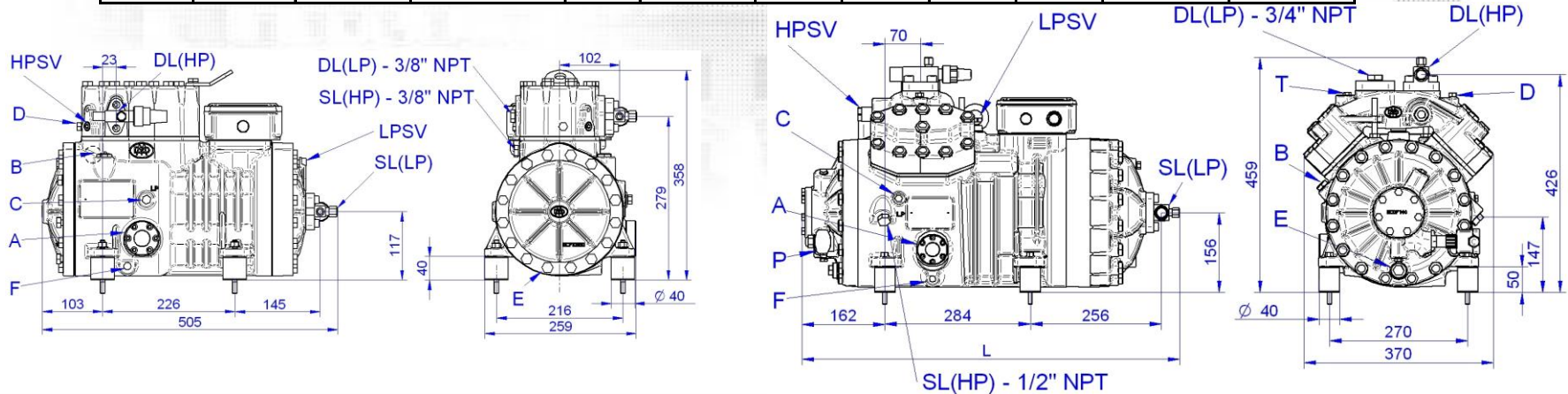
➔ MORE THAN 50.000.000,00 hrs ACCUMULATED RUN TIME

