CO2 REMOVAL SYSTEM

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European EMC Products Limited
Unit 7-9 Saffron Business Centre
Elizabeth Close
Saffron Walden
Essex,
CB10 2NL
Registered in England Number 3209118 | VAT Number 676 547 978

www.euro-emc.co.uk
info@euro-emc.co.uk

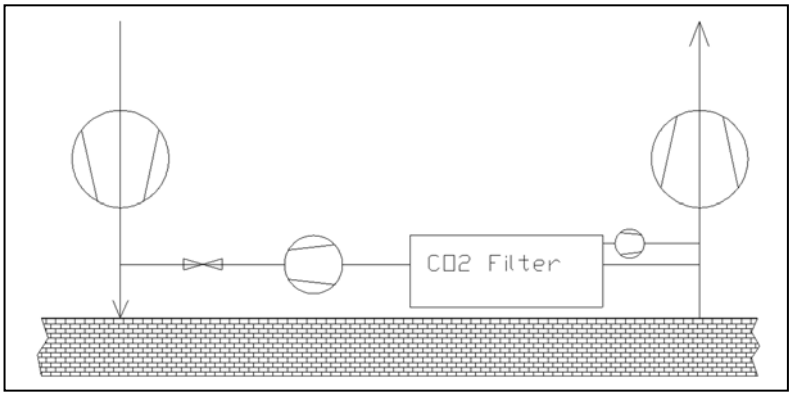
1. Introduction

The sizing of the CO_2 absorption equipment has been based on the following data providedby the customer:

TABLE: CO_2 Absorption Conditions in the Shelter	
Shelter Volume	*608 m^3*
Number of Inhabitants	*22*
Total CO2 Out Breathing rate	*22 x 30 dm^3/h = 0.660 m^3/h*
Assumed Average Indoor Air Temperature	*< 30°C*
Air Circulation	*Once / hour = 608 m3/h = 169 dm3/sec.*
Minimum Residence Time	*1.4 sec.*
Minimum VONEN CO2 Absorbent Bed Volume	*1.4 x 169 dm3 = 236.4 dm3 = 144.7 kg*

The CO_2 Absorption equipment is connected to the shelter's air conditioning ductwork, andit is installed in a most suitable place for efficient air conditioning for the entire shelter.

Figure below: Schematic picture of the CO_2 absorption equipment system installation.



***Picture below:* CO_2 absorption equipment**

2. Operating Principles of CO_2 Absorption Equipment

Carbon dioxide is absorbed by granular amine compound bonded to a porous resin structure. Thechemical reactions are as follows:

Absorption (filtration)

Amine+H_2O -> (Amine-H_2O) and ahead (Amine-H_2O) + CO_2 ⍰ (Amine-H_2CO_3)

Desorption (regeneration)

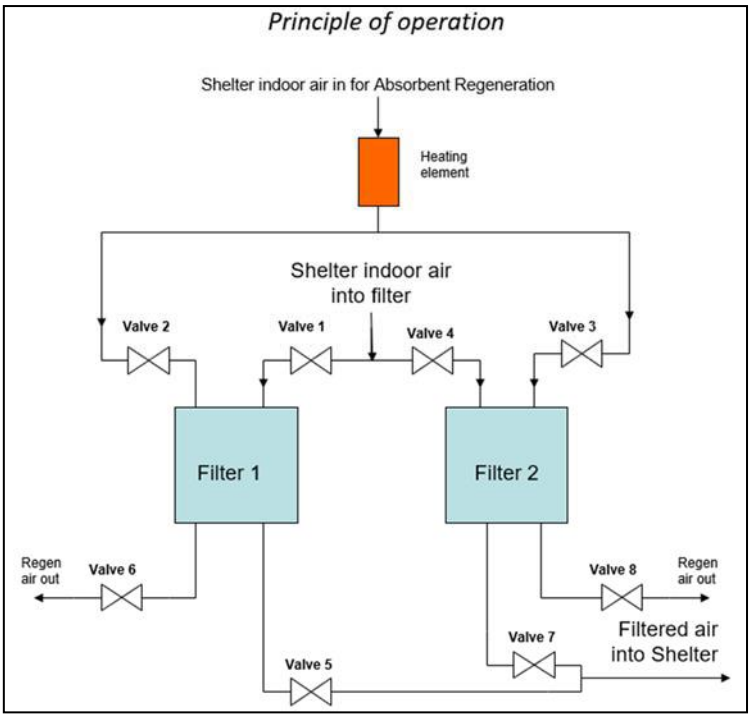
(Amine-H_2CO_3) + heat ⍰ Amine+H_2O + CO_2

As the absorbent becomes exhausted, the weakly bonded carbon dioxide can be desorbed byreversing the process equilibrium, or by heating the absorbent with warm air.

