THE FIRST MAJOR ADVANCEMENT IN CO_2 ABSORBENT TECHNOLOGY SINCE 1924

SpiraLith® Ca
CO_2 ABSORBENT

THE SOLID CHOICE®

"Differences in CO_2 absorbent formulations can translate into significant performance differences."

Micropore.

A world leader in **rebreathing** and **life support** applications

Micropore is a Delaware corporation founded in 1997 and located in Elkton, Maryland.

We package fine powder chemistries into solid absorbent cartridges used to absorb carbon dioxide in rebreathing and life support systems. Micropore products utilizing our patented Solid Absorbent Technology™ significantly outperform granular absorbents and make a difference in the lives of people spanning a wide range of Military, Medical, Submarine, Mining, Diving, Fire-Fighting and Space Exploration applications.

This technology is the first major advance in CO_2 absorbent science in over 100 years and is marketed under the ExtendAir®, MicroSep® and SpiraLithCa® Absorbent brand names.

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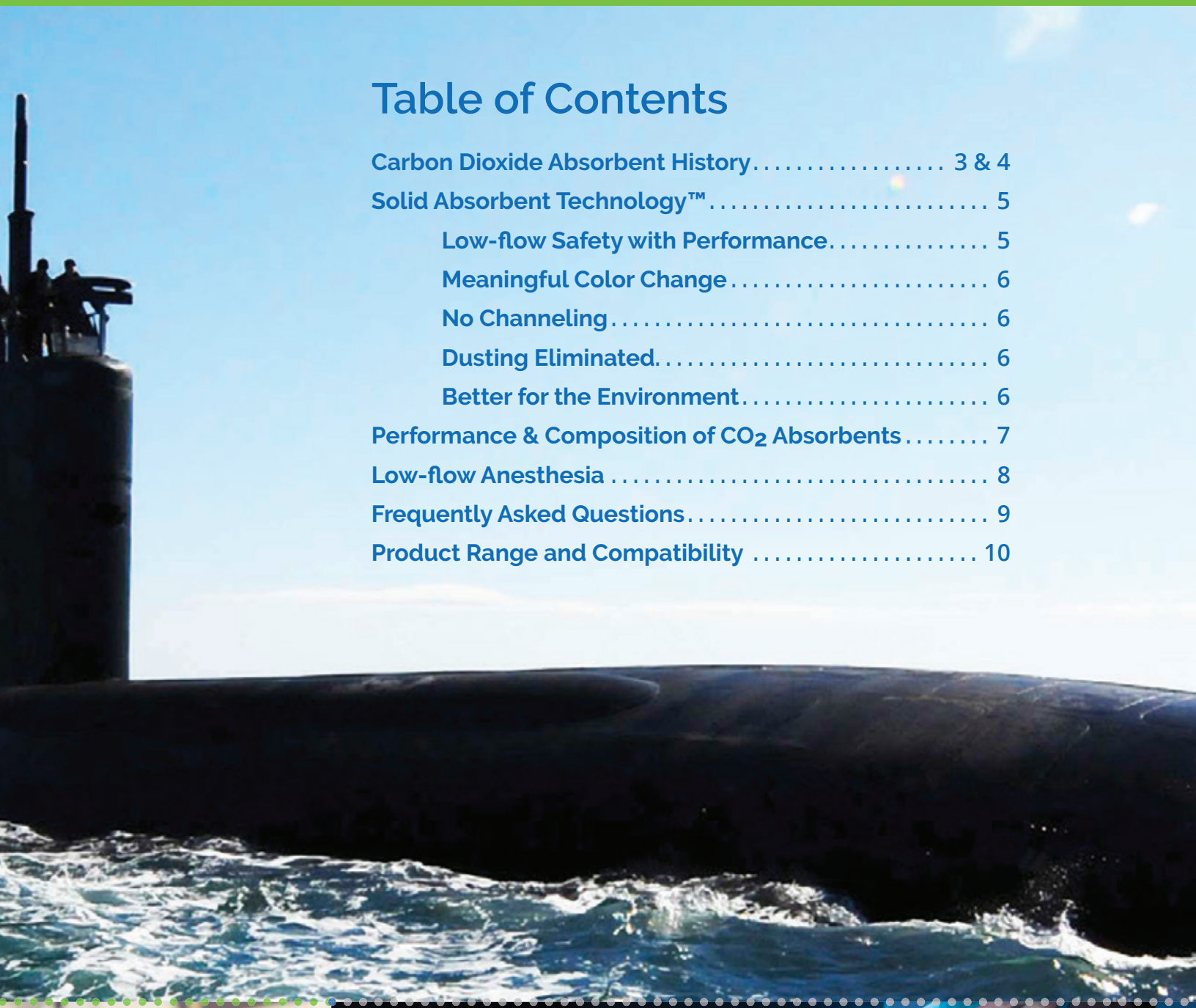
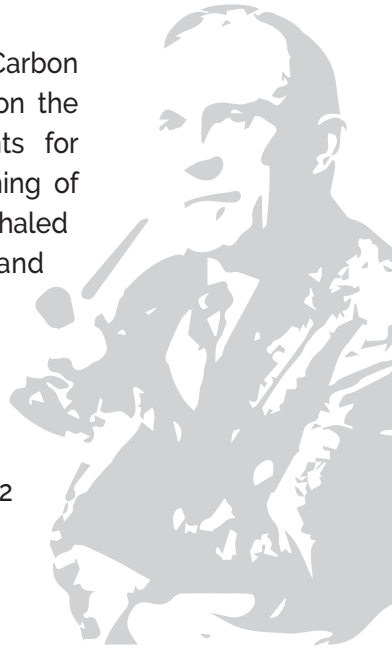


