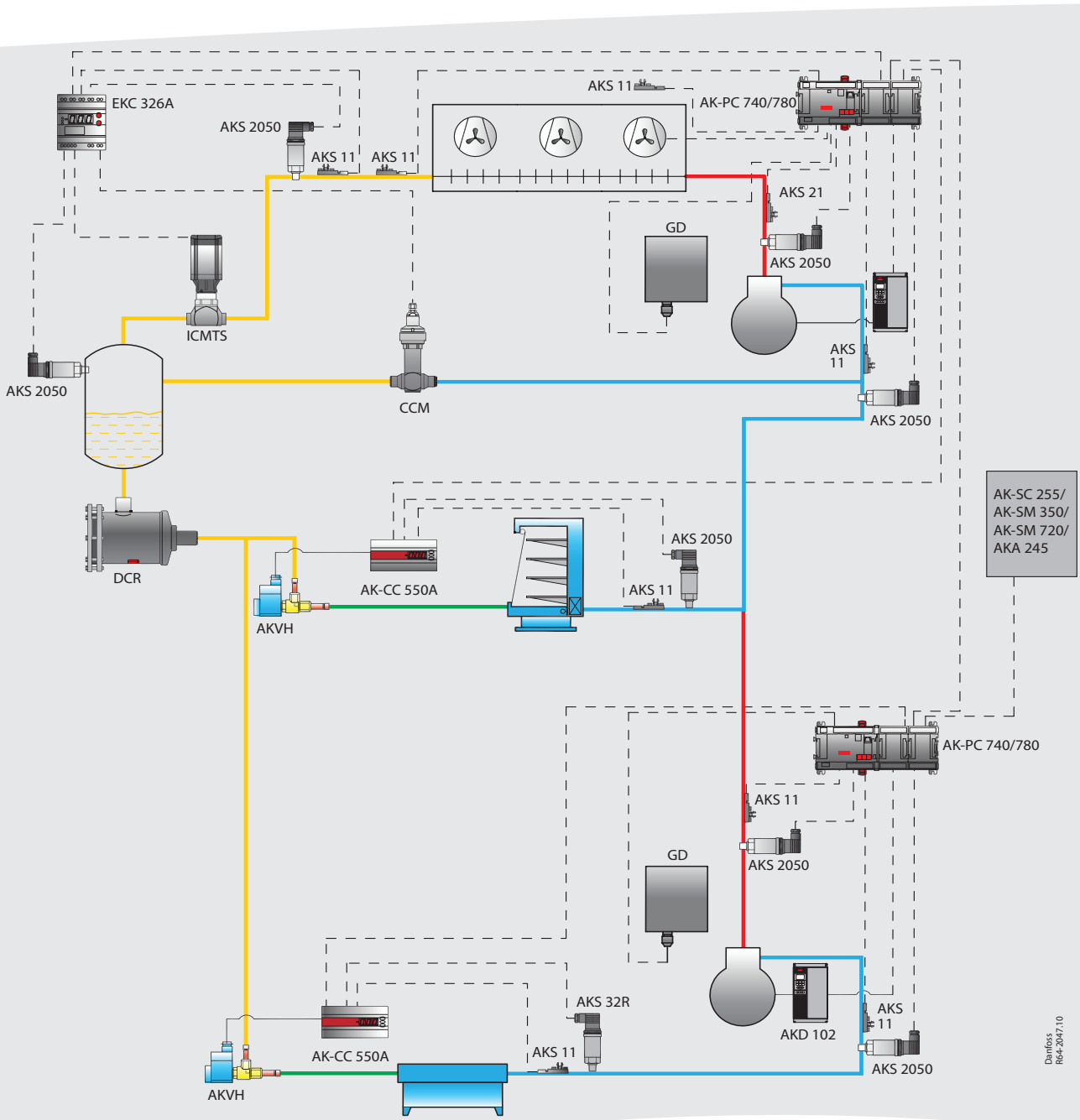
Application guide

Transcritical CO2 booster system

How to control the system



General description

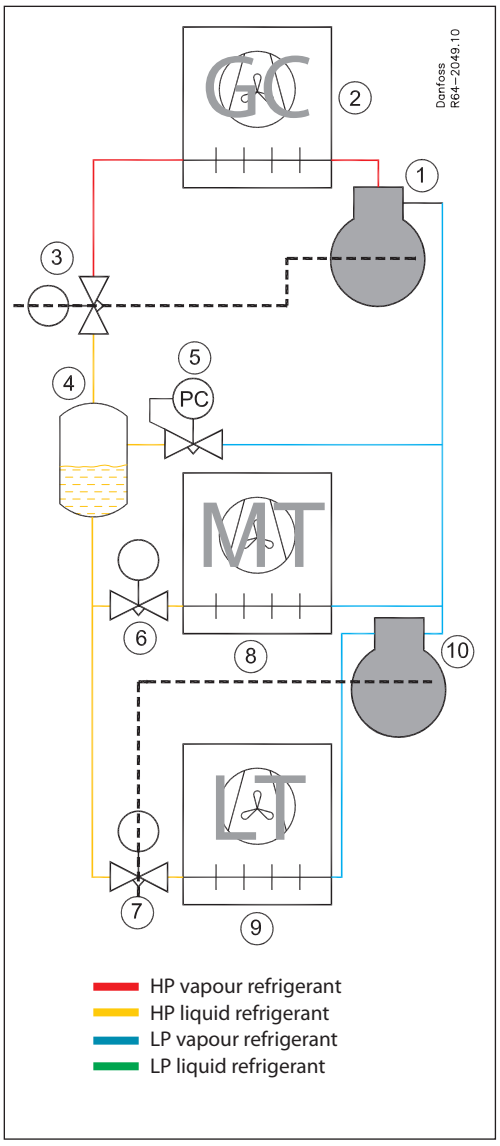
The transcritical booster system is one of the most promising systems in cold climate areas. The reason for this is that the energy consumption is on the same level as R404a systems or better and the design is relatively simple.

A typical CO_2 transcritical booster system is divided in to three pressure sections, High pressure section, Intermediate pressure section, and Low pressure section.

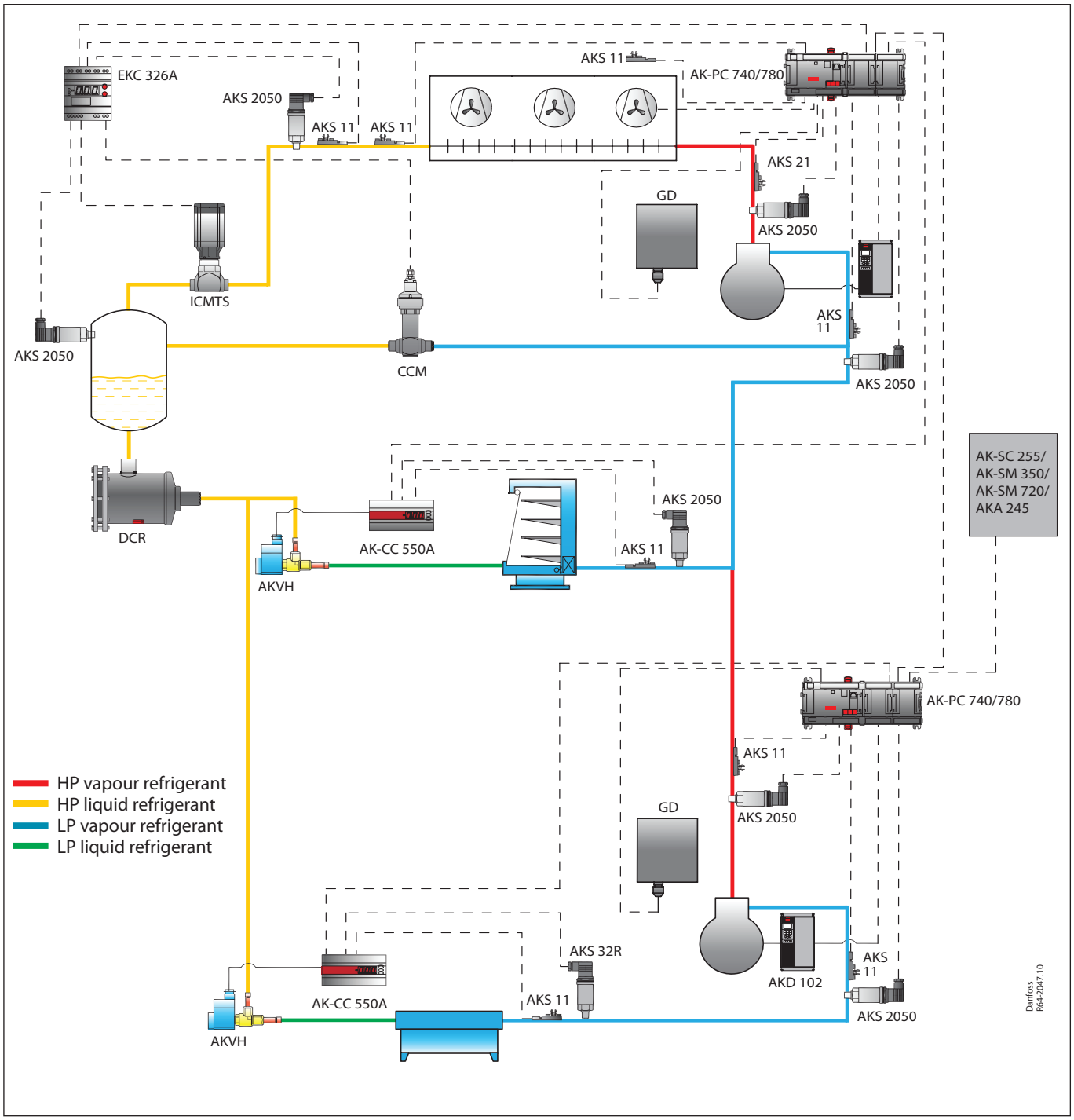
The high pressure section begins at the high pressure compressor (1), through the gas cooler (2) to the high pressure control valve (3). The design pressure in this section is usually between 90 and 120 bar.
The intermediate pressure section begins at the high pressure expansion valve (3) where the flow is divided into gas and liquid in the receiver (4). The gas phase is bypassed to the suction line of the high pressure compressors through a bypass valve (5). The liquid flows to the expansion valves (6 and 7) where it is expanded before the MT (8) and LT (9) evaporators.
The gas from the LT evaporator is compressed in the LT compressor (10) and mixed with the gas from the MT evaporator and from the gas bypass. From here the gas enters the suction line to the HP Compressor and completes the circuit.

