HiCap™ CO_2

Sofnolime® Carbon Dioxide Large Absorber Cartridge.

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The data provided is intended for general guidance and does not necessarily cover all the operational aspects of the cartridges. 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.

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Important note to operators

- **The cartridge is designed to remove carbon dioxide from an enclosed environment as part of a life support system. Consideration needs to be given to any oxygen supply requirements.**

- **This unit is for professional use only and will therefore require operators to be suitable trained.**

A user manual is supplied, but it is the responsibility of the facility operators to supply an operating procedure and training for the end users appropriate for the intended location and conditions.

It is suggested that the supplied user manual should be used to form the basis of the local operating procedure and basic training to the end users. This procedure and training will be specific to a location and depend on the end users requirements.

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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 cartridges use the same crate design to hold the active constituents and are the same physical size (Figure 1). The cartridges are differentiated by labelling and require different operating conditions to produce the specified performance. The cartridges 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 cartridge is described below. The carbon dioxide cartridges 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 cartridges are normally required to remove an initial high concentration of carbon monoxide to low levels as fast as is practical; usually within minutes. Each cartridge is supplied in a sealed gas and water resistant barrier foil packaging to ensure the cartridges are protected from contamination and remain active during storage.

Each cartridge is provided with a seal round the base which provides a gas tight seal when deformed by the weight of the cartridge against a cut-out in a base unit designed to accommodate the cartridge. 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 cartridge (base to top) but the cartridges 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 the procedures are in place to allow safe deployment of the cartridges 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 cartridges before they are required to use them. The descriptions assume the cartridges are deployed in an enclosed volume that allows free circulation and good mixing of air to and from the cartridges.

HiCap™ CO_2 - Sofnolime® Carbon Dioxide Large Absorber Cartridge

This cartridge 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 cartridge. The cartridge 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 cartridge, the volume of the enclosed space and the number of people present - see Table 1 for operational performance. Multiple cartridges should be used simultaneously when the enclosure volume or number of people require it. Each cartridge 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 cartridges 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 cartridges can be deployed immediately on sealing the refuge of 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 cartridges 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 outer foil barrier film (a safety blade is provided with each cartridge)
2. Check that the bases seal is in place and intact, then place the cartridge 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 cartridges available
4. Start the airflow through the cartridge(s) – refer to the OEM base unit operating procedure
5. Exhausted cartridges should be removed and replaced with fresh cartridges 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 cartridges are exhausted and fresh ones are not available the exhausted cartridges should be left in place
7. Exhausted cartridges can be left in place – used HiCap™ CO_2 cartridges 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

Deployment (for carbon dioxide removal)

The number of cartridges 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 production rate or the CO_2 level will continually increase. The deployed CO_2 capacity will determine the time interval that the cartridge(s) can run before they need to be changed for fresh cartridges. The CO_2 production rate will change with respiration rate or may be set by the relevant legislation.

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 cartridges that should be used to provide an acceptable removal rate. The value to the right of this gives the expected time the cartridge(s) will run between changes. More cartridges 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 cartridges to ensure maximum usable capacity is to monitor the CO_2 level in the enclosed space and change the cartridges 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 cartridge; 400 l/min air flow rate per cartridge and 1% max CO_2 inlet concentration)

Volume of enclosure	No. of people 1 to 10	run time (hr)	No. of people 11 to 20	run time (hr)	No. of people 21 to 30	run time (hr)	No. of people 31 to 40	run time (hr)	No. cartridges for 1 air change per hour
m^3	min No. cartridges		min No. cartridges		min No. cartridges		min No. cartridges		
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 no. of people	10		20		30		40
max CO_2 l/hr	144		288		432		576
No. cartridges per hr	0.096		0.192		0.288		0.384
1 cartridge lasts (hr)	10.42		5.21		3.47		2.60

Normal operating range

Marginal or non recommended conditions

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

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 cartridge; 400 l/min air flow rate per cartridge and 1% max CO_2 inlet concentration)

Volume of enclosure	No. of people 1 to 10	run time (hr)	No. of people 11 to 20	run time (hr)	No. of people 21 to 30	run time (hr)	No. of people 31 to 40	run time (hr)	No. cartridges for 1 air change per hour
m^3	min No. cartridges		min No. cartridges		min No. cartridges		min No. cartridges		
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 no. of people	10		20		30		40
max CO_2 l/hr	240		480		720		960
No. cartridges per hr	0.16		0.32		0.48		0.64
1 cartridge lasts (hr)	6.25		3.13		2.08		1.56

Normal operating range

Marginal or non recommended conditions

ref [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 cartridges will not harm the cartridges 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 cartridge for extended periods of time can limit the CO_2 removal rate towards the end of the use period if the cartridge becomes unduly desiccated. Therefore it is recommended that when cartridges 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 cartridges to less than about 15 to 20 hours i.e. change out times should be less than this. For volumes greater than 100m^3 please consult the manufacturer.

