



(ENG) Solutions for CO₂ retail applications

Content

1. WHY USE CO₂ AS A REFRIGERANT?	5
1.1 Thermodynamic properties.....	5
1.2 Subcritical cycle.....	5
1.3 Transcritical cycle.....	5
2. SUBCRITICAL CO₂ CASCADE	7
2.1 CAREL solution	7
2.2 System features	10
2.2.1 DSS: Double system synchronization	10
2.2.2 EEVS: Electronic Expansion Valve Synchronization.....	10
3. TRANSCRITICAL CO₂ BOOSTER	12
3.1 CAREL solution	13
3.2 System features	15
3.2.1 DSS: Double system synchronization	16
3.3 Transcritical CO ₂ condensing units.....	16
4. SUBCRITICAL CO₂: PUMPED	18
3.4 CAREL solution	18
5. COMMON COMPONENTS	20



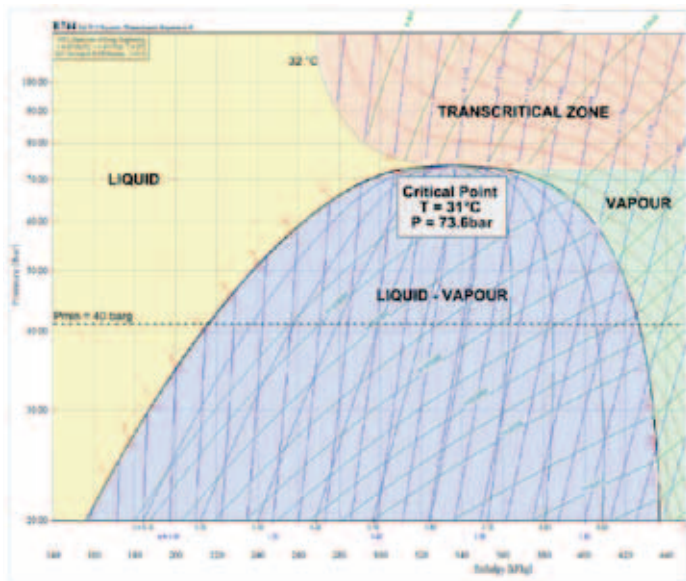
1. WHY USE CO₂ AS A REFRIGERANT?

Despite already having been utilised in the early 1900s, carbon dioxide has only become widely used as a refrigerant in recent years. This is due to increasing interest in natural fluids, as well as legislation that, especially in Europe, aims to limit the use of synthetic refrigerants.

Widely available, even as a waste product from other processes, CO₂ is much less expensive than traditional refrigerants. Together with this economic advantage are other benefits, such as low global warming potential (GWP = 1, no impact on the ozone layer), no dangers relating to toxicity or flammability, and no need to recycle the gas at the end of system life.

1.1 Thermodynamic properties

As well as the economic, political and environmental advantages listed above, CO₂ has several thermodynamic properties that in many different applications can represent advantages and allow it to compete head-to-head with traditional refrigerants.



The main difference between carbon dioxide and synthetic fluids is that the critical point is 31.1 °C, a temperature that is easily reached in many different parts of the planet. At critical point, the density of the liquid and saturated gas are the same, while at higher temperatures there is no longer a boundary between the two phases, and this is referred to as supercritical state. Consequently, pressure and temperature are no longer related, meaning measures need to be adopted to keep these under control, optimise heat exchange and maximise efficiency.

Fluid	Critical Temp. (°C)	Critical Press. (bar)	Saturation Press. (bar)		Volumetric latent heat at -20 °C (kJ/m ³)
			-20 °C	+30 °C	
CO ₂	31.06	73.84	19.7	72.1	14592
R22	96.15	49.9	2.4	11.9	2371
R134a	101.06	40.59	1.3	7.7	1444
R410a	71.36	49.03	4	18.9	3756
R404A	72.1	36.2	3.1	14.3	2820
NH ₃	132.25	113.33	1.9	11.7	2131

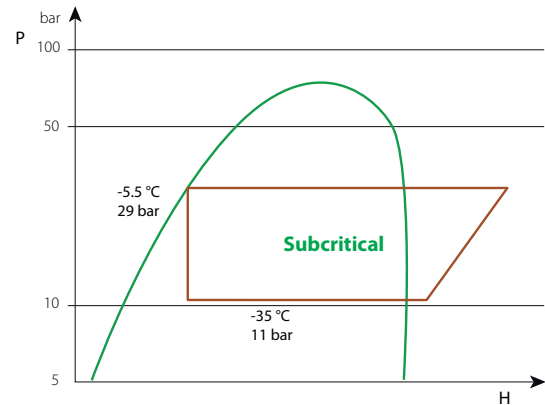
It can also be noted that operating pressures are very high, and this represents the biggest challenge for the components in the installation, such as compressors, valves and piping. Nonetheless, it should be stressed that high pressure means smaller diameter pipes can be used, and pressure drop and compression ratio are lower.

One property of CO₂ is high volumetric latent heat, giving an important advantage as concerns the heat exchangers, the number of circuits and refrigerant charge.

1.2 Subcritical cycle

The simplest application of carbon dioxide as a refrigerant is in the subcritical cycle: CO₂ is used in a secondary low temperature loop, either vapour compression (cascade system) or a pumped loop of liquid CO₂.

Subcritical refrigeration process

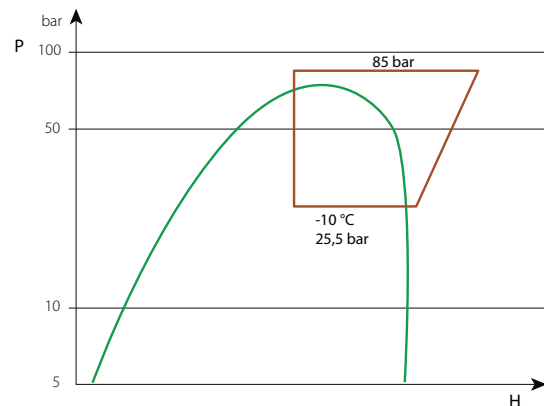


The primary cycle is managed using a traditional refrigerant, with the task of keeping condensing temperature for the CO₂ cycle below the critical point, generally between -5 and -10 °C.

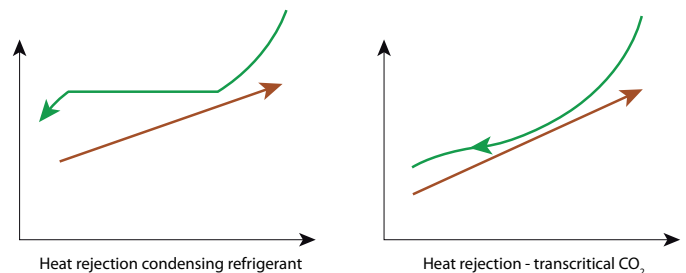
1.3 Transcritical cycle

A CO₂ cycle that exchanges heat with the outside can also be adopted. This is referred to as the transcritical cycle, as in certain periods of the year outside temperature will be near or above the critical point of 31.1 °C.

Transcritical refrigeration process



The main difference compared to a normal refrigeration cycle involves the stage in which the compressed gas is cooled, which does not correspond to constant condensing temperature as in the case of traditional cycles.



Condensation normally takes place at constant pressure, with the gas changing to the liquid phase, while in a transcritical cycle, the temperature of the supercritical gas falls constantly.