The filter consists of two identical filter units. As one unit is filtering, the other is regenerating andvice versa. Each filtering/ CO2 absorption cycle takes 8 hours (can be modified according to customers' requisites). CO2 probe and control units monitor the CO2 content downstream of the filter. When the CO2 absorbent becomes exhausted, filtrating unit is changed to the other unit and the first unit starts regenerating. The process control unit controls the absorption and regenerating cycles automatically, so no user actions are required.

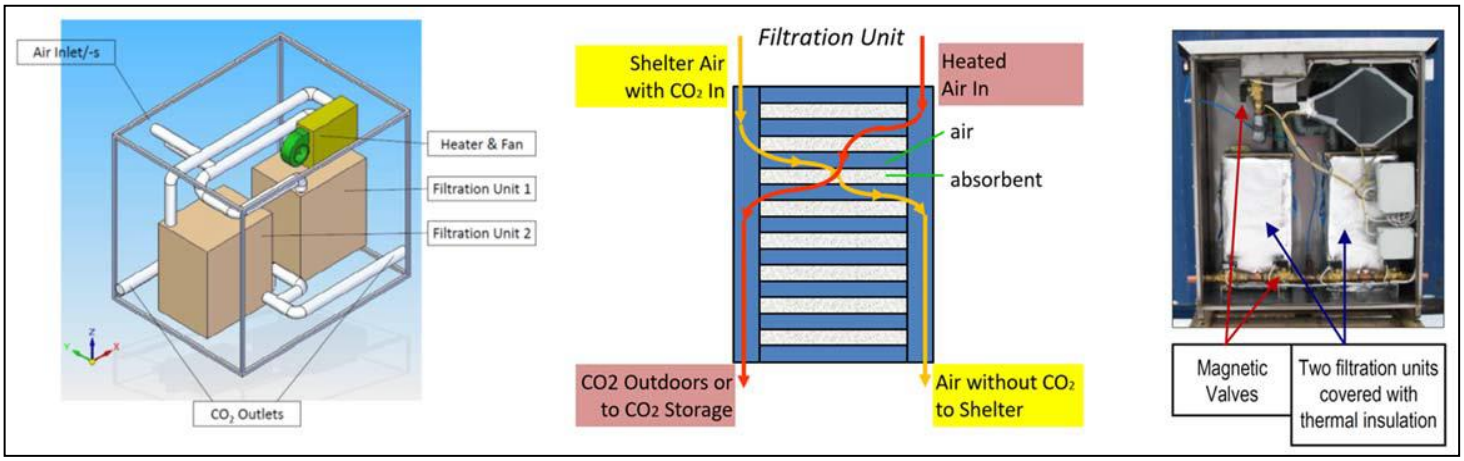
During filtration, the butterfly (wafer) valves of the filtering unit are open, and the shelter indoorair flows through the filter unit and is then circulated back to the shelter interiors.

Picture below illustrates principle of operation:

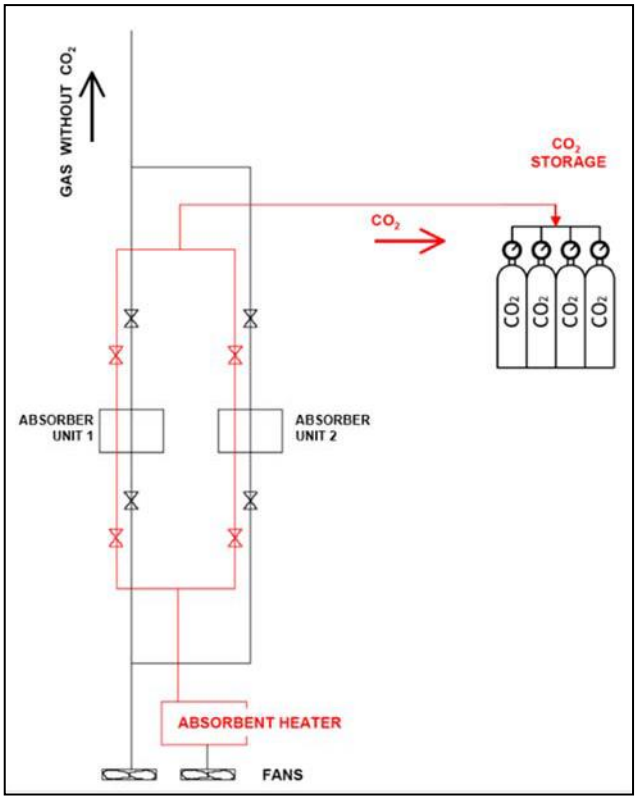


Regeneration is an automatic process controlled by the process control unit. During regeneration,the butterfly valve to shelter interiors is closed. The air heating unit vacuums and heats indoor air,which then heats up the CO2 absorbent. The heated air containing high levels of CO2 is released outdoors or to CO2 storages (see Figure on next page).