Micropore INCORPORATED

CARBON DIOXIDE

Carbon dioxide absorbents were introduced into anesthesia practice in waste by reducing fresh gas flows to allow rebreathing of exhaled gas



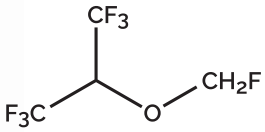
In 1924 Ralph M. Waters[1] published an article titled, Clinical Scope and Utility of Carbon Dioxide Filtration in Inhalation Anesthesia. In that article, and subsequent publications on the topic, Waters[2,3] described his clinical use of a canister containing CO_2 absorbents for administering inhalation anesthesia. His device, the Waters Canister, facilitated rebreathing of exhaled anesthetic vapor leading to (in his words) advantages of economy because fewer inhaled drugs are used, convenience by minimizing "disagreeable odors" in the operating room, and patient welfare by conserving heat and humidity. With the introduction of CO_2 absorption into clinical practice, Waters laid the foundation for the modern practice of inhalation anesthesia, including the development of the circle breathing circuit, which is the primary method used to deliver inhalation anesthetics worldwide today.

Modern anesthesia practice has embraced the use of the circle breathing circuit and CO_2 absorbents to reduce the waste that can occur when delivering inhalation anesthetics. However, common practices prevent the modern anesthetist from achieving the waste reduction Waters was able to accomplish.

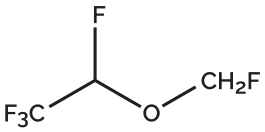
Modern practices have developed in part out of concern for the potential for toxic byproducts due to the interaction between inhalation agents and CO_2 absorbents. Concern for Compound A production while administering Sevoflurane has led to inherently wasteful minimum fresh gas flow (FGF) recommendations well in excess of a closed-circuit condition[4] and carbon monoxide production resulting from the combination of Desflurane and desiccated absorbents has led to wasteful practices for replacing CO_2 absorbents. Meanwhile, managing FGF is the primary strategy for minimizing the environmental contamination from inhaled anesthetics that act as greenhouse gases and contribute to global warming.[5,6]

Waters CO_2 Absorber

Source: *Wood Library Museum of Anesthesiology*



Sevoflurane



Desflurane

1920s

CO_2 absorbents introduced into clinical practice, reducing waste and improving patient welfare.

1990s

Sevoflurance and Desflurane are introduced into clinical practice.

CO_2 absorbents discovered to degrade volatile anesthetics and produce toxic byproducts.

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2. Waters RM. Advantages and Technique of CO_2 Dioxide Filtration with Inhalation Anesthesia. Curr Res Anesth Analg. 1926;5:160–162.
3. Waters RM. Carbon Dioxide Absorption from Anesthetic Atmospheres: (Section of Anæsthetics). Proc R Soc Med. 1936;30:11–22.
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ABSORBENT HISTORY

1924 and are essential when using a closed circle system to minimize without patients suffering the effects of CO_2 retention or poisoning.

Studies have demonstrated that strong bases added to calcium hydroxide were the cause of the toxicity, but that by eliminating potassium hydroxide and reducing the concentration of sodium hydroxide to <2% Compound A and CO production is no longer a concern[7]. As a result, CO_2 absorbents have been developed that can be used safely to minimize anesthetic waste by reducing fresh gas flow to approach closed-circuit conditions. However, due to their granular form, this chemistry change has had a severe impact on the duration of these absorbents.