Storage, Maintenance and Condition checks

The cartridges do not require any maintenance in storage but do need to be stored in such a way that the barrier foil packaging prevents moisture or contamination entering the cartridge.

- The cartridges need to be handled and stored under conditions that prevent damage to the barrier foil packaging i.e. avoid sharp objects or pressure points puncturing the packaging.
- The cartridges should be stored between 0–35C°, out of direct sunlight and protected from wet conditions. The cartridges will not work if the water, present in the material, is frozen.
- Each cartridge is marked with a label on the outside of the packaging that shows the original packed weight of the cartridge.

The cartridges can loose 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 cartridge.

- If the weight changes by more than the weight allowed shown on the label, then cartridge 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 cartridge starts to work less efficiently than documented here.

The cartridges gain weight (approximately 1 kg) in normal use.

Residual risks:

The cartridges 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. HiCap™ CO_2 contains Sofnolime® which is an Irritant, a MSDS is available on request.

Disposal of used or time expired cartridges

The cartridges are constructed from polypropylene which can be recycled when emptied and cleaned. The fill can be disposed of to land fill via a licensed waste disposal contractor. A material safety data sheet 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 cartridge
Operational flow rates	200 to 600 litres per minute per cartridge
Pressure drop per cartridge – not more than	14 mm H_2O gauge at 400 litres per minute flow
Pressure variation between cartridges - not more than	4 mm H_2O gauge (provisional)
Dimensions	400 x 300 x 180 mm
Cartridge weight (as delivered)	14 kg
Storage life	5 years (condition can be monitored by weight change)

Conditions of use and limit of liability – HiCap™ CO_2 - Sofnolime® Filled Large Absorber Cartridge

The cartridges 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 cartridges operated outside these conditions.

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

The cartridges are supplied in a sealed barrier foil bag. The seal must not be broken until the cartridge is required for use as the cartridge can loose or gain water from the atmosphere that can reduce its CO_2 removal performance. The performance of cartridges that have been opened, but not used, for more than a few hours cannot be guaranteed or predicted.

Cartridges with damage to the sealed packaging should not be used. The cartridges are supplied with a weight check and weight tolerance label that allows the user to establish if the cartridges have remained sealed prior to use. The use of cartridges that have failed this weight check requirement or that have damaged packaging cannot be guaranteed by the manufacturer as the performance may be affected.

The way that the cartridges are used is 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 cartridge(s) are to be used before they are deployed.

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

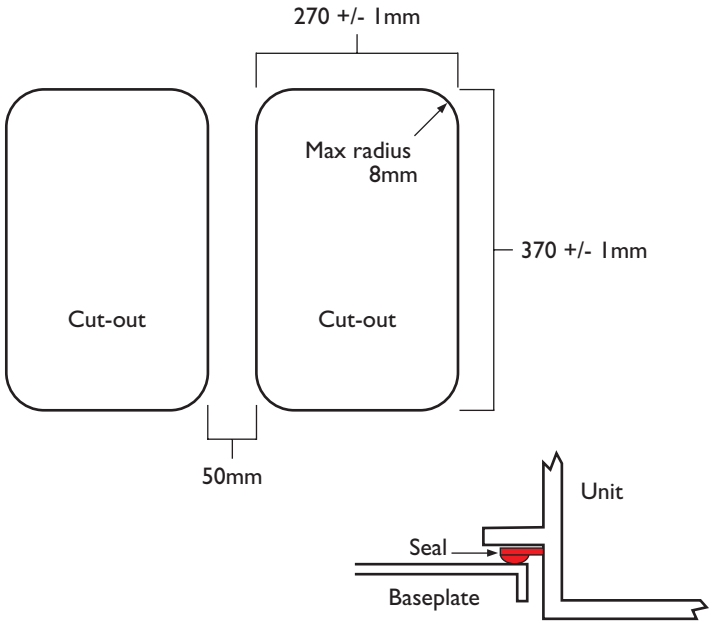
Appendix 1 – air recirculation equipment interface requirements

The cartridges are designed to seal against the base plate cut-out of fan driven air supply equipment.
This base plate cut-out design allows the cartridge's base seal to provide a gas tight seal under the weight of the cartridge. 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 cartridges 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 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 cartridges – 50 mm between inside edges of cut-outs.

Baseplate details



If the cartridges 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 cartridges are fastened or clamped in position. The outside edge of the upper surface can be used to seal against if the cartridges are to be used in a fully ducted system.

The provision of air flow through the cartridge is the responsibility of the equipment provider but it is advised that the airflow should be blown from base to top up through the cartridges. The cartridges should not encounter reversed gas flow during use as this will reduce the capacity of the cartridges. Please contact the manufacture if advice is required on non-standard operating conditions. Cartridges must remain sealed until ready for use. Opened, unsealed cartridges left on the base for extended periods of time may have significantly reduced performance. Only remove the barrier sealing foil immediately before use. The foil barrier film is a strong material and a safety blade is provided with each cartridge. The packaging cannot be torn fully open by hand.

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