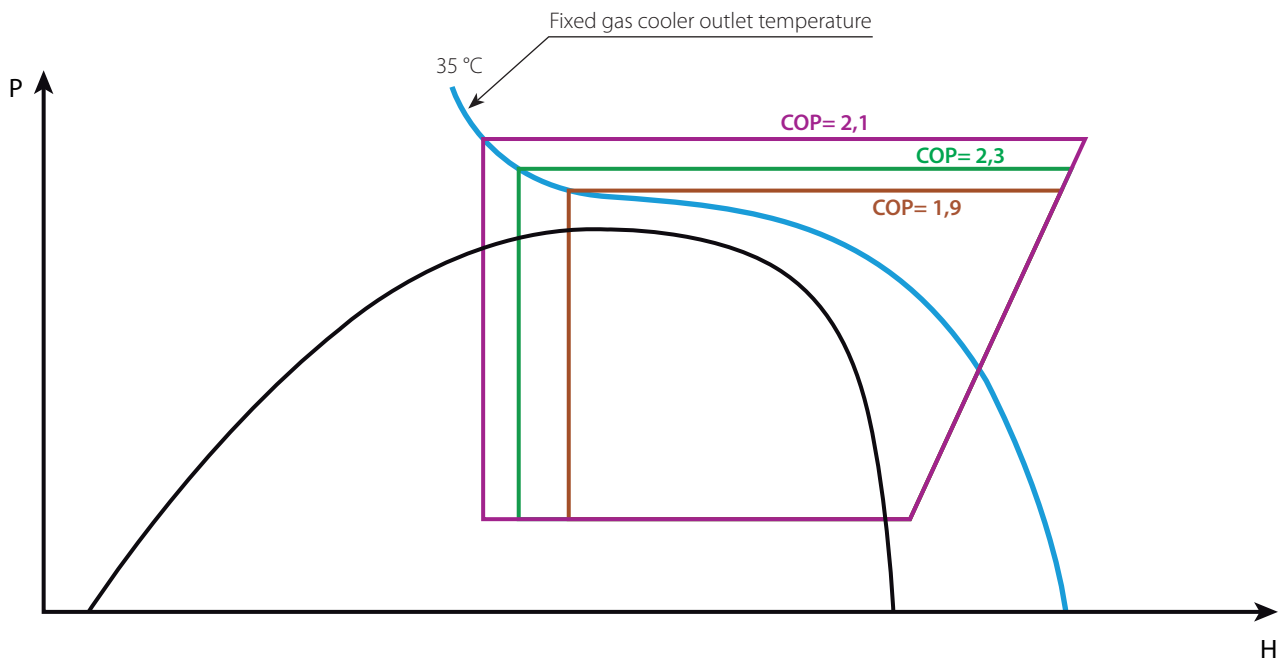
As a result, the high pressure heat exchangers used are designed differently and in fact are called gas coolers rather than condensers.

Heat exchange is assisted by this specific property of carbon dioxide, as in every phase of the cycle the two fluids are much closer in temperature than with traditional condensation. This advantage can be effectively exploited on heat pumps to achieve higher efficiency than traditional units.

As regards the efficiency of the actual cycle itself, pressure at the gas cooler outlet needs to be controlled.

Observing the p-h diagram, for a given gas cooler outlet temperature (shown in blue in the figure), different cycles can be considered based on heat exchanger pressure. It can be seen that, starting from the cycle drawn in brown and increasing the pressure, there is an increase in output (Δh_{EVAP}) that exceeds the increase in compression work (Δh_{COMP}): efficiency is therefore higher. On exceeding the cycle pressure shown in green, the increase in compression work exceeds the increase in cooling output, meaning a reduction in efficiency (cycle drawn in violet).

Therefore, for each gas cooler outlet temperature an optimum pressure can be identified that maximises cycle efficiency.

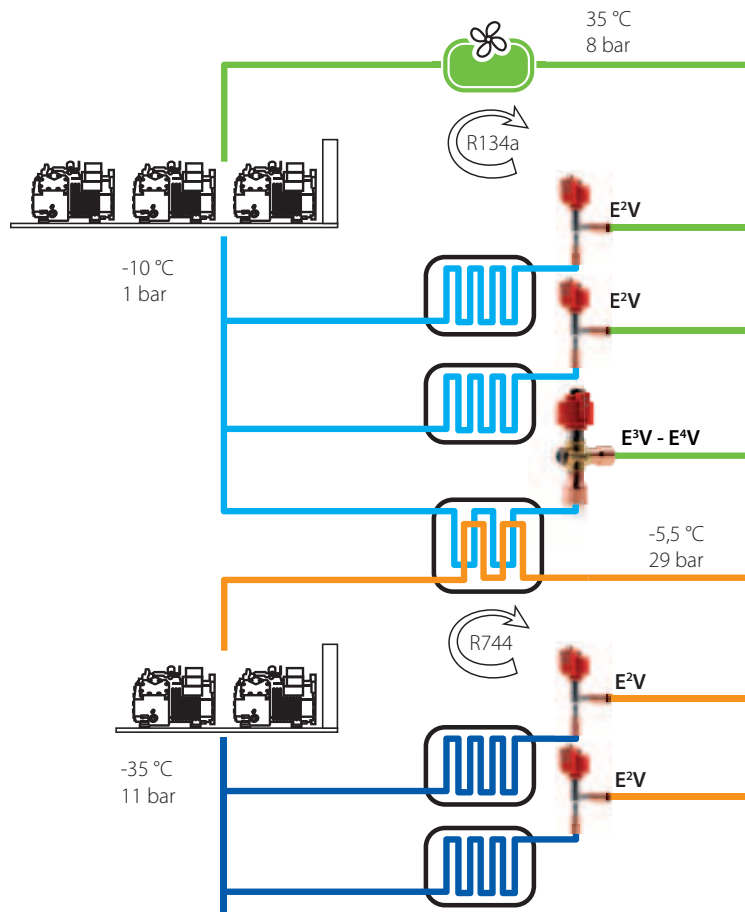


2. SUBCRITICAL CO₂ CASCADE

This solution is ideal for using a natural refrigerant in places with high average temperatures; subcritical CO₂ cascade systems are normally used in hot climates or as the first stage in using CO₂ as refrigerant.

Cascade systems comprise two circuits, one medium temperature (typically R134a, R404a or NH₃) and one low temperature (R744), connected via one or more heat exchangers, normally plate exchangers, which on one side condense the CO₂ and on the other act as normal evaporators for the medium temperature circuit.

Example of a subcritical CO₂ cascade system



PROS

- System relatively similar to a traditional installation (R404)
- Operating pressure similar to traditional systems (max 45 barg)
- Medium HFC gas content
- System efficiency better than standard HFC and can be used in all climates

CONS

- If NH₃ is not used, the installation is not completely green
- If NH₃ is used, the medium temperature compressor rack cannot be used in all countries to serve the medium temperature showcases

2.1 CAREL solution

pRack pR300: compressor rack controller

pRack pR300 manages both the medium temperature and low temperature compressor racks, with one or more controllers, depending on rack dimensions. One instrument alone can manage LT and MT compressor activation and safety (inverters, capacity control and compressors with different capacities), medium temperature condensers (EC fans, inverters, steps), any subcooling systems, synchronisation between the two systems



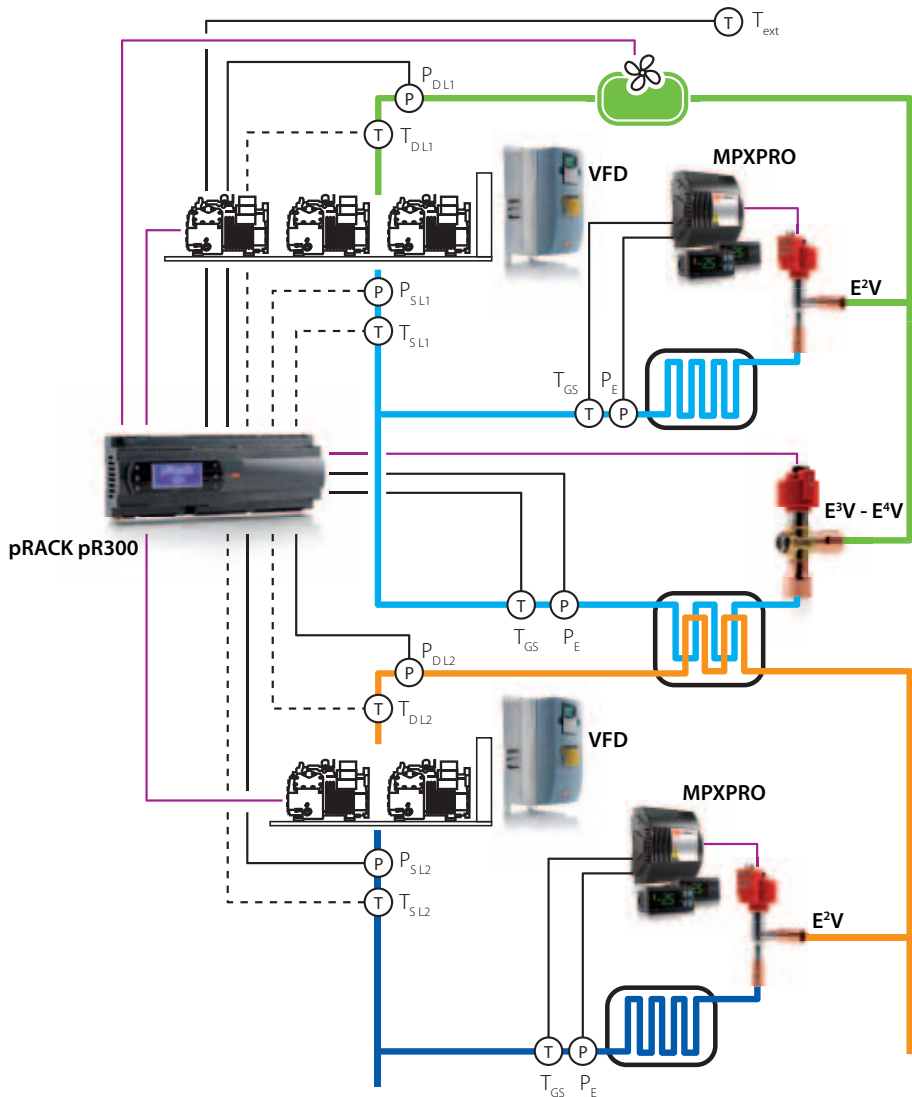
pRACK pR300



and communication with the electronic expansion valve driver on the cascade system heat exchanger.

