ClorDiSys

- Safest Fumigant Method
- Absolute Decontamination
- Replaces EtO, Formaldehyde, and VPHP
- Fast Cycle Times
- US-EPA Registered Technology
- Great Material Compatibility
- True Gas
- No Residuals
- Stress Free Validation
- BSCs to Buildings
- Easiest Cycle Development

Decontamination and Sterilization

Equipment And Services

Minidox-M

Chlorine Dioxide Gas Generator

Cloridox-GMP

Chlorine Dioxide Gas Generator

Steridox-VP

Chlorine Dioxide Gas Vacuum Sterilizer

Chlorine Dioxide Gas Equipment Decontamination Pass-through Chamber

Ph: 908-236-4100 **www.clordisys.com** **info@clordisys.com**

ClorDiSys Solutions, Inc

ClorDiSys Solutions, Inc is the world's largest manufacturer of chlorine dioxide sterilization and decontamination equipment. Founded in 2001, we utilize the highest purity generation method of chlorine dioxide as developed by Johnson and Johnson™ . Our products are manufactured with pride in the United States and are registered with the US EPA for the highest degree of effectiveness. We can provide you with gaseous chlorine dioxide solutions for all of your facilities needs. For those who require the power of gaseous chlorine dioxide on a limited basis, we provide decontamination services where we set up our equipment and decontaminate your equipment, room, suite, or entire facility. Our chlorine dioxide gas decontamination technology provides the ability for short cycle times, quick aeration, and excellent distribution into hard to reach areas while being the safest method available.

Concerned about room decontamination?

- Remove the human factor from the decontamination process.
- Reduce human exposure to disinfecting agents.
- Reduce overall decontamination time.
- Chlorine dioxide offers total process control.

How can chlorine dioxide gas save you money?

- Chlorine dioxide gas can be used instead of steam to decontaminate most items in your bulk sterilizer. Reduce steam costs, increase time between gasket change out, and reduce parts wear and tear (steam heat-up and cool down related issues).
- Reduced personnel expenses (chlorine dioxide is a 1 person process).
- Reduce down time (fastest decontamination times available).
- Reduce or eliminate outbreaks.
- Eliminate cost of contamination related issues (complete decontamination).

Safety Comparison of Fumigation Methods

	Chlorine Dioxide	Vapor Phase Hydrogen Peroxide	Formaldehyde
8 hr TWA (time weighted average)	0.1 ppm ✗	1.0 ppm ✗	0.75 ppm ✗
Odor Detection	YES At 8 hour safety level ✓	NO ✗	YES ✓
Carcinogen	IARC—NO ACGIH—NO ✓	IARC—NO ACGIH—YES (confirmed animal carcinogen) ?	IARC—YES ACGIH—Suspected ✗
Able to be Vented to Environment	YES ✓	YES ✓	NO ✗
Cycle Times (Risk of Exposure) 2500 ft^3 room	3-4 hours ✓	6-12 hours ✗	12+ hours ✗
Typical Concentrations	360 ppm ✓	750 ppm ✗	8000 ppm ✗
Good Penetration and Distribution	YES (gas) ✓	NO (Vapor) ✗	YES (gas) ✓
Ability to Penetrate Water	Yes ✓	NO ✗	No ✗
Equipment Location	Outside Room ✓	Can either be inside or Outside depending on the manufacturer ?	Inside Room ✗
Aeration Time 2500 ft^3 room	30-60 minutes ✓	Typically Overnight ✗	1 hour + cleanup ✗

What is Chlorine Dioxide?

Chlorine Dioxide (CD) is greenish-yellow and is a single-electron-transfer oxidizing agent with a chlorine-like odor. CD has been recognized since the beginning of the century for its disinfecting properties; and has been approved by the US EPA for many applications including the widespread use of CD in the treatment of drinking water. Beyond this and numerous other aqueous applications, the sporicidal properties of *gaseous* CD were demonstrated in 1986. Subsequent to these initial studies, it has been shown that gaseous CD is a rapid and effective sterilant active against bacteria, yeasts, molds, and viruses. The rapid sterilizing activity of CD is present at ambient temperature and at relatively low gas concentration, 1 to 30 mg/L.

Uses

Chlorine dioxide is widely used as an antimicrobial and as an oxidizing agent in drinking water; poultry process water, swimming pools, and mouthwash preparations. It is used to sanitize fruit and vegetables as well as equipment for food and beverage processing. It is used in the life sciences industry to decontaminate animal research facilities. It is also employed in the health care industries to decontaminate rooms, pass-throughs, isolators and also as a sterilant for product and component sterilization. As an oxidizing agent, it is extensively used to bleach, deodorize, and detoxify a wide variety of materials, including cellulose, paper-pulp, flour, leather, fats and oils, and textiles. Approximately 4 to 5 million pounds of chlorine dioxide are used daily. Our process uses approximately 56.6 grams to decontaminate a 2000 ft^3 (56.6 m^3).

Chemical Properties

Pure chlorine dioxide is an unstable gas and therefore is generated as needed. Although chlorine dioxide has "chlorine" in its name, its chemistry is radically different from that of chlorine. When reacting with other substances, it is weaker and more selective. For example, it does not react with ammonia or most organic compounds. Chlorine dioxide oxygenates products rather than chlorinating them. Therefore, unlike chlorine, chlorine dioxide does not produce environmentally undesirable organic compounds containing chlorine.

