User Manual

HiCap™ CO_2 - Sofnolime® carbon dioxide large absorber cartridge

Introduction

The large scale absorber cartridges are available in two formats one for the removal and control of carbon **dioxide** (CO_2) and the other for the removal and control of the much more toxic carbon **monoxide** (CO). Both units use the same crate design to hold the active constituents and are the same physical size (Figure 1). The units are differentiated by labelling and require different operating conditions to produce the specified performance. The units are designed to seal against the base plate cut-out of fan driven air supply equipment.

Figure 1 - dimensions

- Length (mm): 400
- Width (mm): 300
- Height (mm): 170
- Total weight (kg): 14
- Base cut out (mm) 270 x 370

The performance and normal running conditions for each type of unit is described below. The carbon dioxide units are normally required to remove CO_2 that is being continuously produced by people exhaling CO_2 at a steady rate for extended periods of time; hours or days. Whereas the carbon monoxide units are normally required to remove an initial high concentration of carbon monoxide to low levels as fast as is practical; usually within minutes. Each unit is supplied with a removable top and base seals to protect against gas and water contamination to ensure the cartridges are protected and remain active during storage.

Each unit is provided with a flexible gasket around the base which provides a gas tight seal when deformed by the weight of the unit against a cut-out in a base unit designed to accommodate the unit. The size of the base cut-out needs to be 270 x 370 mm (+/- 1 mm). The air stream is normally passed up through the unit (base to top) but the units will operate with the flow reversed. However, the flow should not be reversed during operation as this will reduce the usable capacity.

It is important that procedures are in place to allow safe deployment of the units before they are required. *It is the responsibility of the facility operators to ensure these procedures are adequate for the intended purpose and that training is provided to all personnel who may need to use the units before they are required to use them.* The descriptions below assume the units are deployed in an enclosed volume that allows free circulation and good mixing of air to and from the units.

HiCap™ - Sofnolime® carbon dioxide large absorber cartridge

This unit uses Sofnolime® as the absorbent which chemically reacts with the carbon dioxide to remove it from the air stream. The carbon dioxide is chemically removed and cannot be regenerated from the unit. The unit is designed to remove CO_2 produced by respiration of personnel in an enclosed sealed space. The time each cartridge will last depends on the gas flow rate through the unit, the volume of the enclosed space and the number of people present (see Table 1 for operational performance). Multiple units should be used simultaneously when the enclosure volume or number of people require it. Each unit is designed to be incorporated into a fan driven, purpose built ventilation system designed to run with a nominal airflow of 400 litres per minute gas flow through each cartridge. Gas flows below 200 litres per minute will not damage the units but will reduce the CO_2 removal rate substantially from the figures used in Table 1. Gas flow rates above 600 litres per minute will reduce the time that the CO_2 levels can be maintained at low levels and may reduce the effective CO_2 removal capacity under normal operating conditions.

The units can be deployed immediately on sealing the refuge or space in which they operate, or they can be deployed when the CO_2 level reaches a predefined level. There is usually not a great urgency to deploy the units in the first minutes as the CO_2 level can safely be allowed to rise slightly (up to 1 -2 % CO_2) without significant physiological effects on the occupants of the space.

Sufficient cartridges need to be available to provide CO_2 control to the required level for the specified duration that the space will be occupied.

Operating instructions: carbon dioxide (CO_2) removal

1. Remove the top and base blue seals by lifting the tags and pulling outwards. This will also tear the tamper evident seal and show that the unit has been opened.
2. Check that the base' seal gasket is in place and intact, then place the unit onto the base unit aperture.
3. Warning: all the base (fan) unit apertures must have cartridges installed for correct operation**.** If the base unit has more than one aperture ensure all the apertures are covered with installed cartridges. Use an exhausted cartridge if there are no fresh units available.
4. Start the airflow through the cartridge(s) – refer to the OEM base unit operating procedure.
5. Exhausted units should be removed and replaced with fresh units once they are incapable of removing the CO_2 at the rate it is being produced.
6. In a multi-aperture base unit, if the some units are exhausted and fresh ones are not available, the exhausted units should be left in place.
7. Exhausted units can be left in place. Used Marcisorb™ CO_2 units will continue to remove CO_2 for some time after the specified performance but at much lower rates. Warning: the enclosure CO_2 concentration will start to increase once the CO_2 *removal rate* falls below the production rate irrespective of the remaining *capacity.*
8. If the top and base seals are replaced on used units (to facilitate storage) then they should be stored in such a way that the tamper evident seal (showing open/ void) is clearly visible to prevent re-use of used exhausted units.