At most two plate heat exchangers are normally used to condense the CO₂, and the expansion valve can be managed using the built-in driver on pRack pR300 or an external EVD EVO driver integrated into the system (RS485 fieldbus communication).

Control diagram with one pRack board and one built-in driver



pRack connections

symbol	description	probe type	remarks
T _{ext}	Outside temperature	NTC - HP	
P _{DL1}	Line 1 (medium temperature) discharge pressure	4-20 mA 0-18.2 barg	
T _{DL1}	Line 1 (medium temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P _{SL1}	Line 1 (medium temperature) suction pressure	4-20 mA 0-7 barg	Can be used as backup for PE
T _{SL1}	Line 1 (medium temperature) suction temperature	NTC - HF	For suction superheat control (optional)
P _E	Heat exchanger evaporation pressure	Ratiometric -1-9.3 barg	
T _{GS}	Heat exchanger superheated gas temperature	NTC - HF	
P _{DL2}	Line 2 (low temperature) discharge pressure	4-20 mA 0-44.8 barg	
T _{DL2}	Line 2 (low temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P _{SL2}	Line 2 (low temperature) suction pressure	4-20 mA 0-44.8 barg	
T _{SL2}	Line 2 (low temperature) suction temperature	NTC - HF	For suction superheat control (optional)

MPXPRO & E²V: controller for multiplexed showcases and stepper electronic expansion valve.

Given the speed of CO₂ as a refrigerant, evaporator control is essential for correct system operation. For this purpose, the CAREL E²V stepper electronic expansion valve is important to ensure system stability. Featuring ultracap technology, the MPXPRO + E²V system can guarantee complete closing in the system without using additional solenoid valves.



MPXPRO & E²V

E^xV: Electronic expansion valve

The crucial aspect of this type of installation is the cascade heat exchanger, normally a plate heat exchanger, that condenses the CO₂. Two heat exchangers are sometimes used in order to improve control at low loads and increase safety, and are normally controlled by E^xV stepper electronic expansion valves (in these applications PWM electronic valves cannot guarantee optimum performance).

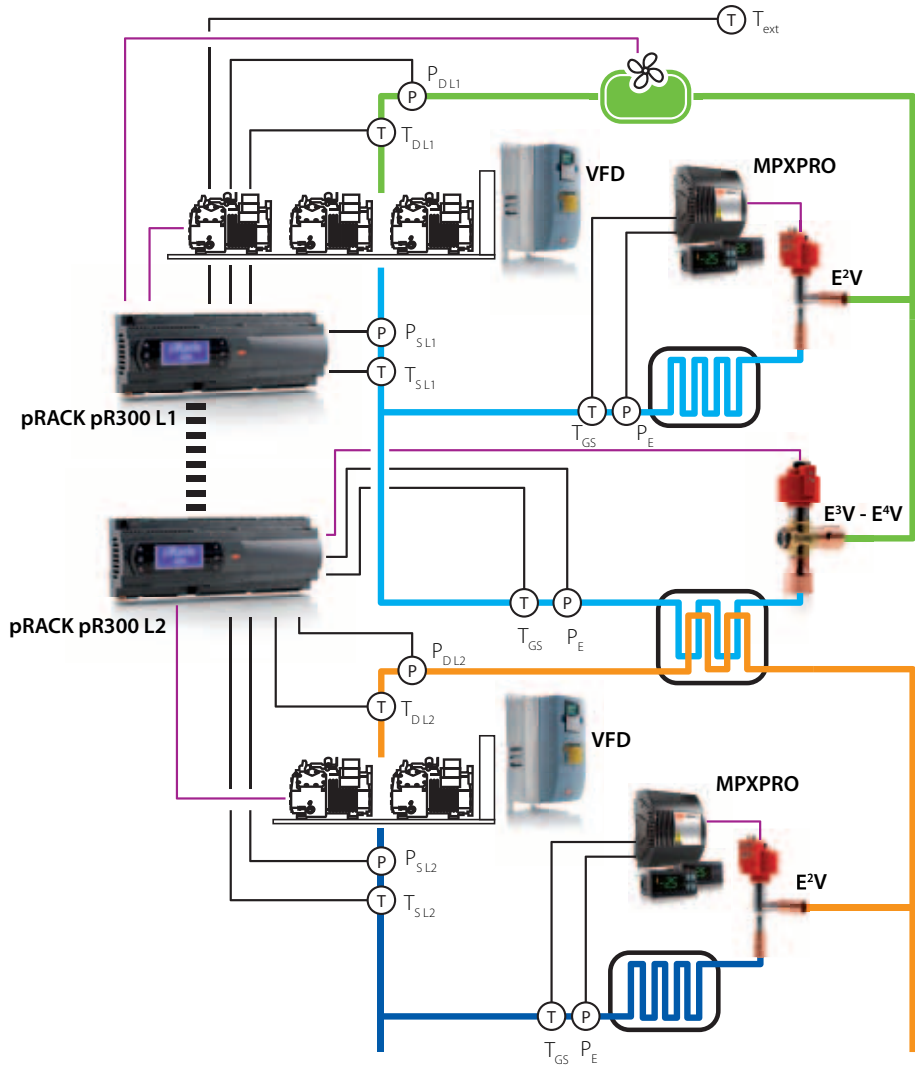
In such applications, as well as traditional suction superheat control, there is direct integration with the low temperature compressor rack if the driver is built into the controller, or via serial communication if an external EVD EVO driver is used.

Due to the nature of the refrigerant, the condensed liquid CO₂ needs to be monitored to ensure good performance



E^xV electronic expansion valves

Control diagram with two pRack boards and one built-in driver



pRack connections for L1

symbol	description	probe type	remarks
T _{ext}	Outside temperature	NTC - HP	
P _{D L1}	Line 1 (medium temperature) discharge pressure	4-20 mA 0-18.2 barg	
T _{D L1}	Line 1 (medium temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P _{S L1}	Line 1 (medium temperature) suction pressure	4-20 mA 0-7 barg	Can be used as backup for P _E
T _{S L1}	Line 1 (medium temperature) suction temperature	NTC - HF	For suction superheat control (optional)

symbol	description	probe type	remarks
P _E	Heat exchanger evaporation pressure	Ratiometric -1-9.3 barg	
T _{GS}	Heat exchanger superheated gas temperature	NTC - HF	
P _{D L2}	Line 2 (low temperature) discharge pressure	4-20 mA 0-44.8 barg	
T _{D L2}	Line 2 (low temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P _{S L2}	Line 2 (low temperature) suction pressure	4-20 mA 0-44.8 barg	
T _{S L2}	Line 2 (low temperature) suction temperature	NTC - HF	For suction superheat control (optional)



2.2 System features

2.2.1 DSS: Double system synchronization

System for communication between the medium temperature and low temperature compressor racks.

The low temperature circuit cannot operate correctly if the medium temperature circuit is not working, therefore communication between the two systems is essential to synchronise operation and modify operation when needed.

Specifically, the following are possible

- start the medium temperature rack when the low temperature rack is operating, both during start-up and in normal operation
- shut down the low temperature rack when the medium temperature rack is not working correctly
- avoid simultaneous compressor starts on the different systems to reduce peaks in energy consumption

2.2.2 EEVS: Electronic Expansion Valve Synchronization

System for communication between the low temperature rack (pRack pR300) and electronic expansion valve driver on the plate heat exchanger, either built-in on pRack pR300 or external (EVD EVO)

The low temperature rack can in this case tell the driver of any changes in cooling capacity and thus modulate evaporator capacity based on CO₂ condensing pressure, without requiring additional probes and ensuring fine and precise condensing pressure control. Exchanging information between the compressor rack and the heat exchanger can also augment traditional superheat control with factors that are vital for this type of installation, such as variation in low temperature rack cooling capacity and trend in CO₂ condensing pressure.

