

1. General

This manual describes the essential steps for the control, activation and operation of the digital capacity regulator DCR22 CO₂. The DCR22 CO₂ is universally applicable - it can be used for digital as well as for conventional capacity control.

A control system for the DCR22 CO₂ is currently not offered by Bock.

The DCR22 CO₂ can be controlled with system-/rack controllers available on the market (notes and limit values in this information must be observed for this purpose). When selecting the system-/rack controller, make sure that it is suitable for the DCR22 CO₂. Observe the specifications and instructions of the system-/rack controller manufacturer. Control of the DCR22 CO₂ is possible, for example, with the AK-PC 782A from Danfoss.

When programming the DCR22 CO₂ capacity regulation, any patent regulations or the specifications of the controller manufacturer must be observed!

The DCR22 CO₂ is available in the following voltage versions:

Voltage	Kit
230V AC	BS 82275
110V AC	BS 82276
24V DC	BS 82277

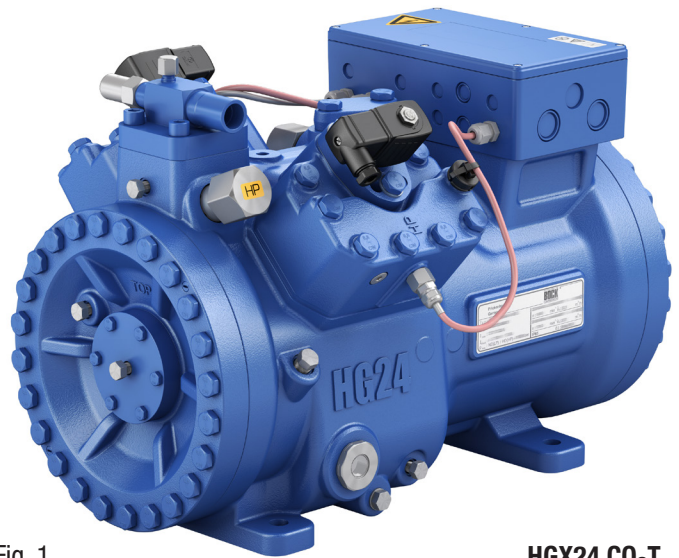


Fig. 1

HGX24 CO₂T

2. Description

No.	Description
1	Pilot valve
2	Solenoid coil
3	Main valve
4	Non-return valve
5	Suction gas area
6	Discharge gas area