Overheat protection is done with two temperature-controlled switches, which open at < 200 °C.



Picture below: Carbon Capture - Heated air withhigh levels of CO2 is released to CO2 storages.



Control unit

The process control unit is Siemens 12/24RC 6ED1 052-1MD00-0BA6.

The unit works with24 VDC and is powered by 6EP1332-1SH42.

Additional relay unit DM8 12/24R 6ED1 055-1MB00-0BA1 is also used.

Valve Control

Valve operation is controlled by outputs Q1 and Q2.

The valves operate in 2 groups, valves1, 5, 3 and 8 are the first group connected to the output Q1

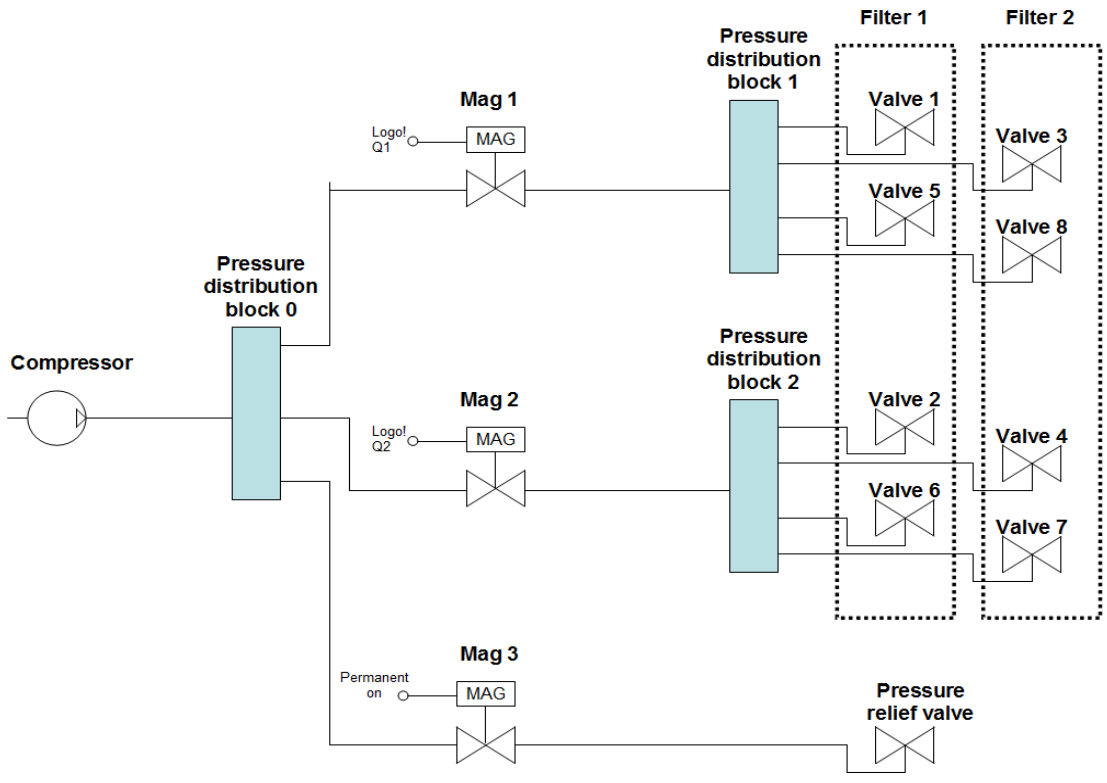
The second group, valves 2, 6, 4 and 7 are connected to the output Q2

Valves are of pneumatic type and spring return ones.

Valve control schematics is illustrated in the figure 2.

The compressor produces pressurized air for valves.

Pressure is fed through magnetic valves to the filter valve groups.



Pressure relief valve

Pressure relief valve is a pneumatic valve with spring return. It is constantly connected to the electrical inlet of the filtration unit. When electricity and therefore pressurized air is available, thesafety relief valve is closed. In case of power failure or lack of pressurized air the safety valve opens and allows bypass through the filtration unit.