Safety procedures are featured in the event of conditions in which system stability cannot be guaranteed.

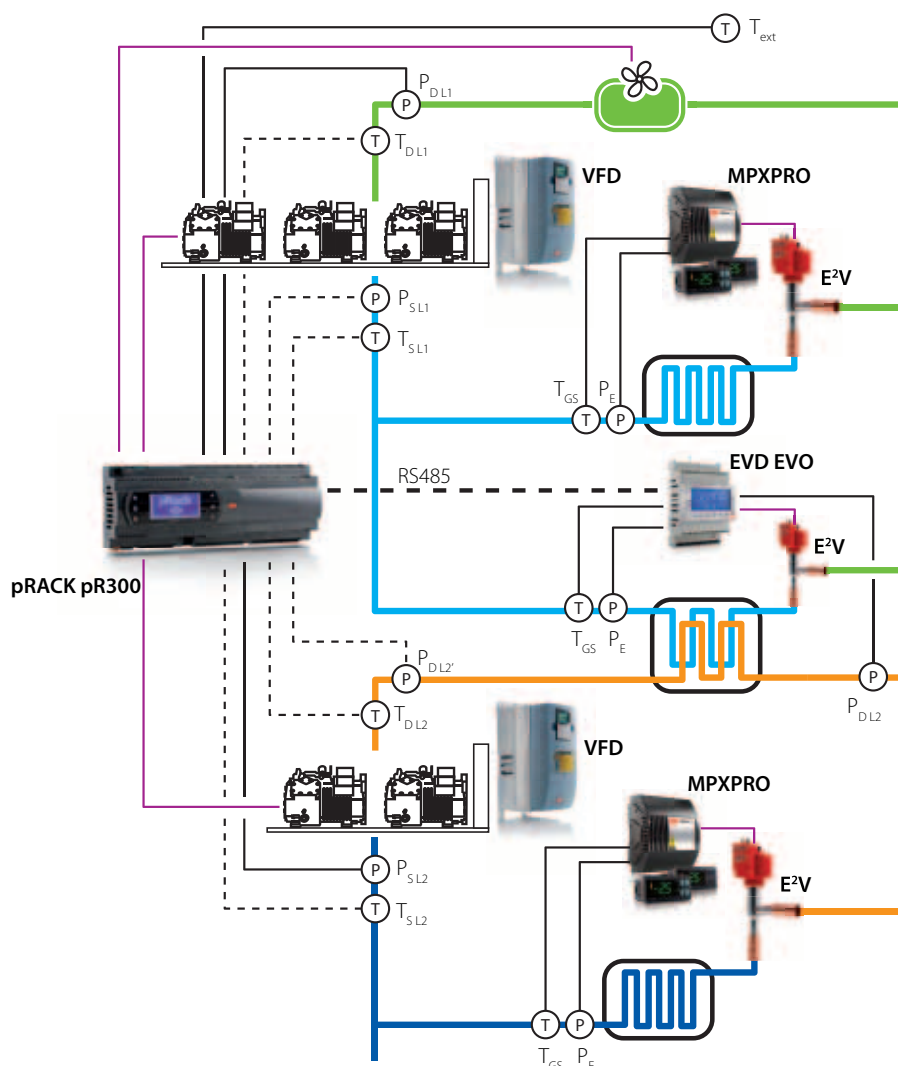
Available for both one and two heat exchangers.

If one or more individual drivers is used, the condensing pressure probe can be connected directly to the EVD EVO driver; in this way, valve control will be directly affected by a safety procedure that tends to open the valve when CO₂ condensing pressure is too high. In this case, the CO₂ condensing pressure probe connected to pRack is optional.

This function can be used in the following configurations:

- pRack pR300 with built-in driver and just one heat exchanger
- pRack pR300 with one individual external EVD EVO driver
- pRack pR300 with two individual external EVD EVO drivers

Control diagram with one pRack board and one individual external driver featuring high CO₂ pressure protection.



pRack connections

symbol	description	probe type	remarks
T_{ext}	Outside temperature	NTC - HP	
P_{DL1}	Line 1 (medium temperature) discharge pressure	4-20 mA 0-18.2 barg	
T_{DL1}	Line 1 (medium temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P_{SL1}	Line 1 (medium temperature) suction pressure	4-20 mA 0-7 barg	Can be used as backup for PE
T_{SL1}	Line 1 (medium temperature) suction temperature	NTC - HF	For suction superheat control (optional)
$P_{DL2'}$	Line 2 (low temperature) discharge pressure	4-20 mA 0-44.8 barg	Can be used as backup for PD L2
T_{DL2}	Line 2 (low temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P_{SL2}	Line 2 (low temperature) suction pressure	4-20 mA 0-44.8 barg	
T_{SL2}	Line 2 (low temperature) suction temperature	NTC - HF	For suction superheat control (optional)

EVD EVO connections

symbol	description	probe type	remarks
P_{DL2}	Line 2 (low temperature) discharge pressure	4-20 mA 0-44.8 barg	
P_e	Heat exchanger evaporation pressure	Ratiometric -1-9.3 barg	
T_{GS}	Heat exchanger superheated gas temperature	NTC - HF	



3. TRANSCRITICAL CO₂ BOOSTER

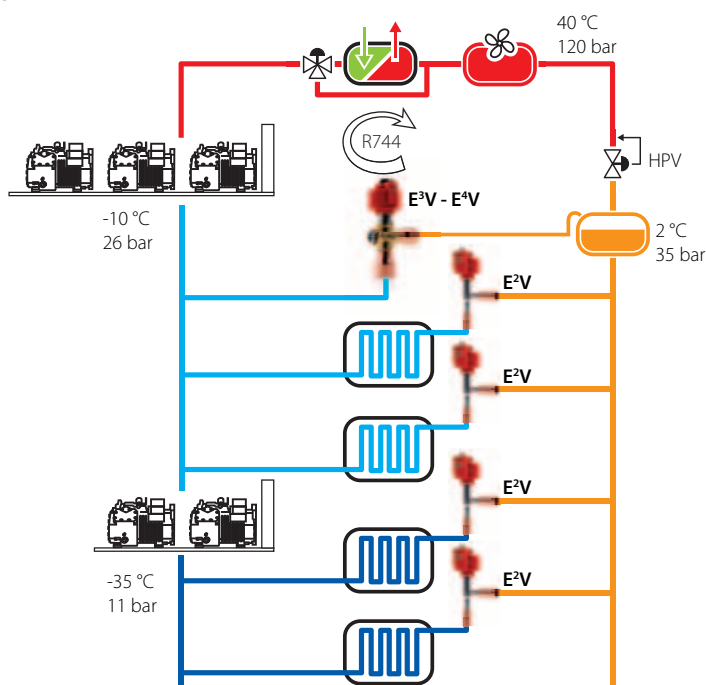
Transcritical CO₂ booster systems are the most promising solutions for using natural refrigerants in retail contexts, above all in climates that are not too hot.

They generally feature three sections with different pressures::

- high pressure: the section from the medium temperature compressor discharge to the HPV valve (in red)
- intermediate pressure: the section from the HPV valve to all the expansion valves (in orange)
- medium pressure: the section from the medium temperature evaporators downstream of the expansion valve to the suction side of the medium temperature compressors (in light blue)
- low pressure: the section from the low temperature evaporators downstream of the pressure regulating valves to the suction side of the low temperature compressors (in blue)

A basic traditional installation is shown in the figure below. Different variants can be found on the market, above all using plate heat exchangers to increase system efficiency and/or assist correct operation. These are not normally part of system operating logic, and are not covered in this document.

Example of a transcritical CO₂ system



In general, the gas is drawn in by the medium temperature compressors at a pressure of around 26 barg (maximum pressure 40-60 barg), and at the compressor discharge normally passes through a heat recovery system (of varying complexity), essential for overall unit efficiency, and the gas cooler. In this section, operating pressure essentially depends on outside temperature, and may vary from minimum values of around 40-45 barg, based on the type of compressors used, to 120 barg, the maximum safety valve pressure. The name gas cooler refers to the fact that, in certain climatic conditions, it may not manage to condense the CO₂, which consequently reaches the high pressure valve in the form of a dense gas. The high pressure valve (HPV) is the heart of this type of installation, making sure it works efficiently and in the most favourable conditions at any given moment; consequently, it lowers the operating pressure of the receiver downstream to 35-40 barg so as to condense the CO₂. Receiver pressure is managed by the regulating valve (RPRV), which works by bypassing the system so as to maintain constant receiver pressure.