➔ UL RECOGNITION FOR CD-400 RANGE

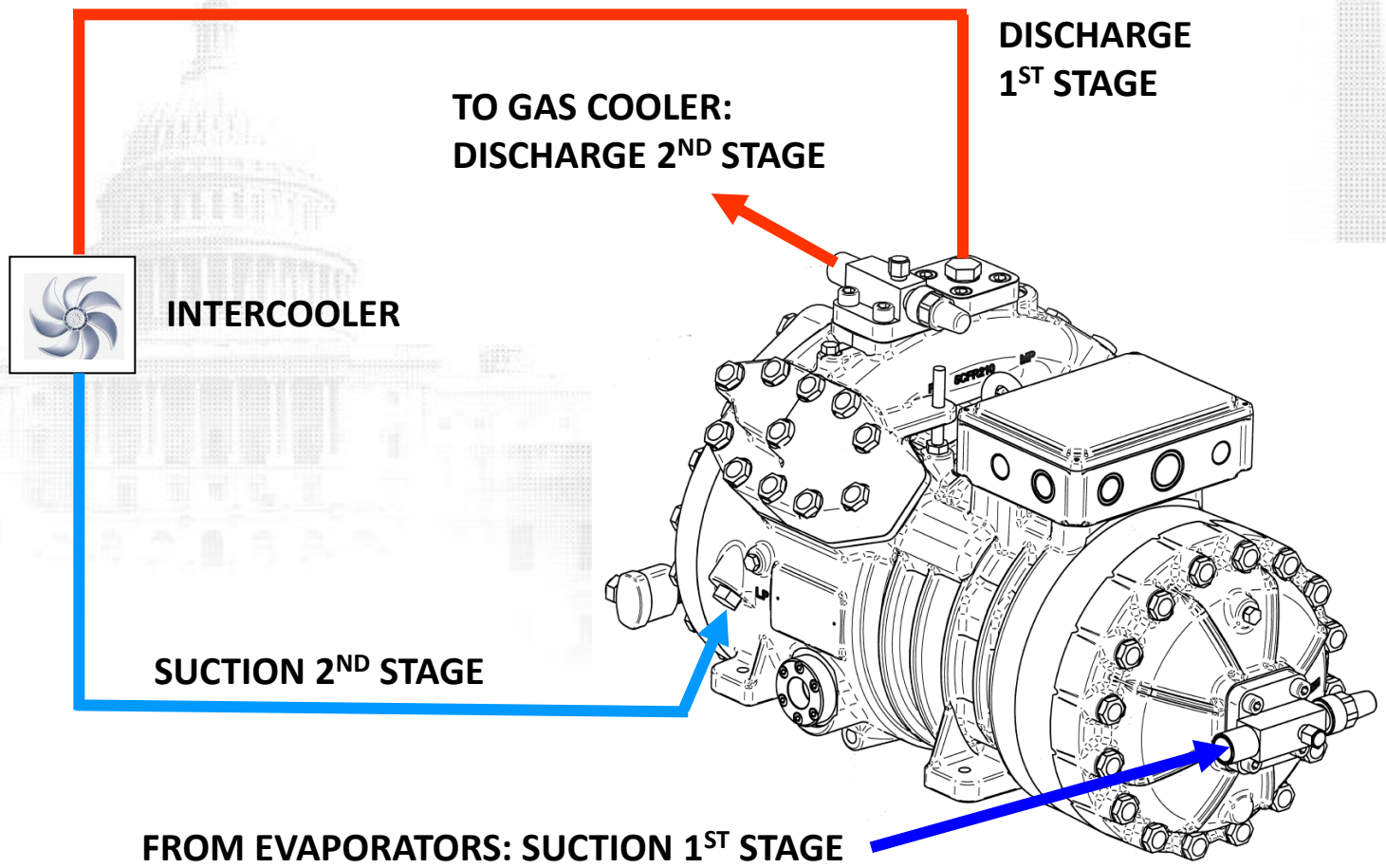


2. DOUBLE STAGE CO₂ COMPRESSORS

SERIE RANGE	MODELLO MODEL	CILINDRI CYLINDERS	VOLUME SPOSTATO DISPLACEMENT [m ³ /h] @ 50 Hz	HP	RPM @ 50 Hz	SUCTION SERVICE VALVE		DISCHARGE SERVICE VALVE		PESO NETTO NET WEIGHT [kg]	CARICA OLIO OIL CHARGE [kg]
						socket welding [mm]	butt welding [mm]	socket welding [mm]	butt welding [mm]		
CD2S200	CD2S300	2 + 1	1,45 + 0,57	3,0	1450	10	14	10	14	75	1,3
	CD2S350	2 + 1	1,82 + 0,57	3,5	1450	10	14	10	14	78	1,3
	CD2S360	2 + 1	2,36 + 0,73	3,8	1450	10	14	10	14	80	1,3
CD2S400	CD2S1200	2 + 2	6,00 + 4,50	12	1450	22	28	22	28	163	2,5
	CD2S1500	2 + 2	7,71 + 5,06	15	1450	22	28	22	28	167	2,5
	CD2S2000	2 + 2	8,92 + 5,85	20	1450	22	28	22	28	171	2,5
	CD2S2500	2 + 2	11,65 + 6,92	25	1450	22	28	22	28	175	2,5
	CD2S3000	2 + 2	13,22 + 7,86	30	1450	22	28	22	28	182	2,5
	CD2S3500	2 + 2	15,11 + 8,98	35	1450	22	28	22	28	191	2,5