The design pressure for the MT section is often 40-45 bar and 25 bar for the LT section. There seems to be a tendency to design MT and LT sides for the same pressure.

The pressure in the receiver is controlled by the CCM stepper motor valve (5). The pressure in the receiver has to be higher than the evaporation pressure in the MT evaporators to ensure differential pressure over the MT expansion valve (6). On the other side, the pressure has to be lower than the design pressure.



Transcritical booster system with gas bypass



Transcritical booster system with gas bypass

Controls

Controls for a transcritical system can be divided into four groups: gas cooler controls, receiver controls, injection controls and compressor capacity controls.

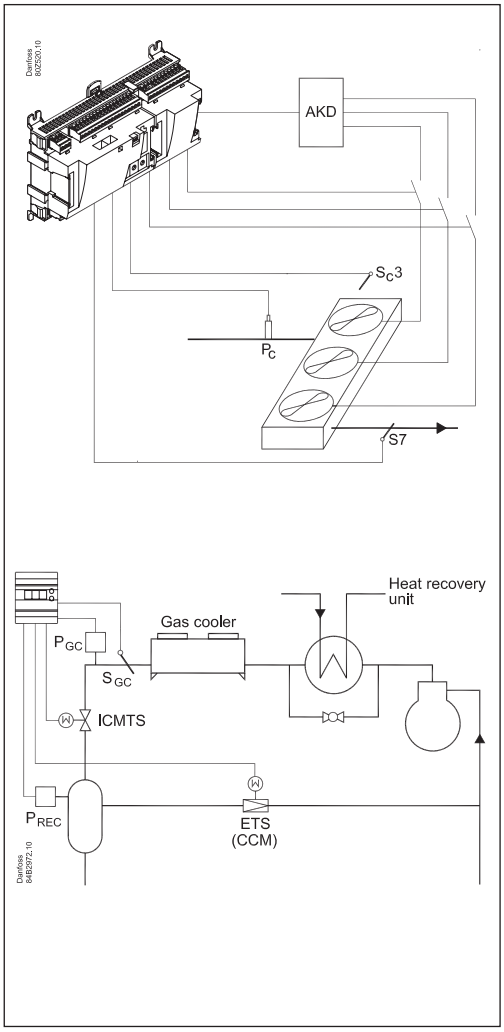
Gas cooler controls

CO_2 temperature out of the gas cooler is controlled by AK-PC 740 or AK-PC 780 (typically variable speed controlled fans). A user defined minimum temperature difference between ambient temperature (air into the gas cooler) and CO_2 media temperature measured just at the outlet of the gas cooler is the reference for control of fans. If the temperature is lower than the set Min. reference point the fans shut down. When no compressors are running the fans stops as well.