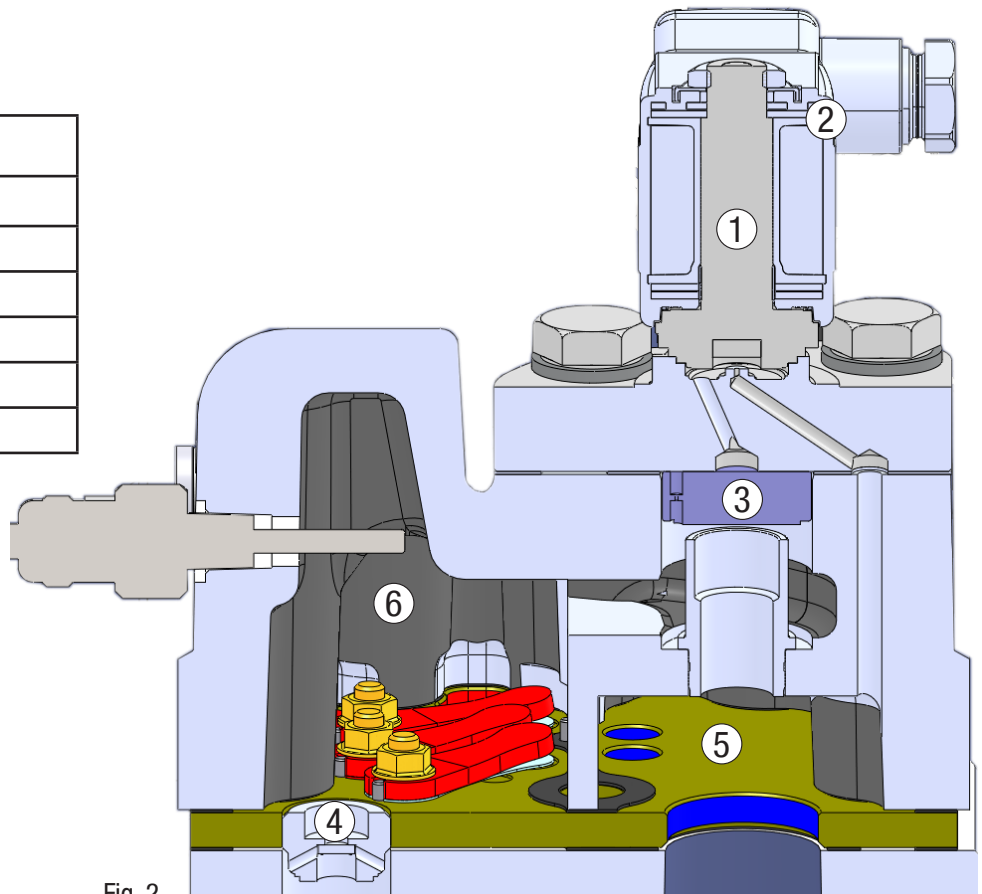


Fig. 2

Cylinder bank activated:

Solenoid coil de-energised. Pilot valve closed. Main valve closed. Cross-section closed. No bypass. Cylinder bank delivers refrigerant from the suction side of the system to the discharge pressure side of the system.

Cylinder bank deactivated:

Solenoid coil energised. Pilot valve opens main valve and therefore cross-section between the discharge and suction side of the cylinder bank. A check valve in the compressor housing prevents refrigerant flowing back from the high pressure side of the system => bypass and compression process just above the suction pressure level => for this cylinder bank, the suction of refrigerant from the system is interrupted, the compression process is thermally uncritical (due to minimum pressure ratio). Bock recommends setting the time limit for all completely deactivated cylinder banks to a maximum of 2 minutes on the compressor, depending on the application. After this time has elapsed, either a cylinder bank should be reactivated or the compressor should be switched off completely. This protects the compressor from thermal damage and insufficient lubrication, as the intake of refrigerant is interrupted when the cylinder banks are deactivated.

3. Digital capacity regulation 4 cylinder

For digital capacity regulation, both cylinder banks can be equipped with one DCR22 CO₂ each. These two cylinder banks are activated/deactivated time-dependently, depending on the capacity requirement. For this purpose, they are switched continuously in alternation by a customer-supplied system controller via PWM signal (pulse width modulation). Both cylinder banks are given the same time specifications (activation/deactivation times) with the same period duration, but they are phase-shifted by half a period. This procedure allows the compressor cooling capacity to be adjusted to a capacity range

between 25¹⁾ and 100%. In addition, suction- and discharge pressure fluctuations can be reduced to a minimum compared to compressor on/off operation.

Example of adjustment to a compressor cooling capacity of 40 % with the digital DCR22 CO₂ capacity controller:

With a period duration of 20 seconds (Bock recommendation), the following time specifications result:

Cylinder bank	Activating time cylinder bank (sec.)	Deactivating time cylinder bank (sec.)	Solenoid coil	Remarks
1	8	- - -	de-energised	
1	- - -	12	energised	
2	8	- - -	de-energised	phase-shifted by half a period to cylinder bank 1
2	- - -	12	energised	phase-shifted by half a period to cylinder bank 1