2. DOUBLE STAGE CO₂ COMPRESSORS LAYOUT



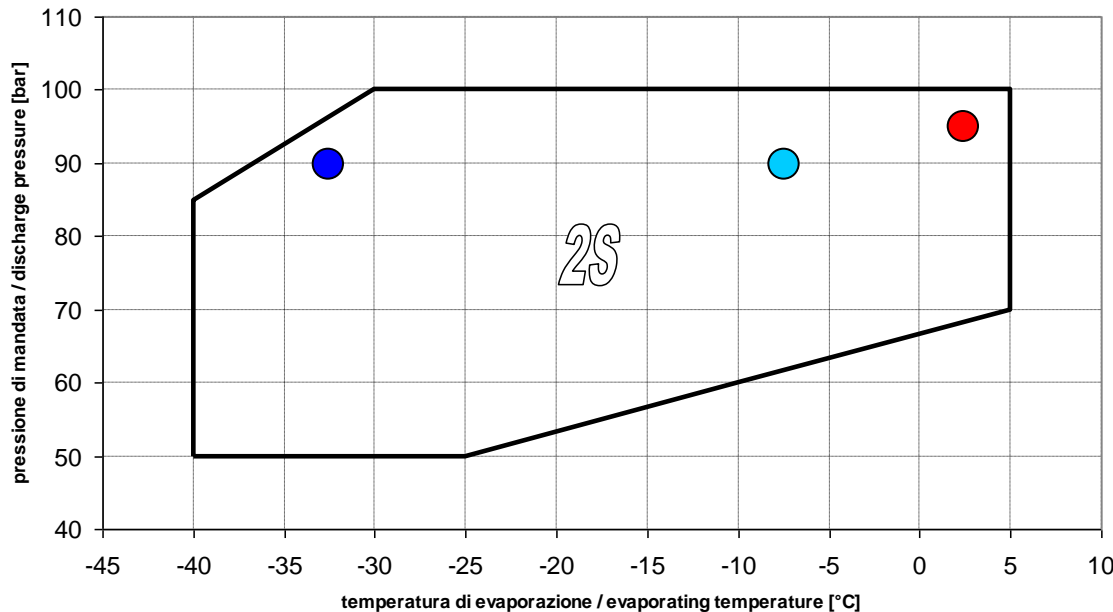
2. DOUBLE STAGE CO₂ COMPRESSORS

→ P_{ss} = 100 bar - P_S = 160 bar

→ WIDE APPLICATION ENVELOPE

→ FREQUENCY CONTROL BETWEEN 50Hz and 80Hz (WITH 460V – 3ph – 60Hz motor)

Diagramma di applicazione / Application envelope



● LT OPERATION

● HT OPERATION

● HP OPERATION

PRODUCT LAUNCH:

→ OCTOBER 2012

NUMBER OF RUNNING COMPRESSORS:

→ MORE THAN 100 pcs

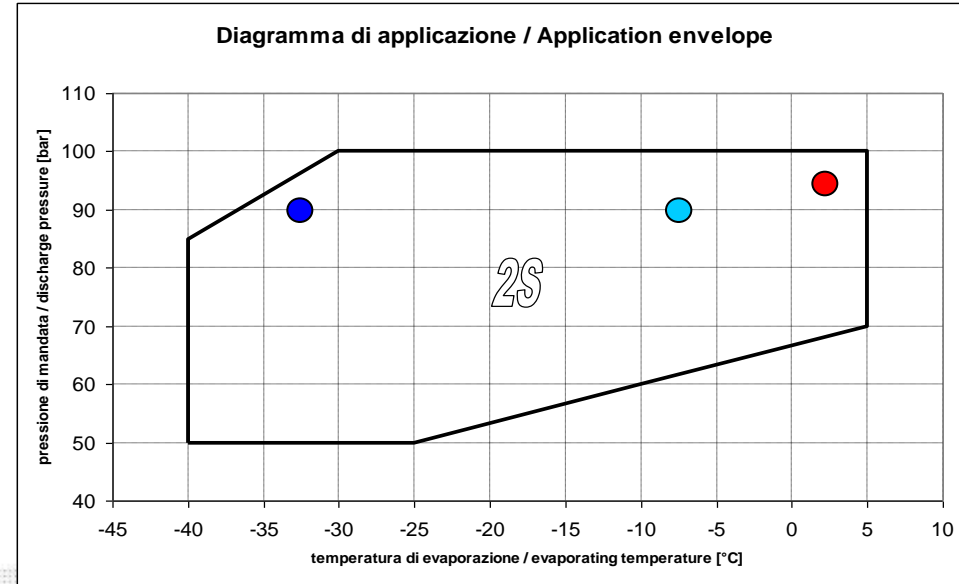
3. APPLICATIONS & BENEFIT

● LT OPERATION

- ➔ SEPARATED HT AND LT PACKS, LESS RISKS
- ➔ FLOATING HEAD PRESSURE DEPENDING ON AMBIENT TEMPERATURE
- ➔ HIGH STANDSTILL PRESSURE ($P_{ss} = 100$ bar)
- ➔ VERY GOOD OPTION FOR LT ONLY SYSTEMS

● HP OPERATION

- ➔ CAPABLE TO WORK UP TO 80Hz
- ➔ CAPACITY LOSS DUE TO LOWER EVAPORATING TEMPERATURES ARE BALANCED BY FREQUENCY INCREASE



4. SYSTEMS EXAMPLES

→ COMPARISON IS MADE BETWEEN TWO DIFFERENT CONFIGURATIONS:

A. TYPICAL BOOSTER RACK (HT + LT IN THE SAME PACKAGE)

A.1: LARGE RETAIL INSTALLATION

A.2: CONVENIENCE STORE

A.3: LT STORAGE, LT ONLY RACK

B. SINGLE AND DOUBLE STAGE COMPRESSORS

B.1: LARGE RETAIL INSTALLATION: HT ONLY RACK + LT CONDENSING UNITS

B.2: CONVENIENCE STORE: HT ONLY RACK + LT CONDENSING UNITS

B.3: LT STORAGE, LT ONLY RACK

→ CAPITAL & RUNNING COSTS ARE COMPARED FOR THE VARIOUS OPTIONS

4. SYSTEMS EXAMPLES

LARGE RETAIL INSTALLATION

HT: MEDIUM TEMPERATURE LOAD (kW)	180.00		
LT: LOW TEMPERATURE LOAD (kW)	30.00		
SOLUTION A1: BOOSTER SYSTEM			
HT: HIGH TEMPERATURE	N.4 CD 3500 M	26.7 m ³ /h each	
LT: LOW TEMPERATURE	N.3 CD 750 B	8.47 m ³ /h each	
TOTAL ESTIMATED COST [US \$]	125,000.00		
@-35°C / -10°C / 35°C Tgcout / 90 bar			
TOTAL POWER CONSUMPTION [kW]	137.50		
@-35°C / -10°C / 15°C Tcond			
TOTAL POWER CONSUMPTION [kW]	54.00		
SOLUTION B1: n.2 CONDENSING UNITS + n.1 HT ONLY RACK			
HT: HIGH TEMPERATURE	N.4 CD 3000 M	20.2 m ³ /h each	
LT: LOW TEMPERATURE	N.2 CD 2S 3500	15.11 m ³ /h each	
TOTAL ESTIMATED COST [US \$]	140,000.00		
@-35°C / -10°C / 35°C Tgcout / 90 bar			
TOTAL POWER CONSUMPTION	133.00		
@-35°C / -10°C / 15°C Tcond			
TOTAL POWER CONSUMPTION [kW]	53.50		
SOLUTION B1	HIGHER CAPITAL COST		
	\$ 1,700.00 SAVINGS PER YEAR		

LARGE RETAIL

DOUBLE STAGE TECHNOLOGY IS NOT PROVIDING CAPITAL COST REDUCTION

DOUBLE STAGE TECHNOLOGY PROVIDES SOME ENERGY SAVINGS

CALCULATION ESTIMATED ON: COST FOR OFF-THE-SHELF-EQUIPMENT - PHILADELPHIA WEATHER PROFILE - 0.20 \$ / kWh

4. SYSTEMS EXAMPLES

CONVENIENCE STORE

HT: MEDIUM TEMPERATURE LOAD (kW)	30.00
LT: LOW TEMPERATURE LOAD (kW)	4.00

SOLUTION A2: BOOSTER SYSTEM

HT: HIGH TEMPERATURE	N.3 CD 1000 M	6.92 m3/h each
LT: LOW TEMPERATURE	N.2 CD 180 M	1.89 m3/h each

TOTAL ESTIMATED COST [US \$] 95,000.00

@-35°C / -10°C / 35°C Tgcout / 90 bar

TOTAL POWER CONSUMPTION [kW] 24.20

@-35°C / -10°C / 15°C Tcond

TOTAL POWER CONSUMPTION [kW] 8.60

SOLUTION B2: n.2 CONDENSING UNITS + n.1 HT ONLY RACK

HT: HIGH TEMPERATURE	N.3 CD 700 M	4.74 m3/h each
LT: LOW TEMPERATURE	N.2 CD 2S 360	2.36 m3/h each

TOTAL ESTIMATED COST [US \$] 95,000.00

@-35°C / -10°C / 35°C Tgcout / 90 bar

TOTAL POWER CONSUMPTION [kW] 20.50

@-35°C / -10°C / 15°C Tcond

TOTAL POWER CONSUMPTION [kW] 8.40

**SOLUTION B2 SAME CAPITAL COST
 \$ 5,000.00 SAVINGS PER YEAR**

CONVENIENCE STORE

**DOUBLE STAGE TECHNOLOGY PROVIDES
 SAME CAPITAL COSTS**

**DOUBLE STAGE TECHNOLOGY PROVIDES
 MORE INTERESTING ENERGY SAVINGS**

CALCULATION ESTIMATED ON: COST FOR OFF-THE-SHELF-EQUIPMENT - PHILADELPHIA WEATHER PROFILE - 0.20 \$ / kWh

4. SYSTEMS EXAMPLES

LT STORAGE

HT: MEDIUM TEMPERATURE LOAD (kW)	0.00
LT: LOW TEMPERATURE LOAD (kW)	75.00

SOLUTION A3: BOOSTER SYSTEM

HT: HIGH TEMPERATURE	N.3 CD 3000 H	17.84 m ³ /h each
LT: LOW TEMPERATURE	N.3 CD 1200 B	13.84 m ³ /h each