Sufficient cartridges need to be available to provide carbon dioxide control from the intended duration of stay for the rated number of people present in the enclosure or shelter. Refer to the HiCap™ CO_2 user manual or equipment manufacturer's manual for correct use of the system.

Deployment (for carbon dioxide removal)

The number of units required is determined primarily by the number of people present, but also by the volume of the enclosed sealed space. The number of people determines the required CO_2 removal ***capacity*** and the volume of the enclosed space determines the minimum required removal ***rate*****.** The total CO_2 removal rate needs to be greater than the CO_2 production rate or the CO_2 level will continually increase. The deployed CO_2 capacity will determine the time interval that the unit(s) can run before they need to be changed for fresh units. Table 1 shows typical data for a range of operational conditions for people relaxed and exhaling an average of 0.24 l/minute (14.4 l/hr) CO_2. Table 2 shows the same data for a higher CO_2 exhalation rate of 0.4 l/minute (24 l/hr) CO_2. The main body of the table (shaded in blue) shows the normal operating range. The red shaded areas show marginal or non-recommended conditions.

Select the volume of the enclosure in the left column then select the column with the maximum number of people in the top row. The intersection gives the minimum number of units that should be used to provide an acceptable removal rate. The value to the right of this gives the expected time the unit(s) will run between changes. More units than this minimum will maintain a lower CO_2 concentration for a longer time interval. The time interval between changes will depend on the number of people present and their activity level. The best way of operating the units to ensure maximum usable capacity is to monitor the CO_2 level in the enclosed space and change the units when the CO_2 concentration reaches a predetermined level – typically 1 or 2 % CO_2.

The supplementary information is provided to allow other conditions to be calculated if required.

Table 1 – typical data for a range of normal operating conditions – people at rest.

(**Assumes: 0.24 l/min CO_2 per person**; 1,500 l/CO_2 per unit; 400 l/min air flow rate per unit and 1% max CO_2 inlet concentration)

			for 1% CO_2 max						
Volume of enclosure	No of people 1 to 10	run time (hr)	11 to 20	run time (hr)	21 to 30	run time (hr)	31 to 40	run time (hr)	No units for 1 air change per hour
m^3	min No. units		min No. units		min No. units		min No. units		
10	**1**	**10.42**	**1**	**5.21**	1	3.47	1	2.60	0.42
20	**1**	**10.42**	**1**	**5.21**	1	3.47	1	2.60	0.83
30	**2**	**20.83**	**2**	**10.42**	**2**	**6.94**	2	5.21	1.25
40	**2**	**20.83**	**2**	**10.42**	**2**	**6.94**	**2**	**5.21**	1.67
50	3	31.25	**3**	**15.63**	**3**	**10.42**	**3**	**7.81**	2.08
60	3	31.25	**3**	**15.63**	**3**	**10.42**	**3**	**7.81**	2.50
70	4	41.67	4	20.83	**4**	**13.89**	**4**	**10.42**	2.92
80	4	41.67	4	20.83	**4**	**13.89**	**4**	**10.42**	3.33
90	4	41.67	4	20.83	**4**	**13.89**	**4**	**10.42**	3.75
100	5	52.08	5	26.04	5	17.36	**5**	**13.02**	4.17
max people	10		20		30		40		
max CO2 l/hr	144		288		432		576		
No units per hr	0.096		0.192		0.288		0.384		
1 unit lasts (hr)	10.42		5.21		3.47		2.60		

Table 2 – typical data for a range of normal operating conditions people entrapped [1)]

(**Assumes: 0.4 l/min CO_2 per person**; 1,500 l/CO_2 per unit; 400 l/min air flow rate per unit and 1% max CO_2 inlet concentration)

			for 1% CO_2 max						
Volume of enclosure	No of people 1 to 10	run time (hr)	11 to 20	run time (hr)	21 to 30	run time (hr)	31 to 40	run time (hr)	No units for 1 air change per hour
m^3	min No. units		min No. units		min No. units		min No. units		
10	**1**	**6.25**	**1**	**3.13**	1	2.08	1	1.56	0.42
20	**1**	**6.25**	**1**	**3.13**	1	2.08	1	1.56	0.83
30	**2**	**12.50**	**2**	**6.25**	**2**	**4.17**	2	3.13	1.25
40	**2**	**12.50**	**2**	**6.25**	**2**	**4.17**	**2**	**3.13**	1.67
50	3	18.75	**3**	**9.38**	**3**	**6.25**	**3**	**4.69**	2.08
60	3	18.75	**3**	**9.38**	**3**	**6.25**	**3**	**4.69**	2.50
70	4	25.00	4	12.50	**4**	**8.33**	**4**	**6.25**	2.92
80	4	25.00	4	12.50	**4**	**8.33**	**4**	**6.25**	3.33
90	4	25.00	4	12.50	**4**	**8.33**	**4**	**6.25**	3.75
100	5	31.25	5	15.63	5	10.42	**5**	**7.81**	4.17
max people	10		20		30		40		
max CO2 l/hr	240		480		720		960		
No units per hr	0.16		0.32		0.48		0.64		
1 unit lasts (hr)	6.25		3.13		2.08		1.56		