Minimum pressure is kept by the EKC 326A controlling the ICMTS high pressure expansion valve. The controller guarantees the system's maximum performance by maintaining the optimal pressure in the gas cooler when regulation takes place in the transcritical range. The controller will always optimise to a subcritical state.
Optimum pressure in the transcritical range is based on a pressure and temperature reading. Both sensors must be fitted in the outlet immediately after the gas cooler.

Extra refrigeration capacity ("extra compressor")
This function improves the system's refrigeration capacity by increasing the pressure in the gas cooler. The function is activated in the EKC326A via a "dry contact" switch .

Heat recovery or heat pump
This function will increase the gas pressure to a set value. The value can either be fixed value or can vary in accordance with an input signal of 0-10 V.
This function works both in subcritical and transcritical ranges.



Receiver controls

To reduce the pressure in distribution systems, the gas bypass is introduced.
After the high pressure expansion, the gas and liquid are separated and the gas is bypassed directly to the suction side of the compressor.
The liquid is distributed to the evaporators.
This makes it possible to use standard pressure components.

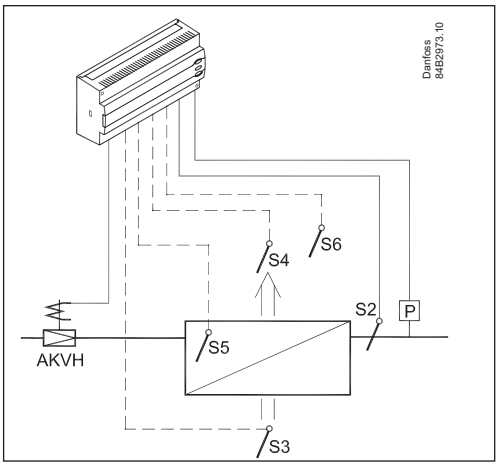
The receiver pressure can be controlled by EKC326A so that pressure is kept at a set reference point. This control requires the installation of a CCM valve and a pressure transmitter

Ensuring that the receiver pressure is not too low
A limit value can be set, and if the pressure falls below this value, the ICMTS valve will be opened. The valve will then open gradually through the associated P band.

Injection controls

Injection control for the case and cold room evaporators is a standard electronic controller. AK-CC 550A utilising pulse-width-modulating injection valves AKV and patented software algorithms to optimise system performance and operation. It's important to select a pressure transmitter for superheat measuring covering the full pressure range ex. In a 40 bar system a pressure transmitter AKS 2050 -1 ->59 bar has to be selected!

When to use AKV or AKVH valves
Both HT and LT side of the system can use standard 52 bar AKV valves for 40 bar liquid system. When a 60 bar liquid system is implemented then the AKVH 90 bar valves should be used.

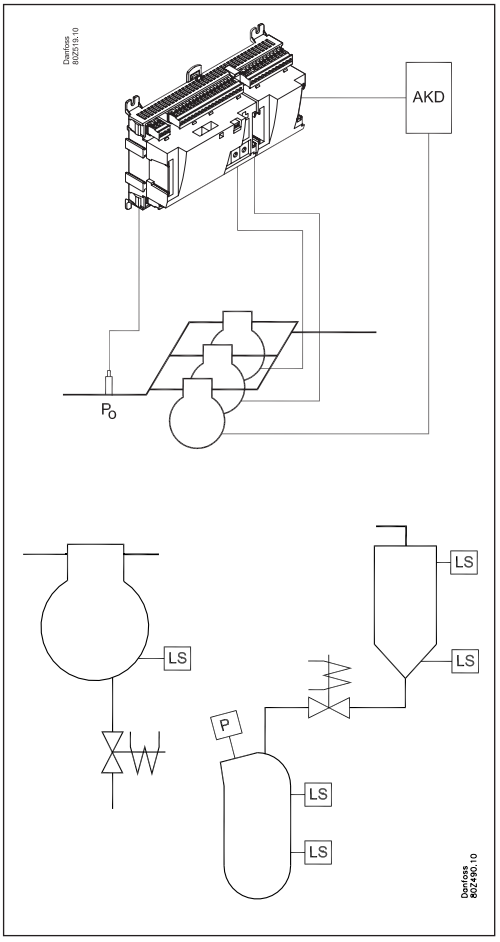


Compressor capacity controls

Pack controller AK-PC 740 (up to 4 compressors) or AK-PC 780 (up to 8 compressors) controls the suction pressure and is a standard controller for controlling one suction group in any refrigeration system. The controller is capable of regulating variable speed of two compressors combined with one-step compressors of the same or different sizes, depending on the choice of coupling pattern.
The AK-PC 740/780 is also able to coordinate the LT and HT start to ensure a smooth operation.