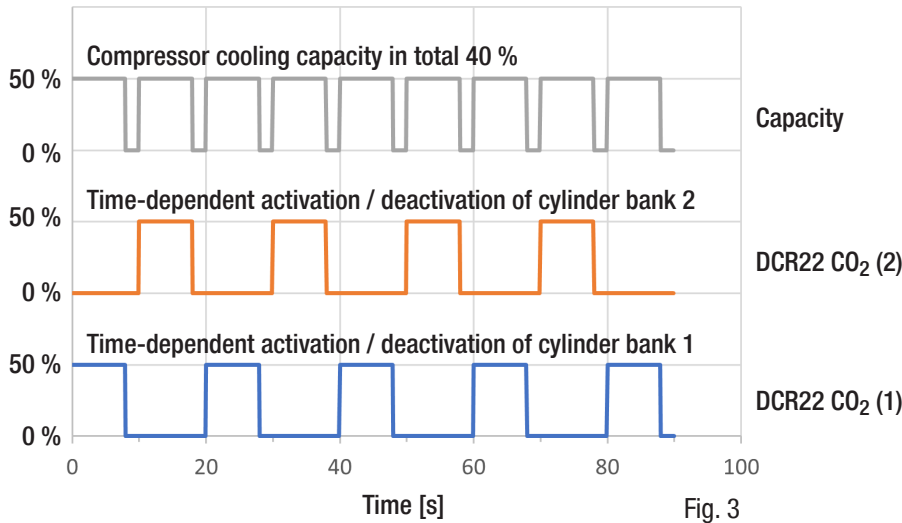


Fig. 3

For capacity requirements > 40 %, the activation times of the cylinder banks are increased linearly and the deactivation times of the cylinder banks are reduced accordingly, while the period duration remains the same.

With a capacity demand of 100 % from the system controller, both cylinder banks are permanently active.

Regulation principle	Number capacity regulators	Performance adjustment	Compressor cooling capacity	Period duration
Digital	2	stepless	25 - 100 % ¹⁾	20 sec. ²⁾
Conventionally	1	steady	50 or 100 %	-

¹⁾ Taking into account the operating point of the application with regard to discharge- and motor temperature and taking also into account system parameters (such as oil return and regulation behaviour), capacities below 40 % can also be controlled. Bock recommends the use of a hot gas temperature sensor (accessory) for this purpose. For this capacity range < 40 %, it may make sense to

increase the period duration (e.g. from 20 to 30 s => reduction of the switching frequency).

²⁾ Depending on the system behaviour and operating point, a period duration deviating from the Bock recommendation (= 20 seconds) can be selected. This can be in a range of 10 to 60 seconds.

4. Digital capacity regulation 6 cylinder

For digital capacity control, two of the three cylinder banks are each equipped with a DCR22 CO₂. These two cylinder banks are activated/deactivated time-dependently, depending on the capacity demand. For this purpose, they are switched continuously in alternation by a customer-supplied system controller via PWM signal (pulse width modulation). Both cylinder banks are given the same time specifications (activation/deactivation times) with the same period duration, but they are phase-shifted by half a period. This procedure allows the compressor cooling capacity to be adjusted to a capacity range

between 33 and 100%. In addition, suction- and dischargepressure fluctuations can be reduced to a minimum compared to compressor on/off operation.

Example of adjustment to a compressor cooling capacity of 40 % with the digital DCR22 CO₂ capacity controller:

With a period duration of 20 seconds (Bock recommendation), the following time specifications result:

cylinder bank	Activating time cylinder bank (sec.)	deactivating time cylinder bank (sec.)	Solenoid coil	Remarks
1	2	- - -	de-energised	
1	- - -	18	energised	
2	2	- - -	de-energised	phase-shifted by half a period to cylinder bank 1
2	- - -	18	energised	phase-shifted by half a period to cylinder bank 1