[1)] Criteria for the design of refuge stations Drake, Fellow & Bates

Effect of moisture

The Sofnolime® absorbent needs some water vapour to be present to work efficiently. The optimum required amount of water is incorporated into the material as supplied. High humidity air flow through the units will not harm the units and indeed will help maintain optimum performance providing liquid water is not allowed to enter the cartridge. Adding extra liquid water to the cartridge will decrease the capacity by causing local flooding in the absorber that prevents air flow. High air flow rates of very dry air passed through the unit for extended periods of time can limit the CO_2 removal rate towards the end of the use period if the unit becomes unduly desiccated. Therefore it is recommended that when units are used in very low humidity conditions (<50% RH), that the operating procedures design takes the run time into account and limits the operating period of the individual units to less than about 15 to 20 hours i.e. change out times should be less than this. For enclosure volumes greater than 100m^3 please consult the manufacturer.

Storage, maintenance and condition checks

The units do not require any maintenance in storage but do need to be stored in such a way that the top and base seals continue to prevent moisture or contamination entering the unit.

- The units need to be handled and stored under conditions that prevent damage to the seals.
- The units should be stored between 0 – 35°C, out of direct sunlight and protected from wet conditions. The units will not work if the water, present in the material, is frozen.
- Each unit is marked with a label on the outside of the packaging that shows the original packed weight of the unit.

The units can lose moisture if the packaging is damaged therefore the weight change can be used as a measure of the seal integrity and the condition of the unit.

- If the weight changes by more than the weight allowed and shown on the label, then unit should be replaced.
- This weight change allowance assumes the weight change is due to water loss or contamination and indicates the point at which the unit starts to work less efficiently than documented here.

The units gain weight (approximately 1 kg) in normal use, therefore if a unit is weighted, the label on the side of the cartridge itself can be used to check if unit have been used.

Residual risks

The units produce heat as the reaction of CO_2 proceeds. This temperature can reach approximately 50°C at the outlet. Consideration of this additional heat load should be incorporated into the design of the system in which it is to be used.

Disposal of used or time expired units

The units are constructed from polypropylene which can be recycled when emptied and cleaned. The units cannot be refilled as this will not give a reliable or known performance. The fill can be disposed of to land fill via a licensed waste disposal contractor. A material safety data sheet (SDS)

for the Sofnolime™ absorbent is available on request. Local legislation may apply to disposal or recycling. Advice on individual cases can be sought from the manufacturer or your local supplier.

Specification

- **Carbon dioxide capacity**: greater than 1,400 litres (@ 400 l/min to 0.5% CO_2 at outlet)
- **Carbon dioxide capacity**: greater than 1,500 litres (@ 400 l/min to 1% CO_2 at outlet)
- **Normal operating gas flow rate**: 400 litre per minute per unit
- **Operational flow rates**: 200 to 600 litres per minute per unit
- **Pressure drop per unit**: not more than 14 mm H_2O gauge at 400 litres per minute flow
- **Pressure variation between units**: not more than 4 mm H_2O gauge (provisional)
- **Dimensions**: 400 x 300 x 180 mm
- **Unit weight** (as delivered): 14 kg
- **Storage life**: 5 years (condition can be monitored by weight change)

The data provided above is intended for general guidance and does not necessarily cover all the operational aspects of the units. Each individual case needs to be properly assessed for safe operation by the facility managers.

Further advice and help in producing your own operational procedures for the safe deployment of the large absorber cartridges is available on request from the manufacturer.

Conditions of use and limit of liability – HiCap™ CO_2 – Sofnolime® filled large absorber cartridge

The units are designed to be used as part of a purpose built air purification system that can operate within the documented design parameters. No liability or guarantee of performance can be accepted for units operated outside these conditions.

The performance is guaranteed only if the units are used and stored within the declared operational limit set by the manufacturer and documented in the user manual.

The units are supplied with tamper evident seals. The base and top seal **must not be removed** until the unit is required for use as the unit can lose or gain water from the atmosphere that can reduce its CO_2 removal performance. The performance of units that have been opened, but not used, for more than a few hours cannot be guaranteed or predicted.