3. Technical Data - CO_2 Absorption Equipment

- Dimensions – see drawings in ENCLOSURES.
- Total operating weight of the filter with absorbent cells installed: Approx. 800 kg.
- Absorber Casing fabricated from AISI 304 Stainless Steel (Option 316L SS).
- Design Pressure: Atmospheric.
- Absorbent: An amine compound in Ø 1 mm polystyrene granules, 245 litres / eachCO2 unit
- Weight of absorbent in one filtering unit: 150 kg; 300 kg total per the two filtering units of the filter.
- Residence Time during CO2 absorption: 1.5 sec.
- CO_2 Absorbent Design Temperature *during CO2 absorption*: 0° - 50°C.
- Magnehelic zero-centre pressure gauge to indicate pressure drop.
- Connections / Flanges: According to customer's specifications.
- OPTION: Surface treatment of casing: Pickling.

Technical Details - CO2 Absorption Equipment	
Dimensions, length x width x height, mm	3400 x 1800 x 2300 – Can be revised if required
Power Supply	230VAC 50 Hz or according to customer's specification
Power Input, Filtration Low/High	200 W / 400 W
Power Input / Regeneration L/H	2 kW
Total Consumption / Regeneration, approx.	7 kWh
Airflow / Filtration Low/High	max. 608 m3/h, 169 liters/sec.
CO2 Absorption Capacity	approx. 900 liters
Sound Level dB(A) Low/High	47 dB / 54 dB
Voltage / Fan / Filtration Low/High	140/180 VAC
Airflow / Regeneration	25 l/s; 90 m3/h
Power Input / Heating element	2 kW
Voltage / Fan / Regeneration	90VAC

4. Performance - CO_2 Absorption Equipment

- Filtration Efficiency: Up to 100% at 25°C, 608 Nm^3/h absorption rate *).
- Residence Time: Approx. 1.45 sec at 608 m^3/h CO_2 absorption rate.
- Pressure Drop at 608 m^3/h absorption rate:
  - Pre-Filters Clean: approx. 90 Pa
  - Pre-Filters Dirty: approx. 200 Pa **).

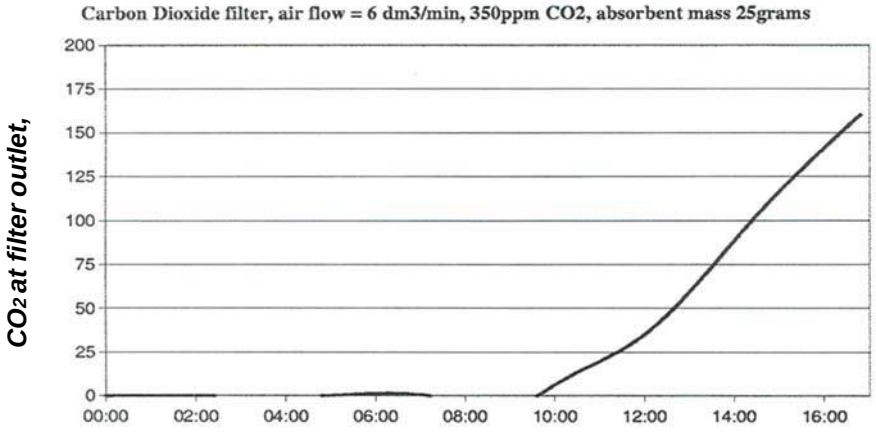
*) *Filtration efficiency decreases gradually as the absorbent saturates. Ideal inlet air conditions:*

1) Air Temperature: between 0 and 50°C. A higher temperature can weaken the efficiency. Below 0°C humid absorbent freezes and is not capable of absorbing CO2.

2) 50% Relative Humidity. No CO2 absorbent performs well in dry air. It is our view that the 30% RH, although low, isenough for good CO2 absorption.

***) The duct-line (from the 169 m2 Shelter space to the CO2 Absorber unit) pressure drop must be added to the pressure drop caused by the Absorber Unit.*

Picture below: CO2 Absorption Capacity of 25 grams of, Temperature 22°C; Ambient Pressure:



x axis: time, hours

5. Maintenance of CO_2 Absorption Equipment

Pre filter replacement

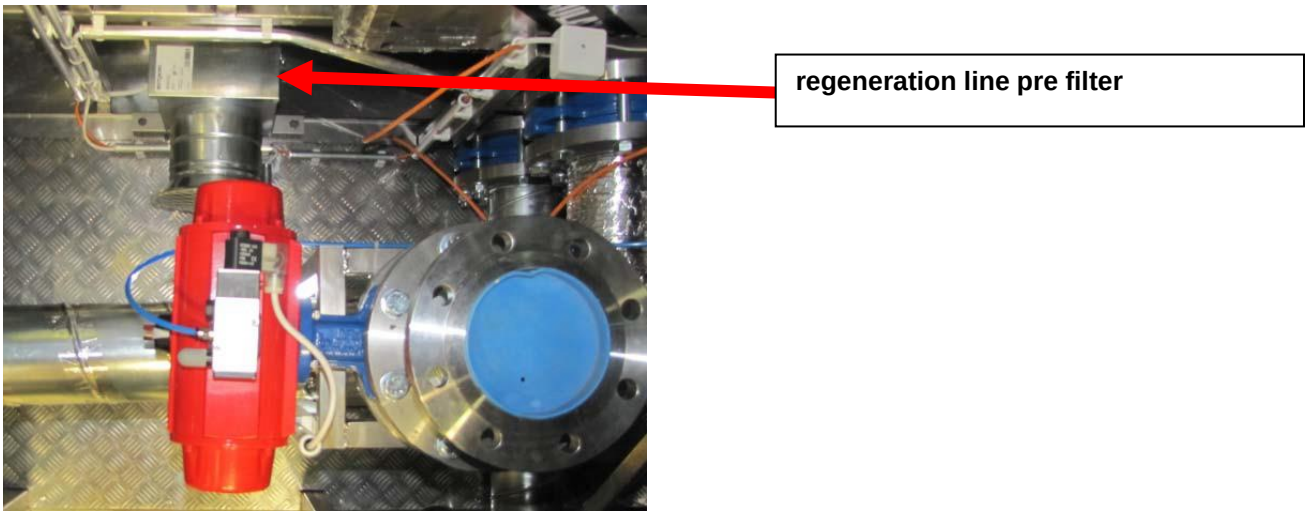
The pre filters are located inside the breather unit. The service life of pre filters depends on the amount of dust particles in the indoor air. Normally the filters are replaced once or twiceper year. Regeneration inlet pre filter is located upstream of the regeneration fan, near the floor of the filtration unit. Filtration inlet filters are located before filtration inlet valves.

CO2 Absorbent replacement

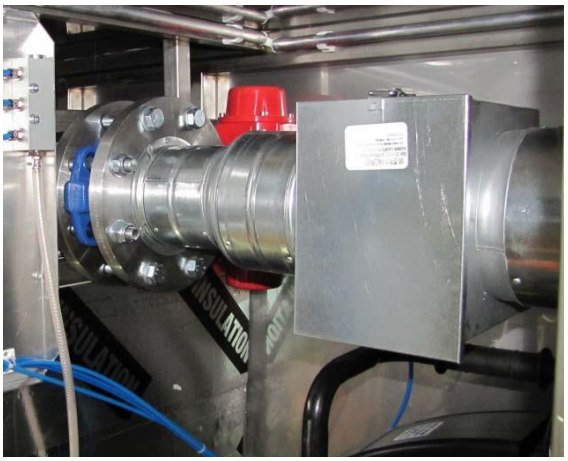
The absorbent cells have to be stored in their vacuum packings. Depending on the frequency and duration of the operation, the absorbent cells must be replaced after approx. 180 days' use.

The CO2 breather filter itself is maintenance free, the CO2 filter material has a long time depending on several conditions. The user needs only take care of the exchange of pre filters in the regeneration inlet and filtration inlets. The excess water must also be removed from thecompressor unit.

Figure below: Regeneration air inlet pre filter.



Pictures below: Left and right air inlet pre filters.



6. Spare parts for 2 years' operation

At the maximum 608 Nm^3/h filtration air flow, the residence time is ideal 1.5 seconds. Depending on the monthly filtration rate, we estimate that the consumption of absorbent cells is roughly approx. one set for six months of operation. Since the initial set of absorbentcells is included in the equipment price and delivery, we estimate that you will not need anyadditional sets of absorbent cells unless the cells have been removed from their vacuum packings and been installed in the equipment, and further the absorber has been operating for at least six (6) months.

The *pre-filters* can be cleaned with a vacuum cleaner or by beating gently, but they cannot bewashed. The cleaning should be done after the pressure drop indicated by the differential pressure gage has increased by 100-120 Pa. Pre and post filters should be replaced after the filter media has started to deteriorate.

7. Documentation

A) Manufacturer's ISO 9001 Certificate.
B) Certificates of Conformity.
C) As-Built Drawings.
D) Absorber Data Sheets.
E) Material Certificates (EN 10204/3.1).
F) Dimensional Control Reports.
G) Leak Test Reports.
H) Factory Acceptance Reports.
I) IO&M Instructions.

Additional documentation is issued according to separate agreement.