In 2005 the Anesthesia Patient Safety Foundation convened the CO_2 Absorbent Desiccation Safety Conference to develop a consensus statement on the use of CO_2 absorbents so as to reduce the risk of adverse interactions with volatile anesthetics. The resulting consensus recommended use of CO_2 absorbents whose composition is such that exposure to volatile anesthetics does not result in significant degradation of the volatile anesthetic[8].

Still, today, practices persist that result in unnecessary waste of both anesthetic agents and absorbents. While CO_2 absorbents may seem like a commodity item, differences in formulations can translate into significant performance differences, and absorbent choice should not be based on unit price alone. A modern practice of inhalation anesthesia utilizing a circle system to greatest effect requires reducing fresh gas flow to approach closed-circuit conditions, thoughtful selection of CO_2 absorbent, and changing based on inspired CO_2[7].

SpiraLithCa's® revolutionary Solid Absorbent Technology™ is the first major advance since 1924, and solves all the problems associated with granular absorbents. Incorporating the latest low-flow chemistry (SpiraLithCa® uses <1% NaOH) with no reduction in duration allows clinicians to take advantage of low-flow anesthesia and its benefits without consequence.

2000s

APSF convenes CO_2 Absorbent Desiccation Safety Conference; recommends absorbents that do not degrade volatile anesthetics.

2010s

Industry adoption of absorbents with low-flow safe chemistry that eliminate the degradation of volatile anesthetics becomes commonplace.

SpiraLithCa®

Micropore introduces SpiralithCA® with <1% NaOH. Solid Absorbent Technology™ results in no reduction in capacity while eliminating dusting and channeling.

2020s

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Micropore INCORPORATED

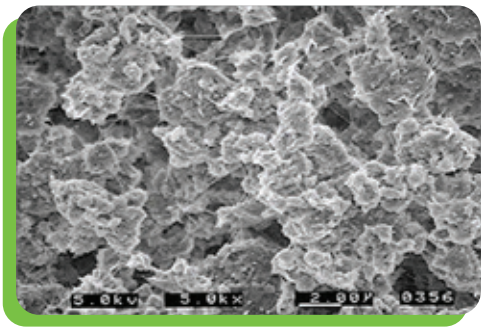
SOLID ABSORBENT

Disruptive SOLUTIONS To All

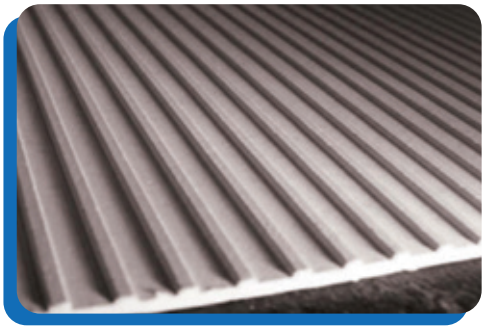
What is **Solid Absorbent Technology™?**

Micropore's Solid Absorbent Technology™ represents a revolutionary advance in carbon dioxide absorption. Using far less binder than granular absorbents, absorbent particles are bound together at the nano level to create shock, vibration, and dust resistant micro-porous gas absorbent sheets. These sheets are then used to create absorbent cartridges with preformed flow channels engineered to eliminate channeling and maximize absorbent utilization.

Our technology also allows us to incorporate low-flow safe chemistry without paying the "duration penalty" to which all granular absorbents are subject. In short, Solid Absorbent Technology™ solves all the problems associated with granular absorbents.



Micrograph of absorbent structure showing polyethylene binder



View of finished absorbent material with preformed flow channels

Low-flow Safety with **Superior Duration** and **Performance**

Carbon dioxide absorbents are known to degrade volatile anesthetics and produce toxic byproducts such as Compound A, Carbon Monoxide, and Formaldehyde, preventing clinicians from fully embracing and/or utilizing true low-flow anesthesia. In recent years, several absorbents have addressed this issue and eliminated toxicity concerns by removing KOH and reducing NaOH concentrations to less than 2%. However, the incorporation of these chemistry changes has had severe consequences negatively impacting performance (dust & efficiency) and significantly decreasing canister duration. We call this the "duration penalty."

Solid Absorbent Technology™ allows SpiraLithCa® Absorbent to utilize chemistry safe for low-flow anesthesia (<1% NaOH) without sacrificing superior duration.