Oil management / oil equalisation
The build in oil management system covers most systems found on the market today. Can be used with CO_2 as well as all other conventional refrigerants and support input signals from:
- Level switch on compressor
- Level switch on oil separator
- Level switch on oil receiver
- Pressure transmitter on oil receiver

Oil supply to the compressors is managed by activating solenoid valves with user defined ON/Off pulse sequences.

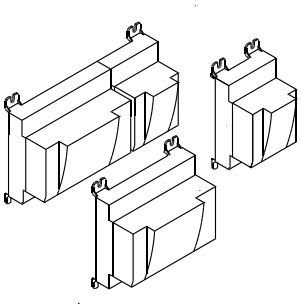


High pressure control

The Danfoss CO_2 controllers have more pressure safety functions which prevents safety valves to open and hereby loss of charge.

EKC 326 gas cooler controller
A max receiver pressure setting will force close the gas valve in case of too high receiver pressure.

AK PC 730 pack controller
A max compressor discharge pressure safety function will reduce compressor capacity

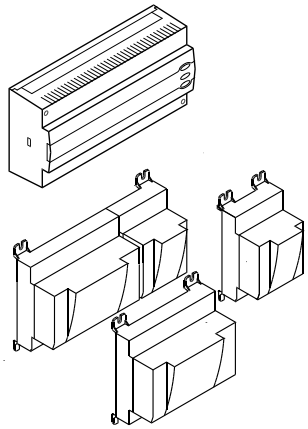


AK-PC 740
Flexible controller for capacity control of compressors and condenser fans (gas cooler fans). Number of I/O can be extended with AK-XM extension modules.

- 4 compressors with up to 3 un-loaders
- 6 fans.
- Max. 60 inputs/outputs
- Variable speed control on lead compressor and condenser fans.
- Build in oil Management functions

AK-PC 780
As AK-PC 740 plus:

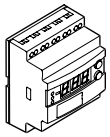
- 8 compressors with up to 3 un-loaders
- 8 fans.
- Max. 100 inputs/outputs.



AK-CC 550A
Dedecated refrigeration appliance control with great flexibility to adapt to all types of refrigeration appliances and cold storage rooms. Control of 1 evaporator.

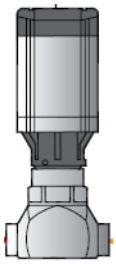
AK-CC 750
Flexible refrigeration appliance controller for control of up to 4 evaporators.

Day/night thermostat with ON/OFF or modulating principle
- Adaptive control of superheat
- Adaptive defrosting based on evaporator performance
- Natural, electric or hot gas defrost
- Case cleaning function for documentation of HACCP procedure
- Door function
- Light control



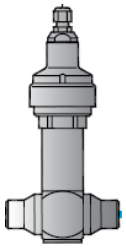
EKC326A
Controller to optimise transcritical CO_2 gas pressure and receiver pressure.

- Maximum COP
  The controller guarantees the system's maximum performance by maintaining the optimal pressure in the gas cooler when regulation takes place in the transcritical range.
- Regulating the receiver pressure based on the receiver pressure reading
- Heat recovery with adjustable reference pressure, 0-10 V.



ICMTS
Direct operated motorised valve driven by actuator type ICAD 600TS.
0/4->20 mA
0/2->10 Volt

- Designed for high pressure CO_2 systems with applications for a maximum working pressure of 140 bar / 2030 psig.
- Regulating cone ensures optimum regulating accuracy, particularly at part load.
- Manual opening possible via ICAD 600TS or Multifunction tool.
- The PTFE seat provides excellent valve tightness.
- Magnet coupling - real hermetic sealing.



CCM
Electrically operated stepper valve

- Specifically designed for operation in CO_2 systems as an expansion valve, and as a gas bypass valve in subcritical applications.
- Up to 90 bar (1305 psi) working pressure
- Precise positioning for optimal control of intermediate pressures
- Possibility of bi-flow operation
- MOPD up to 50 bar (725 psi)