Receiver pressure is managed by the regulating valve (RPRV), which works by bypassing some of the gas so as to maintain constant receiver pressure. From the receiver, the liquid flows to all the medium and low temperature showcases; it is then expanded by the expansion valves on the low temperature evaporators and then drawn in by the LT compressors and subsequently remixed with the gas from the medium temperature evaporators and the receiver pressure regulating valve (in this section, maximum pressure may range from 25 to 60 barg).

These gases - at different temperatures - are then drawn in by the medium temperature compressors. The most common variants include:

- gas cooler for low compressor discharge temperature
- plate heat exchangers between the gas from the RPRV and the liquid line, with the dual purpose of subcooling the liquid at the evaporators and offsetting the heating effect of the RPRV valve
- plate heat exchangers between the suction side of the medium temperature compressors and the gas cooler outlet, with the dual purpose of assisting mixing between the different gases on the compressor suction side and further cooling the gas exiting the gas cooler

PROS

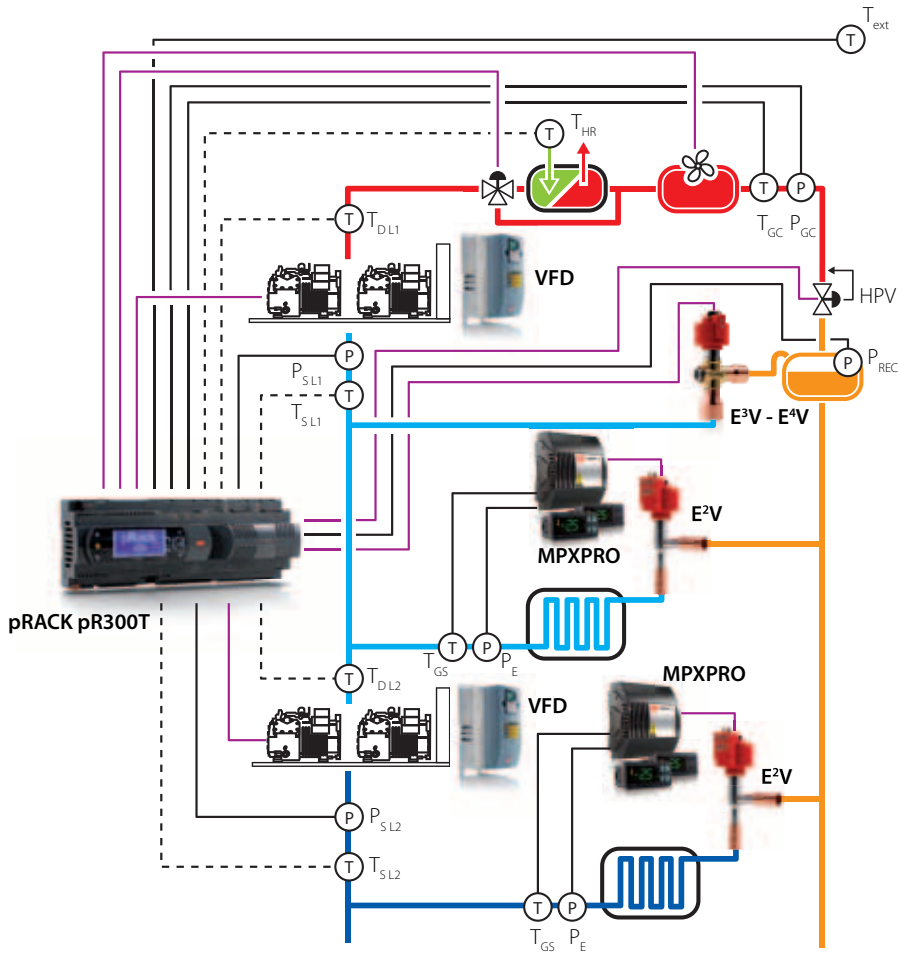
- system that completely uses natural refrigerants (CO₂)
- various studies have shown higher efficiency than any other type of installation (traditional R404a or subcritical CO₂) at average outside temperatures less than 15°C
- technology becoming standardised, costs are falling

CONS

- high pressures involved (up to 120 barg)
- systems are normally more complex than traditional ones
- not yet completely applicable to hot climates, low efficiency

3.1 CAREL solution

Control diagram with one pRack board and built-in twin driver



pRack pR300T connections

symbol	description	probe type	remarks
T _{ext}	Outside temperature	NTC - HP	
P _{GC}	Gas cooler pressure	4-20 mA 0-150 barg	
T _{GC}	Gas cooler outlet temperature	NTC - HF	
T _{HR}	Heat reclaim temperature	NTC - HF	For heat recovery system control (optional)
P _{REC}	Receiver pressure	4-20 mA 0-60 barg	
P _{SL1}	Line 1 (medium temperature) suction pressure	4-20 mA 0-44.8 barg	
T _{SL1}	Line 1 (medium temperature) suction temperature	NTC - HF	For suction superheat control (optional)
T _{DL2}	Line 2 (low temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P _{SL2}	Line 2 (low temperature) suction pressure	4-20 mA 0-44.8 barg	
T _{SL2}	Line 2 (low temperature) suction temperature	NTC - HF	For suction superheat control (optional)



pRack pR300T: controller for transcritical CO₂ compressor racks

pRack pR300T provides complete management - in single or multi-board configurations - of both small and medium-large transcritical CO₂ systems. One instrument alone can manage LT and MT compressor activation and safety, any heat recovery systems, the gas cooler, the oil recovery system, the high pressure valve (HPV) and receiver pressure regulating valve (RPRV). The HPV and RPRV valves can be managed directly by pRack pR300T with built-in driver or with external EVD EVO driver. Both instruments are compatible with all valves available on the market.



pRack pR300T

MPXPRO & E²V : controller for multiplexed showcases and stepper electronic expansion valve

Given the speed of CO₂ as a refrigerant, evaporator control is essential for correct system operation. For this purpose, the CAREL E²V stepper electronic expansion valve is important to ensure system stability. Featuring ultracap technology, the MPXPRO+E²V system can guarantee complete closing in the system without using additional solenoid valves.



MPXPRO & E²V

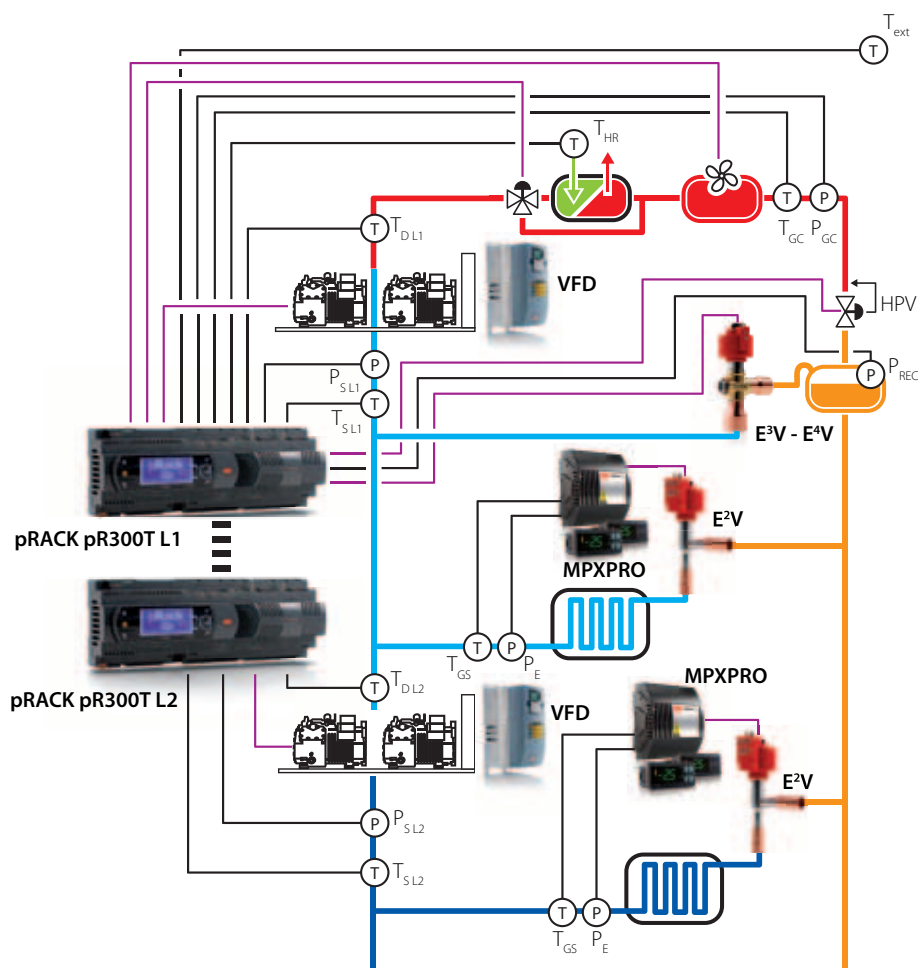
E²V: Electronic expansion valve

Standard CAREL E²V stepper expansion valves have a maximum pressure of 45 barg, and therefore can be normally used (as expansion valves on showcases and RPRVs) in all systems where maximum receiver pressure is 45 barg. In cases where maximum receiver pressure is higher than this value, the E2V*CS* series can be used, designed specifically for transcritical CO₂ applications with a maximum pressure of 140 barg. These valves can also be used as high pressure valves (HPV) and receiver pressure regulating valves (RPRV) on small compressor racks.