TECHNOLOGY™

SpiraLith® Ca CO_2 ABSORBENT

Problems of Granular Absorbents

NO CHANNELING

Channeling is a well-known problem inherent to all granular absorbents, resulting in highly variable duration performance and color change, increased canister usage, and significant unreacted absorbent waste ending up in landfills. Channeling can also present a safety concern when lack of visible color change encourages continued use of product, while granules along the path of least resistance are completely expired and degrading volatile anesthetic to toxic byproducts.

Solid Absorbent Technology's™ uniform, flow pathways eliminate channeling and guarantee SpiralithCa® users experience:

- Reliable, consistent, superior performance.
- Meaningful color change you can rely on to determine exhaustion.
- Increased absorption efficiency and far greater percentage of chemical contents reacted.

COLOR CHANGE

Granular absorbent color change is unreliable and meaningless, due to random flow, channeling, and their tendency for color reversion during periods of non-use. What is visible on the outside of the canister does not reflect what is happening inside. In fact, it is not uncommon for exhausted canisters to have little or no visible color change, rendering them useless, confusing, and even dangerous, as desiccated canisters are known to produce toxins.

With Solid Absorbent Technology™ what you see on the outside is exactly what is transpiring on the inside. Our patented color window system is the only indicator system predicting remaining canister life.

- Reduced changeouts and waste!
- Increased clinician confidence!
- Color change does not revert!

DUSTING ELIMINATED

DUST related problems are a very serious issue associated with ALL granular absorbents and well-known to cause complications negatively impacting patient safety, costs, machine health, and the time and efforts of hospital staff, particularly anesthesia providers, technicians, and biomedical engineers.

Solid Absorbent Technology™ eliminates all dust related complications/problems:

- Risk of patients inhaling caustic dust.
- Biomed calls & rescheduled surgeries from anesthesia machines failing pre-use tests.
- Cost of frequent disposable part replacement, particularly sensors and o-rings.

ENVIRONMENT

Everyone is aware of the global efforts to reduce the amount of plastic and chemicals entering our environment. Inhaled anesthetics are known to deplete the ozone layer and most granular absorbents are very caustic.

Solid Absorbent Technology™ provides an opportunity to significantly reduce environmental footprint:

- Superior duration means users contribute far less plastic and chemicals to our landfills.
- Low-flow safe chemistry allows users to reduce inhaled anesthetics entering our atmosphere.
- SpiraLith is non-hazardous by California CCR Title 22 – Fathead Minnow Hazardous Waste Screen Bioassay.

Performance and Composition of Competing Absorbents

Product Name	Form	Molecular Sieve Free[4]	Permanent Color Change	Eliminates Dust	Eliminates Channeling	Pass Ca Fish Test[5]	Eliminates Agent Degradation[1]			PERFORMANCE[2] Time per 100ml of product for $FICO_2$ to reach 0.5%	
							Carbon Monoxide	Compound A	Formaldehyde	Minutes	CV[3] (%)
LoFloSorb	Granular	6.5% Silica	NO	NO	NO	NO	YES	YES	YES	50	5
Amsorb Plus	Granular	YES	YES	NO	NO	?	YES	YES	YES	56	6
Litholyme	Granular	YES	NO	NO	NO	?	YES	YES	YES	59	5
Dragersorb Free	Granular	YES	NO	NO	NO	?	YES	YES	YES	69	4
Spherasorb	Granular	4% zeolite	NO	NO	NO	NO	NO	NO	NO	70	1
Sodasorb	Granular	YES	NO	NO	NO	NO	NO	NO	NO	78	5
Medisorb	Granular	YES	NO	NO	NO	NO	NO	NO	NO	88	5
Dragersorb 800+	Granular	YES	NO	NO	NO	NO	NO	NO	NO	91	1
SpiraLithCa®	Solid	YES	YES	YES	YES	YES	YES	YES	YES	95	1

SpiraLithCa's® unique composition and superior performance provide the opportunity to achieve significant reductions in overall cost of anesthesia delivery, while simultaneously improving patient safety and reducing environmental footprint:

- Far superior CO_2 absorption efficiency without performance variation (see table above).
- Elimination of dust problems and channeling, along with fewer product changes reduces utilization of clinician, technician, engineering, and nursing time and efforts, especially related to biomed service calls and surgery rescheduling due to anesthesia machines failing their pre-use tests.
- Reduction in anesthesia costs due to ability to utilize low flows for extended periods of time without worries of Compound A, Carbon Monoxide, or Formaldehyde production.
- Permanent, reliable, consistent color change increases user confidence and decreases waste.
- Significant reductions in environmental footprint and waste; far fewer canisters are discarded and those that are have a much higher percentage of their chemical contents reacted than traditional granular absorbents, which will have remaining absorption capacity ranging from 13.5% to 73.3%, with a mean of 44.8%.[6] Additionally, SpiraLithCa® Absorbent satisfies California State's strict requirements for disposal as non-hazardous waste.[5]

REFERENCES AND FOOTNOTES

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2. Jiang Y, Bashraheel MK, Liu H, et al. In vitro efficiency of 16 different $Ca(OH)_2$ based CO_2 absorbent brands. J Clin Monit Comput. 2019;33:1081–1087.
3. CV: Coefficient of variation is used to calculate the consistency and uniformity of data. Higher numbers represent greater volatility and variability, while lower numbers represent greater consistency and reliability. SpiraLithCa® users can expect superior performance each and every single time.
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Low-flow Anesthesia and SpiraLithCa® the Solid Choice™

The popularity of low-flow anesthesia has exploded in recent years as the medical community has become aware of its tremendous economic, environmental, and safety benefits. However, many providers are still reluctant to implement this practice because of safety concerns, as CO_2 absorbents are known to degrade volatile anesthetics. Absorbents with <2% NaOH have eliminated this concern at the cost of inferior product duration.

SpiraLithCa® has the highest absorption efficiency of any CO_2 absorbent available, while utilizing low-flow safe chemistry, low-flow.

ECONOMIC

Healthcare organizations and providers today are under tremendous pressure to cut costs without sacrificing patient safety. Utilization of low-flow anesthesia is a great opportunity to realize this goal, while simultaneously increasing patient safety and decreasing environmental footprint. Anesthesia providers consistently using lower than average fresh gas flows save thousands of dollars annually.

ENVIRONMENTAL

Volatile anesthetics are potent greenhouse gases that harm our environment by depleting the ozone layer and contributing to global warming. These gases also remain in the atmosphere far longer than carbon dioxide. In the United States, the healthcare sector accounts for 8% of total U.S. greenhouse gas emissions. A relatively simple way to reduce and reuse anesthetic agents is to utilize low fresh gas flows.

WASTE REDUCTION is also of great environmental concern. Everyone is well aware of the global efforts being exerted to reduce plastic and chemicals entering landfills. Absorbent canisters are made out of plastic and contain residual amounts of volatile anesthetics and unreacted chemical contents. Disposal is often regulated and costly.

SpiraLithCa® contributes less waste and chemicals to our landfills. Solid Absorbent Technology™ ensures a far greater percentage of each canister's chemical contents are reacted and our superior clinical duration means far fewer canisters are disposed of.

PATIENT SAFETY

Patient safety is perhaps the most important benefit of low-flow anesthesia. Barring preventive interventions, hypothermia occurs in more than half of all surgical patients undergoing anesthesia[7] and postoperative pulmonary complications (PPCs) are common, costly, and increase patient mortality.[8] Many studies have shown that low-flow anesthesia improves heat and moisture conditions of the anesthetic gas and has a positive impact on respiratory function and mucociliary clearance, while reducing fluid loss.[9] It also helps limit risks of hypothermia and surgical site infections by better maintaining core body temperature and humidity level.[10] With laparascopic procedures, surgical humidification has even been proven to reduce recovery time.[11]

SpiraLithCa® CO_2 ABSORBENT

Frequently Asked Questions

What are the advantages of using SpiraLithCa®?

- Highest absorption efficiency of any absorbent.
- The only color indicator window system predicting remaining product life. You will know when to change canisters with confidence and decrease waste from prematurely discarded cannisters.
- Discarded canisters have a much higher percentage of the chemical contents reacted, further reducing their impact on the environment.
- Irreversible, reliable color change that accurately indicates exhausted state; (eliminates possibility of accidentally using expired product).
- Eliminates dust issues!
  - Risks of caustic dust inhalation by patients or staff.
  - Biomed calls and rescheduling from machines failing pre-use tests.
  - Frequent dust related part replacement (particularly o-rings and sensors).
  - Corrosion of metal machine parts.
  - Dust related machine servicing and cleaning.
  - Better for the environment; far superior duration of canisters and ability to safety utilize low-flow anesthesia reduces the plastics, chemicals, and volatile anesthetics entering our landfills and environment.
- Anesthetic savings due to ability to safely use low-flow for extended periods of time without worrying about agent degradation or toxin production.
- Waste and disposal savings due to ability to dispose of as non-hazardous waste, as well as significant reduction in actual amount of waste disposed of.
- Time savings due to reduced frequency of canister changes.
- Prefilled, disposable canisters available for most anesthesia machines mean simplified ordering from a single source
- Ability to safely deliver low-flow anaesthesia for extended time periods.
- Solid Absorbent Technology™ with engineered flow channels completely eliminates channeling and duration variability.
- Manufactured in the U.S., reducing supply-chain complexity and risk.
- Sales and clinical support readily available by phone, text, or email.
- Does not deteriorate into dust during shipping, handling, or use.