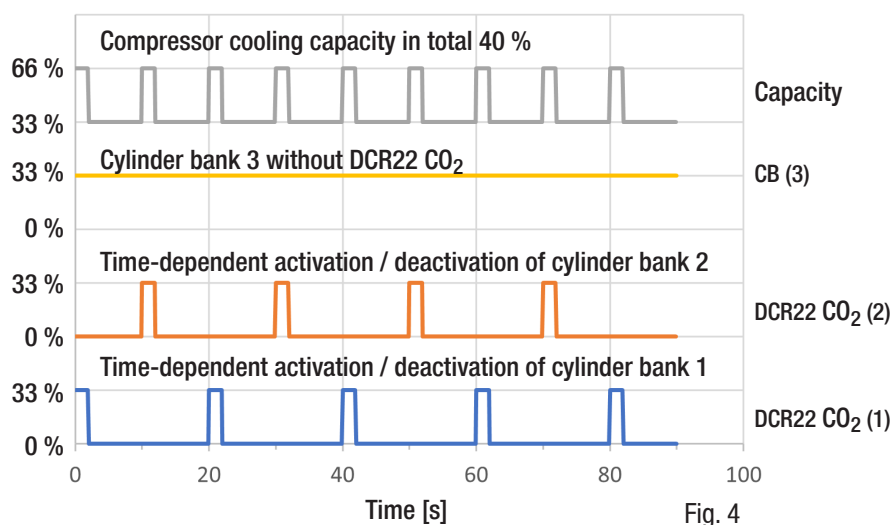


Fig. 4

For capacity requirements < 40 %, the DCR22 CO₂ (2) must be permanently deactivated, the DCR22 CO₂ (1) operates as shown in Fig. 4 with an activation/deactivation time of 2/18 seconds => capacity adjustment to 37 %. If further capacity reduction is necessary, the additional permanent deactivation of the DCR22 CO₂ (1) can reduce the compressor cooling capacity to 33 %. Both cylinder banks are now permanently deactivated.

For capacity requirements > 40 %, the activation times of the cylinder banks are increased linearly and the deactivation times of the cylinder banks are reduced accordingly, while the period duration remains the same.

With a capacity demand of 100 % from the system controller, all cylinder banks are permanently active.

Regulation principle	Number capacity regulators	Performance adjustment	Compressor cooling capacity	Period duration
Digital	2 ¹⁾	stepless	33 - 100 % ¹⁾	20 sec. ²⁾
Conventionally	2	steady	33, 66 or 100 %	-

¹⁾ Taking into account the operating point of the application with regard to discharge- and motor temperature and taking also into account system parameters (such as oil return and regulation behaviour), capacities below 40 % can also be controlled.

For this, the compressor must be equipped with a total of three DCR22 CO₂. Two DCR22 CO₂ are operated digitally (i.e. continuously in alternation). The third DCR22 CO₂ is operated conventionally and in this case permanently deactivates its cylinder bank.

Bock recommends the use of a hot gas temperature sensor (accessory) for this purpose.

For the capacity range < 33 %, it may make sense to increase the period duration (e.g. from 20 s to 30 s => reduction of the switching frequency).

²⁾ Depending on the system behaviour and operating point, a period duration deviating from the Bock recommendation (= 20 seconds) can be selected. This can be in a range of 10 to 60 seconds.

5. Limitations in operation

Thermal load can cause increased restrictions during operation with capacity regulators. The lower the part-load requirements on the compressor, the more unacceptably high discharge temperatures can occur due to the reduced refrigerant mass flow and the associated poorer motor cooling.

For this reason, a thermal protection thermostat is included in the scope of delivery of the DCR22 CO₂.

For further monitoring, Bock recommends the use of a hot gas temperature sensor (accessory).

The oil return from the system to the compressor must be guaranteed (observe general recommendations for system design at part load). The compressor application limits may be restricted depending on capacity regulation and application area. The specified minimum operating times and maximum compressor starts per operating hour must be complied with.

Temperature limits:

- 140° C Warning, if necessary adjustment of the minimum partial load requirement necessary by system controller.
- 150° C max. continuous operating temperature
- 160° C Switch-off temperature via thermal protection thermostat (per cylinder cover)

6. Requirements for the system controller

Due to the high switching frequency of the solenoid coil of the DCR22 CO₂, care must be taken with the control electronics that the outputs are capable of switching inductive loads frequently (observe the specifications of the respective manufacturer).

A system controller for the DCR22 CO₂ is currently not offered by Bock. When programming the DCR22 CO₂ capacity control, any patent regulations or the specifications of the controller manufacturer must therefore be observed!

7. Note on the operating behaviour of the DCR22 CO₂

The DCR22 CO₂ control allows individual cylinder banks to be activated and deactivated quickly. This process directly changes internal operating parameters, resulting in a constantly changing load and varying throughputs in the respective cylinder bank. This results in variable running behaviour and operating noise.

Compressor application limits, drawings, 3-D-Data and further informations, see Bock VAP (compressor selection tool) under vap.bock.de

In the event of inquiries please contact our Department for Application Technology, phone +49 7022 9454-0.