E²V electronic expansion valve

Control diagram with two pRack boards and built-in twin driver



pRack pR300T connections for L1

symbol	description	probe type	remarks
T_{ext}	Outside temperature	NTC - HP	
P_{GC}	Gas cooler pressure	4-20 mA 0-150 barg	
T_{GC}	Gas cooler outlet temperature	NTC - HF	
T_{HR}	Heat reclaim temperature	NTC - HF	For heat recovery system control (optional)
P_{REC}	Receiver pressure	4-20 mA 0-60 barg	
P_{sL1}	Line 1 (medium temperature) suction pressure	4-20 mA 0-44.8 barg	
T_{sL1}	Line 1 (medium temperature) suction temperature	NTC - HF	For suction superheat control (optional)

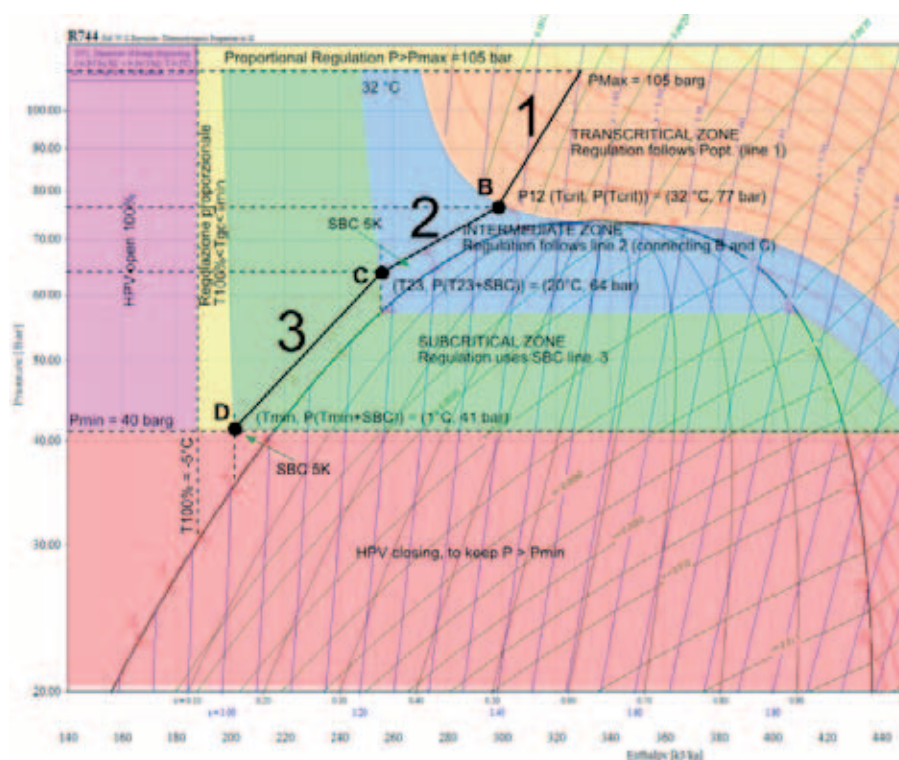
pRack pR300T connections for L2

symbol	description	probe type	remarks
T_{dL2}	Line 2 (low temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P_{sL2}	Line 2 (low temperature) suction pressure	4-20 mA 0-44.8 barg	
T_{sL2}	Line 2 (low temperature) suction temperature	NTC - HF	For suction superheat control (optional)

3.2 System features

The HPV valve control algorithm on pRack pR300T is managed based on the gas cooler outlet temperature T_{GC} and gas cooler pressure P_{GC} . Depending on operating conditions, the system can work in:

- transcritical operating conditions (line 1), in which the instrument controls the HPV valve so as to maintain the best set point and maximise compressor rack COP
- subcritical operating conditions (line 3), in which instrument attempts to maintain a certain level of subcooling
- transition operating conditions (line 2), in which the instrument attempts to keep the transition from transcritical to subcritical as smooth as possible, considering that the refrigerant in such situations is neither in the liquid nor gas phase.

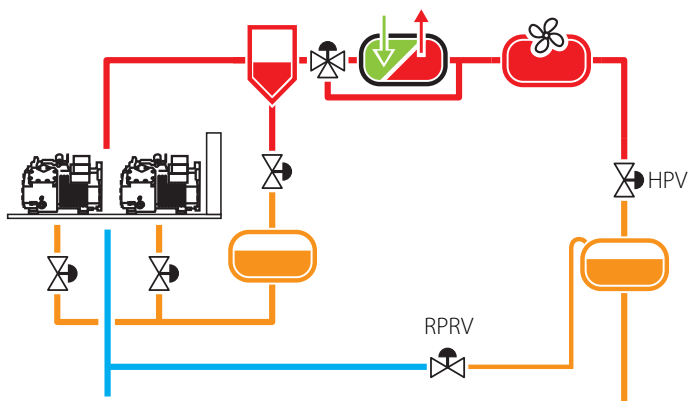


RPRV valve management aims to maintain constant pressure inside the receiver around a set point; in extreme conditions it may modify the operating conditions of the HPV so as to ensure the system as a whole operates correctly.

The oil recovery system manages oil levels in the separator, controls the receiver injection solenoid valve, as well as the pressure difference from compressor rack suction pressure, and also manages the injection of oil into the various compressors, with alarms triggered if injection is not sufficient.

An important factor in system operation, this function can also be used with the electromechanical oil recovery systems that are widely available on the market to simply monitor and log system operation for subsequent verification.



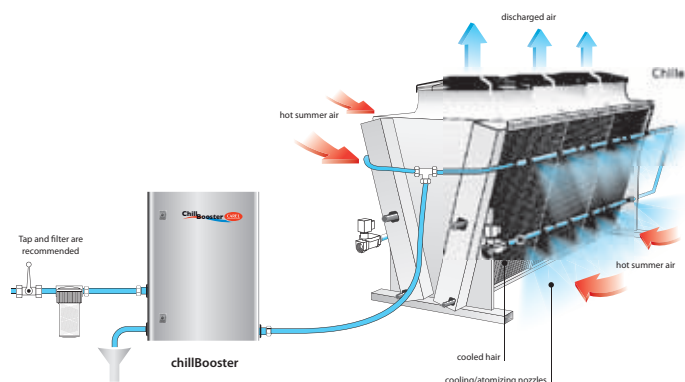


The **heat recovery** system is very important for overall system efficiency, and is managed so as to maximise the amount of heat recovered, modifying operation of both the gas cooler of the high pressure valve.

Chillbooster: evaporative cooling system for CO₂ gas cooler

Especially suitable for installations in temperate climates, where the outside temperature exceeds 30 °C just a few days a year, this is a simple evaporative cooling system that can decrease the outside temperature perceived by the gas cooler by between 5 and 15 °C.

An optimum way to improve the efficiency of a transcritical system in hot temperatures, it integrates perfectly with pRack pR300T so as to ensure operation only in critical conditions or as a safety measure.



3.2.1 DSS: Double system synchronization

System for communication between the medium temperature and low temperature compressor racks.

The low temperature circuit cannot operate correctly if the medium temperature circuit is not working, therefore communication between the two systems is essential to synchronise operation and modify operation when needed.