Is SpiraLithCa® Absorbent approved by the FDA?

- Class 1 Devices such as CO_2 absorbents do not require 510(k) approval. However, Micropore is an FDA registered manufacturer.

Why is Solid Absorbent Technology™ better than granules?

Granular absorbents are comprised of dusty, loose pellets or granules that can shift and settle. This leads to channeling where expired air takes the path of least resistance, creating random channels that become exhausted long before the rest of the absorbent is consumed. SpiraLithCa® is comprised of absorbent powders bound together by a polymer matrix to form a solid absorbent sheet. It is specifically engineered to have uniform air passages that eliminate channeling and ensure uniform cartridge use and longer duration.

How do I know when to change-out SpiraLithCa®?

Micropore recommends canisters be discarded when inspired carbon dioxide ($FiCO_2$) rises above the level deemed appropriate by the physician. Normally, this is 0.5% to 1.0% (5mmHg to 10mmHg). SpiraLithCa® is the only absorbent with a color indicator window system which predicts remaining product life.

What is the shelf-life and how should I store SpiraLithCa® Absorbent?

Typically, shelf-life is two years. The use by date is clearly indicated on canisters. Store in ambient humidity above 15°C / 59°F in an environment that minimizes exposure to artificial or UV light. Avoid exposure to direct sunlight.

How should I dispose of SpiraLithCa® Absorbent?

SpiraLithCa® should be disposed of according to the hospital protocol for non-hazardous waste. It should be noted that traces of volatile anesthetic agent may be present within the canister and, therefore, the material should not be incinerated, as combustion is possible.

What anesthetics can be used with SpiraLithCa®?

Halothane, enflurane, isoflurane, desflurane and sevoflurane.

Is SpiraLithCa® Absorbent safe to handle?

Under DOT recommendation, Calcium Hydroxide is classified and labeled as corrosive. All absorbents are corrosive and should be handled using gloves, but SpiraLithCa® does not dust, eliminating the need for a mask.

Who owns Micropore?

Micropore is a privately held Delaware C-corporation.

Where can I buy SpiraLithCa® Absorbent?

If you would like to place an order, please contact Micropore at 302-731-4100 or info@spiralithusa.com. We will either take your order directly or refer you to the appropriate distributor.

www.spiralithusa.com

SpiraLithCa®
CO_2 ABSORBENT

SpiraLithCa® Absorbent Products & Compatibility

Anesthesia Machine	RX-2903C	RX-3903C	RX-3719C	RX-3616C
Dräger				
Apollo	YES			
Fabius	YES	YES		
Tiro	YES			
Perseus		YES		
Zeus	YES			
GE – EZChange module must be installed to utilize RX-3719C				
Aisys			YES	
Aespire			YES	
Avance			YES	
Aestiva				YES
Mindray				
A3-A9				YES

* Information may change. Stay updated at spiralithusa.com

SpiraLithCa® CO_2 ABSORBENT

SpiraLith® Ca
CO_2 ABSORBENT

SOLID ABSORBENT TECHNOLOGY = SUPERIOR PERFORMANCE

Finally!

ZERO DUST

+ NO CHANNELING

+ SAFE FOR LOW-FLOW

+ EASIER USE & LOGISTICS

+ SUPERIOR DURATION/COST

+ BETTER FOR THE ENVIRONMENT

THE SOLUTION TO ALL PROBLEMS WITH GRANULAR ABSORBENTS

FINE POWDER CHEMISTRIES PACKAGED FOR PERFORMANCE™

Micropore INCORPORATED

Making a difference in the lives of others™

MADE IN THE USA

spiralithusa.com

1000 Konica Drive, Elkton, MD 21921 U.S.A. | info@spiralithusa.com | Phone: +1 (302) 731-4100 | Fax: (302) 731-8214