TOTAL ESTIMATED COST [US \$] 130,000.00

@-35°C / -10°C / 35°C Tgcut / 90 bar

TOTAL POWER CONSUMPTION [kW] 80.00

@-35°C / -10°C / 15°C Tcond

TOTAL POWER CONSUMPTION [kW] 40.00

SOLUTION B3: LT ONLY RACK

HT: HIGH TEMPERATURE	NONE	
LT: LOW TEMPERATURE	N.5 CD 2S 3500	15.11 m ³ /h each

TOTAL ESTIMATED COST [US \$] 115,000.00

@-35°C / -10°C / 35°C Tgcut / 90 bar

TOTAL POWER CONSUMPTION [kW] 77.00

@-35°C / -10°C / 15°C Tcond

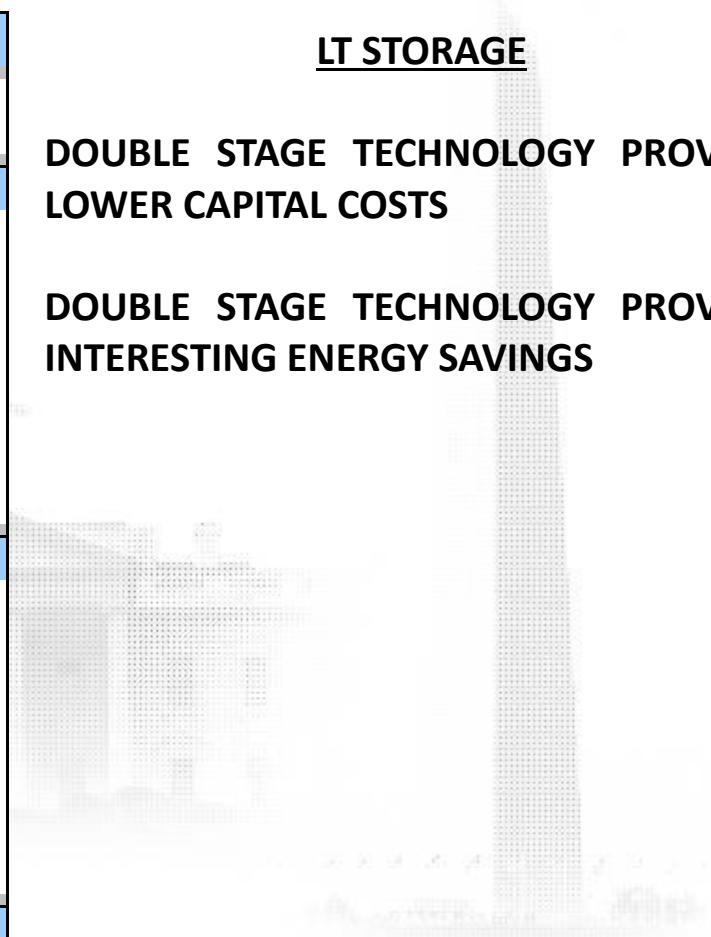
TOTAL POWER CONSUMPTION [kW] 39.00

**SOLUTION B3 LOWERCAPITAL COST
 \$2,500.00 SAVINGS PER YEAR**

LT STORAGE

DOUBLE STAGE TECHNOLOGY PROVIDES LOWER CAPITAL COSTS

DOUBLE STAGE TECHNOLOGY PROVIDES INTERESTING ENERGY SAVINGS



CALCULATION ESTIMATED ON: COST FOR OFF-THE-SHELF-EQUIPMENT - PHILADELPHIA WEATHER PROFILE - 0.20 \$ / kWh

5. CONCLUSIONS

- ➔ **A NEW RANGE OF 2-STAGE TRANS-CRITICAL CO₂ COMPRESSORS IS PRESENTED**
- ➔ **THE NEW RANGE FEATURES WIDE OPERATING ENVELOPE BEING SUITABLE FOR MANY APPLICATIONS**
- ➔ **2 STAGE TECHNOLOGY ALLOWS FOR SEVERAL ADVANTAGES**
 - **SPLIT LT and HT SYSTEMS IN TYPICAL RACKS APPLICATIONS - LESS RISKS**
 - **GET THE ADVANTAGE OF FLOATING HEAD PRESSURE ALSO FOR LT UNITS**
 - **HEAT PUMP OPERATION FOR LT AMBIENTS THANKS TO HIGH MAX SPEED**
- ➔ **A COMPARISON BETWEEN VARIOUS INSTALLATION KINDS IS MADE**
 - **2-STAGE COMPRESSORS OFFER INTERESTING SOLUTIONS TO DECREASE SUPERMARKETS CAPITAL and RUNNING COSTS**



THANK YOU !