Specifically, the following are possible

- start the medium temperature rack when the low temperature rack is operating, both during start-up and in normal operation
- shut down the low temperature rack when the medium temperature rack is not working correctly
- avoid simultaneous compressor starts on the different systems to reduce peaks in energy consumption

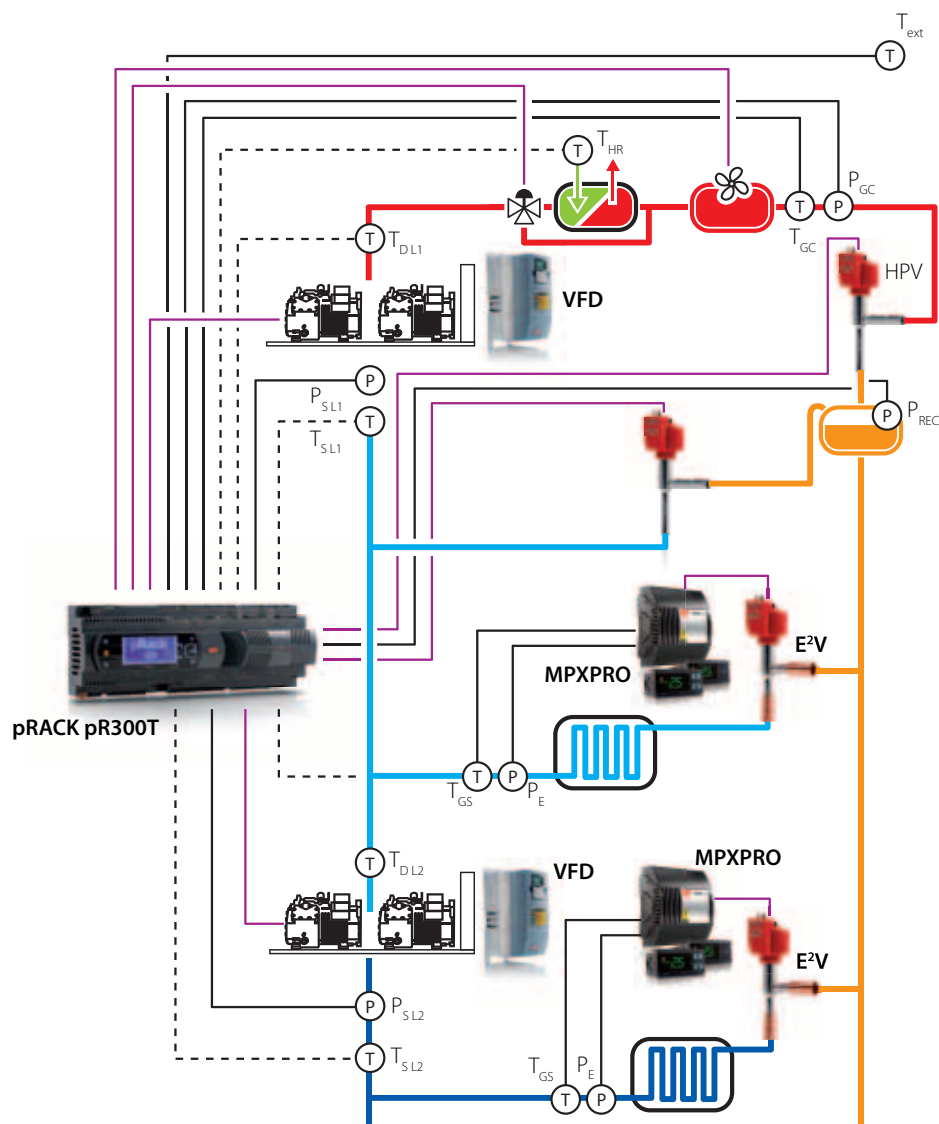
3.3 Transcritical CO₂ condensing units

For small applications, CAREL can offer a complete and integrated solution using E2V*CS stepper valves, suitable for these types of units and featuring much simpler assembly than the larger solutions available on the market.

Carel E2V*CS CO₂ valves have maximum operating pressure 140 barg and 90 bar differential, and can be used in these types of applications with capacities up to 40 kW.

This compact solution comprises a single controller fitted with built-in driver and ultracap for direct management of E2V*CS valves used as HPVs and RPRVs. The scalability of the pRack platform allows the same user interface to be used for these types of applications, with special focus on installation costs and simple operation.





symbol	description	probe type	remarks
T_{ext}	Outside temperature	NTC - HP	
P_{GC}	Gas cooler pressure	4-20 mA 0-150 barg	
T_{GC}	Gas cooler outlet temperature	NTC - HF	
T_{HR}	Heat reclaim temperature	NTC - HF	For heat recovery system control (optional)
P_{REC}	Receiver pressure	4-20 mA 0-60 barg	
P_{SL1}	Line 1 (medium temperature) suction pressure	4-20 mA 0-44,8 barg	
T_{SL1}	Line 1 (medium temperature) suction temperature	NTC - HF	For suction superheat control (optional)
T_{DL2}	Line 2 (low temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P_{SL2}	Line 2 (low temperature) suction pressure	4-20 mA 0-44,8 barg	
T_{SL2}	Line 2 (low temperature) suction temperature	NTC - HF	For suction superheat control (optional)

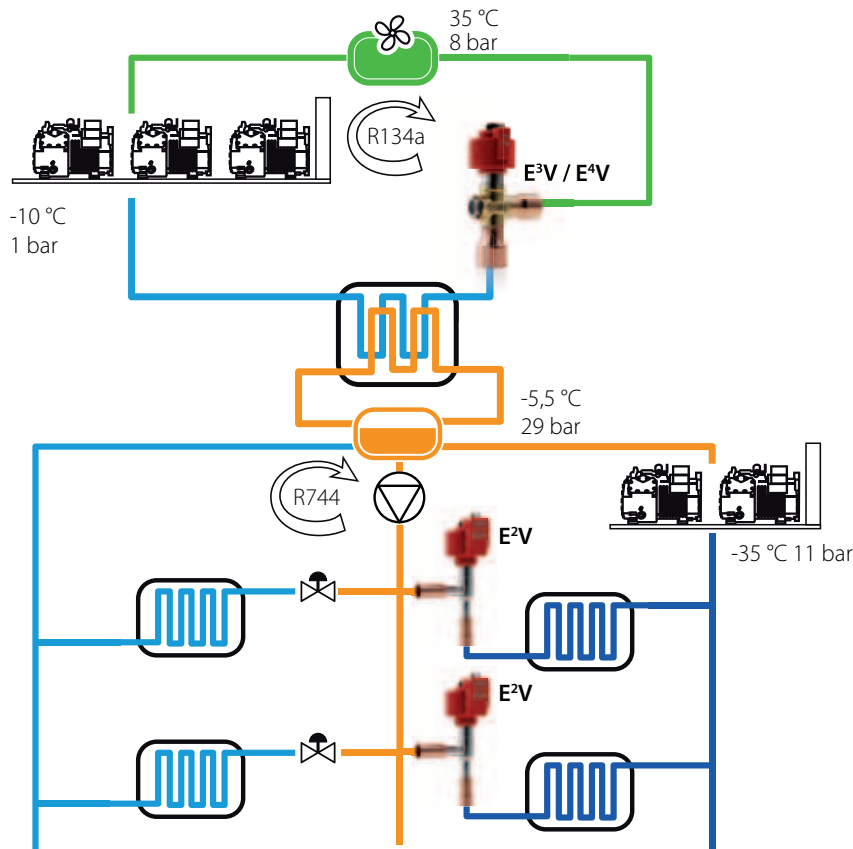


4. SUBCRITICAL CO₂: PUMPED

Not as widely used as traditional cascade subcritical systems, these aim to limit the use of HFC refrigerants only to the equipment room. The medium temperature showcases are supplied with pumped liquid CO₂ while the low temperature showcases are fitted with expansion valves. The CO₂ is cooled by a dedicated chiller (NH₃ or R134a) inside a tank, normally with a tube bundle evaporator.

In addition to traditional systems, these also include pumps that circulate the liquid CO₂ to the medium temperature evaporators, where it is not expanded, but rather is simply superheated, returning to the receiver in the semi-liquid phase.

Example of pumped subcritical CO₂ system



PROS

- low non-natural refrigerant content;
- possibility to use ammonia (NH₃), limited to the equipment room only;
- completely green installation inside the store display area.

CONS

- very sensitive to pumping system piping size;
- additional pump energy consumption.

3.4 CAREL solution

pRack pR300: compressor rack controller

This manages both the chiller compressors - based on the CO₂ pressure inside the receiver - and the low temperature compressors, applying the same synchronisation functions between the two systems. One important aspect in this type of system is coordinated operation of the medium temperature rack with the tube bundle evaporator controller, to prevent problems of low pressure.