Units with damage to the blue top and base seals should not be used. The units are supplied with a weight check and weight tolerance label that allows the user to establish if the units have remained sealed prior to use. The use of units that have failed this weight check requirement, or that have been damaged, cannot be guaranteed by the manufacturer as the performance may be affected.

The way the units are used are the responsibility of the user and/or facility operator. It is strongly recommended that the facility operator should carry out a risk assessment of the way in which the unit(s) are to be used before they are deployed.

The units comply with the essential safety requirements of the EU Mechanical Directive and are labelled accordingly.

Appendix 1 – air recirculation equipment interface requirements

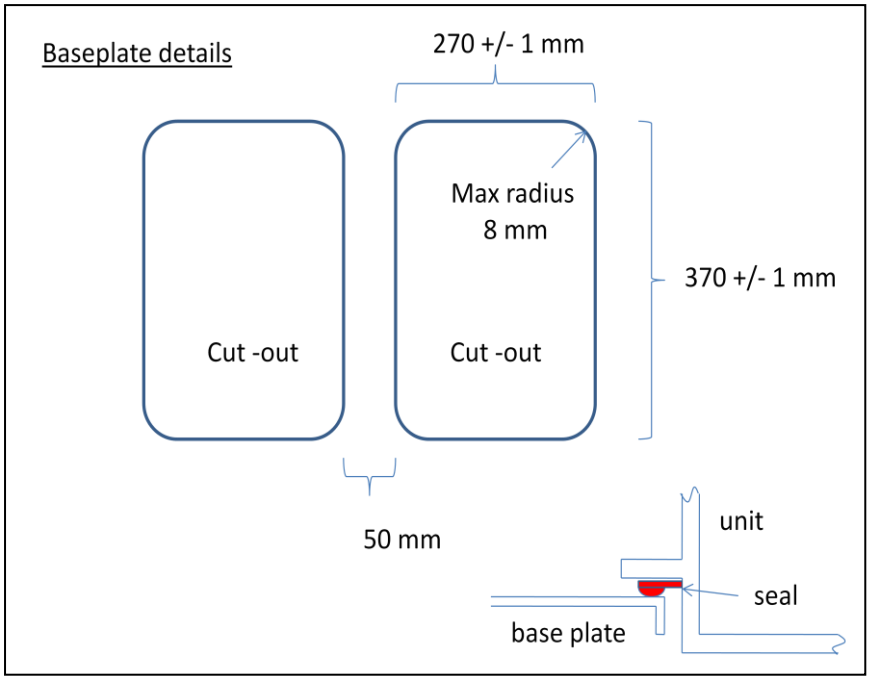
The units are designed to seal against the base plate cut-out of fan driven air supply equipment.

This base plate cut-out design allows the unit's base seal to provide a gas tight seal under the weight of the unit. In order to achieve this, the base plate needs to be flat with a cut-out of the correct size to allow the seal to function.

The units weigh circa. 15kg – 33lbs each so the base plate must be sufficiently stiff to support the weight and prevent distortion of the base plate preventing the seal from working. It is recommended that the base plate should be constructed from a flat stainless steel sheet that is sufficiently thick, or stiffened, to prevent distortion in use. A turned over edge is preferred to prevent sharp edges damaging the seals or the fingers of the operators. The recommended dimensions are given below.

Base cut-out dimensions

- Length 370 mm +/- 1 mm
- Width 270 mm +/- 1 mm
- Maximum radius of corners 8 mm (but can be any value less)
- Minimum recommended separation between units – 50 mm between inside edges of cut-outs



If the units need to be secured in position, the top edge of the base flange can be used to clamp against. Care should be exercised to ensure the base seal is not distorted to the point it fails to seal if the units are fastened or clamped in position. The outside edge of the upper surface can be used to seal against if the units are to be used in a fully ducted system.

The provision of air flow through the unit is the responsibility of the equipment provider, but it is advised that the airflow should be blown from base to top, up through the units. The units should not encounter reversed gas flow during use as this will reduce the capacity of the units.

Please contact the manufacture if advice is required on non-standard operating conditions. Units must remain sealed until ready for use. Opened, unsealed units, left on the base for extended

periods of time, may have significantly reduced performance. Only remove the top and base blue seals immediately before use.

Molecular Products Ltd

Parkway, Harlow Business Park
Harlow, Essex, CM19 5FR, UK

T +44 (0)1279 445111
F +44 (0)1279 401231

E sales@molprod.com
W www.molecularproducts.com