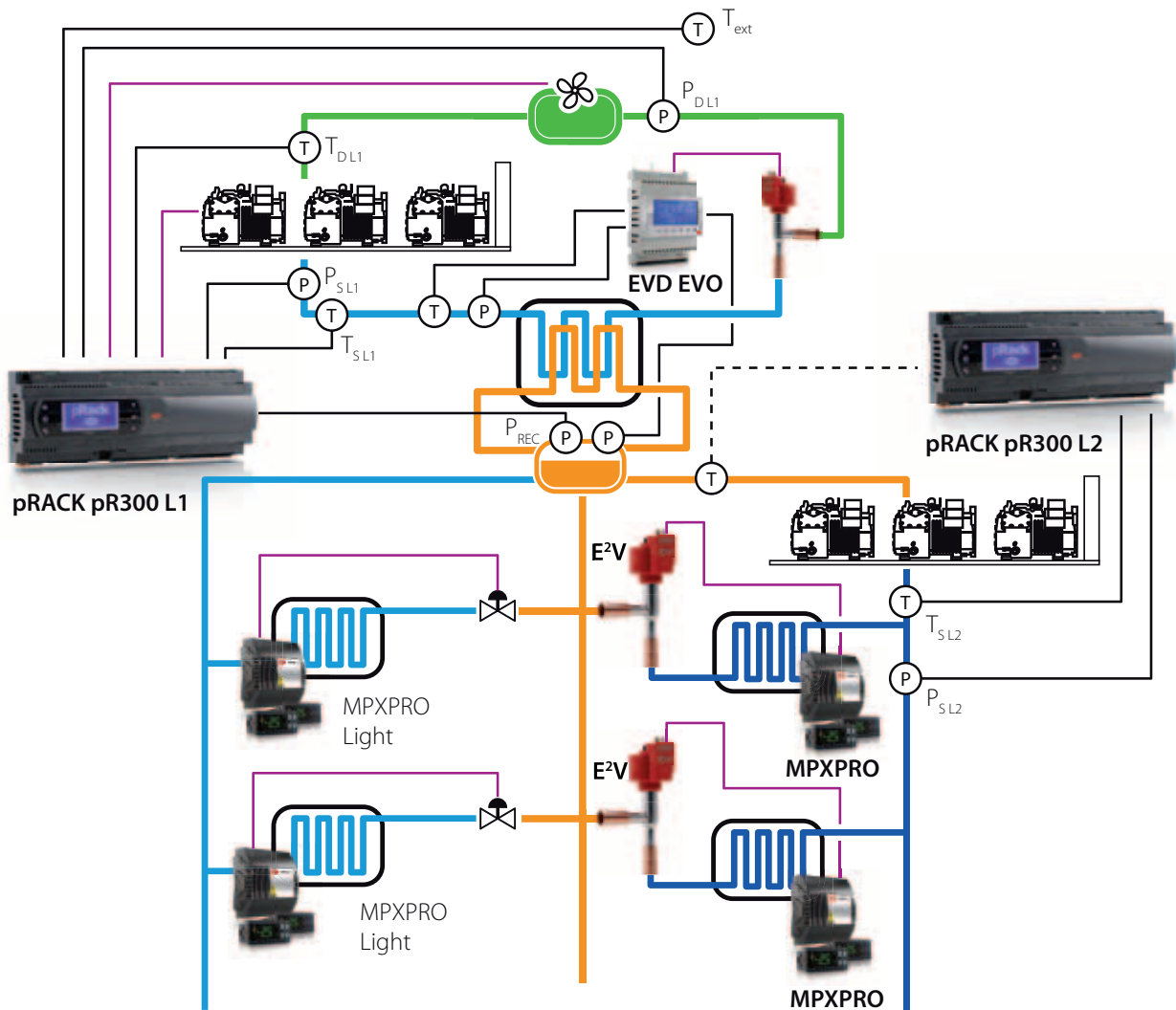
Receiver pressure control is the main task, given the quantity of refrigerant inside and consequently its significant inertia, and therefore it is essential to activate the compressors based on receiver pressure; medium temperature compressor suction pressure will therefore only be monitored for safety reasons, to prevent problems of low pressure.

pRack can also manage simple pumping systems with or without inverter



pRACK pR300

Control diagram with two pRack boards



pRack pR300 connections on L1

symbol	description	probe type	remarks
T _{ext}	Outside temperature	NTC - HP	
P _{D L1}	Condensing pressure line 1 (medium temperature)	4-20 mA 0-18.2 barg	
T _{D L1}	Line 1 (medium temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P _{S L1}	Line 1 (medium temperature) suction pressure	4-20 mA 0-10 barg	For low pressure alarm control
T _{S L1}	Line 1 (medium temperature) suction temperature	NTC - HF	For suction superheat control (optional)
P _{REC}	CO ₂ receiver pressure	4-20 mA 0-10 barg	For medium temperature compressor control

pRack pR300T connections on L2

symbol	description	probe type	remarks
T _{D L2}	Line 2 (low temperature) discharge temperature	NTC - HF	For discharge temperature control (optional)
P _{S L2}	Line 2 (low temperature) suction pressure	4-20 mA 0-44.8 barg	
T _{S L2}	Line 2 (low temperature) suction temperature	NTC - HF	For suction superheat control (optional)

EVD EVO connections

symbol	description	probe type	remarks
P _{REC}	Line 2 (low temperature) discharge pressure	4-20 mA 0-44.8 barg	
P _E	Heat exchanger evaporation pressure	Ratiometric -1-9.3 barg	
T _{GS}	Heat exchanger superheated gas temperature	NTC - HF	

MPXPRO and MPXPRO light

MPXPRO for the low temperature showcases with electronic expansion valve, and MPXPRO light for medium temperature showcases where no electronic expansion valve is required, rather simply refrigerant management based on demand from the showcase. Compatible with the full option version, MPXPRO light standardises wiring and installation.



EVD EVO and E²V drivers

Management of the tube bundle evaporator is critical in this type of application, the size of the evaporator, the inertia of the load and the proximity of the compressors require very fine control that needs to adapt quickly to compressor activation or deactivation, respond gradually to changes in load, not flood the compressors and protect against low suction pressure alarms. The functions of the EVD EVO driver and the low superheat, low suction pressure and high CO₂ condensing pressure protection must therefore be correctly calibrated based on the features of the installation (number and type of compressors, evaporator and receiver size, whether receivers are used on the suction side, system dynamics)



Driver EVD EVO e E²V

5. COMMON COMPONENTS

In addition to the solutions already described, CAREL Retail sistema offers a series of other products that are essential for system management.

PVPRO: supervisory system

Single point of access to the entire system, this allows fine tuning, continuous monitoring and logging of data, communication with the outside and alarm management.

Remote or local access with various functions to optimise system operation and increase safety:

- Floating suction pressure: optimises the compressor rack suction pressure set point based on actual system requirements
- Dew point broadcast: to modulate showcase anti-sweat heaters using the dew point reading inside the store
- Parameter control: to monitor vital system operating parameters, even offline, preventing accidental modifications
- Energy: to monitor system energy consumption, create scheduled reports clearly showing system performance
- KPI (Key performance indicators): for a quick and effective overview of the operation of the different units and clearly establish where action needs to be taken
- Recovery procedure: together with the compressor rack, to interact directly with all the unit controllers in the event of rack malfunctions and schedule restart to get the system up and running again



PVPRO: supervisory system

DPWL: gas leak sensors

Available for all types of refrigerant, the CO₂ leak sensor in particular is very important for installations both in equipment rooms and inside the store itself. Directly interfaceable with the electronic controllers via analogue signals or the supervisory system via Modbus RTU, these constantly monitor the level of CO₂ in the room and quickly identify any gas leaks that may be harmful to humans.

CO₂ is in fact heavier than air and can cause asphyxiation, in the event of leaks it tends to accumulate at floor level, therefore the sensors should be installed around 30-40 cm from the floor and near the refrigeration units.



DPWL: gas leak sensor

VFD: inverters

Available for both compressors and fans, the CAREL VFD range of inverters covers all applications, including CO₂, and together with the pRack range allows finer control of evaporation pressure.



VFD: inverter

Probes and transducers

Vast range of temperature probes and pressure transducers, available in various types, completely covering all applications with natural refrigerants

- 4-20 mA pressure probes: recommended on compressor racks
- Ratiometric pressure probes: recommended on showcases and in cold rooms
- NTC and pT1000 temperature probes
- NTC and pT1000 clamp-on temperature probes: recommended for installation on pipes



Probes and transducers

pLoads: load control

Device for controlling loads based on system energy consumption, this activates and/or deactivates the different loads only when possible. Integrated into pRack pR300, it reduces compressor rack cooling capacity when necessary.



pLoads: load control

pChrono: scheduler

Device for scheduling the activation of lights, pumps and any other devices inside the installation, so as to maximise energy savings not only in the refrigeration system, but also the air-conditioning and building management systems.



pChrono: scheduler





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