Chlorine dioxide is a true gas at room temperatures, meaning it is able to achieve excellent distribution naturally throughout a space. It distributes just the same way that oxygen does in a room, with the level or oxygen being the same throughout the entire room.

As it has a greenish-yellow color, it is able to be accurately monitored in real-time using a UV-vis Spectrophotometer. This makes chlorine dioxide gas the only method with an accurate and true concentration monitoring system.

Chemical Formula:	ClO_2
Molecular Weight:	67.45 g/mole
Melting Point:	-59°C
Boiling Point:	+11°C
Density:	2.4 times that of air

Antimicrobial Properties / Mode of Action

Chlorine dioxide (ClO2) acts as an oxidizing agent and reacts with several cellular constituents, including the cell membrane of microbes. By "stealing" electrons from them (oxidation), it breaks their molecular bonds, resulting in the death of the organism by the break up of the cell. Since chlorine dioxide alters the proteins involved in the structure of microorganisms, the enzymatic function is broken, causing very rapid bacterial kills. The potency of chlorine dioxide is attributable to the simultaneous, oxidative attack on many proteins thereby preventing the cells from mutating to a resistant form. Additionally, because of the lower reactivity of chlorine dioxide, its antimicrobial action is retained longer in the presence of organic matter.

Is Chlorine Dioxide Environmentally Friendly? YES

Chlorine dioxide's special properties make it an ideal choice to meet the challenges of today's environmentally concerned world. Actually, chlorine dioxide is an environmentally preferred alternative to elemental chlorine. When chlorine reacts with organic matter, undesirable pollutants such as dioxins and bio-accumulative toxic substances are produced. Thus, the EPA supports the substitution of chlorine dioxide for chlorine because it greatly reduces the production of these pollutants. It is a perfect replacement for chlorine, providing all of chlorine's benefits without any of its weaknesses and detriments. Most importantly, chlorine dioxide does not chlorinate organic material, resulting in significant decreases in trihalomethanes (THMs), haloacetic acids (HAAs) and other chlorinated organic compounds. This is particularly important in the primary use for chlorine dioxide, which is water disinfection. Other properties of chlorine dioxide make it more effective than chlorine, enabling a lower dose and resulting in a lower environmental impact.

How Does CD React With Water? It is the only agent able to decontaminate water

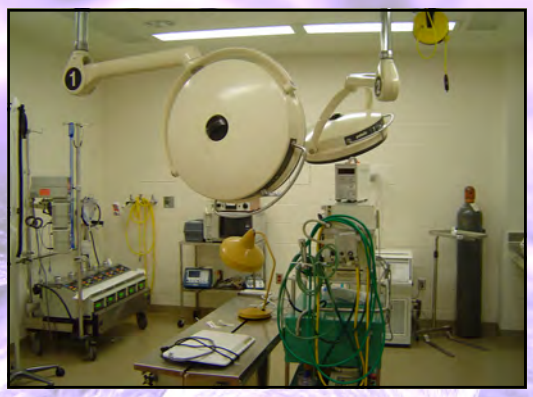
Gaseous CD is the only decontaminant that penetrates water and decontaminates both the water and the surface beneath. In order to maximize process reproducibility and minimize materials effects when using the ClorDiSys Sterilization Systems, it is best to avoid pools or puddles of liquid water. However, if small amounts of liquid are present the efficacy of chlorine dioxide is not affected. The reason that small amounts of water will not impact sterilization efficacy is that chlorine dioxide is readily soluble in water. Provided that the quantity of water is small the gas concentration in the water reaches equilibrium quickly.

In any case, the final concentration of chlorine dioxide in the water will be higher than the concentration in the gaseous environment. Furthermore the activity of chlorine dioxide in water is even greater than its activity in the gaseous phase. Its bactericidal, virucidal and sporicidal properties in water have been demonstrated at minimum concentrations of 0.20-0.25 mg/L (aq) with temperature dependent D-values for common water contaminants in the range of 16 to 40 seconds at 30 to 20 ^oC. For gaseous applications, D-values at 20^oC for common indicator organisms are 14-45 seconds at 20-10 mg/L (gas).

Chlorine Dioxide Gas Applications

Isolators

Pass-through Rooms



Surgical Suites

Large Animal Holding Rooms

Animal Holding Rooms

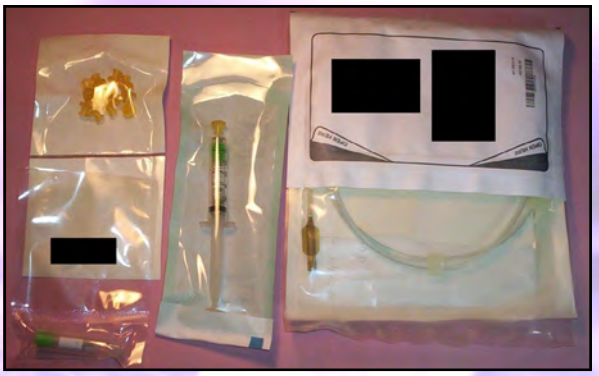
Decontamination Chamber

Modified Autoclaves

Laboratories

Clean Rooms

Biological Safety Cabinets



Products and Components

HEPA Housings

Equipment Decontamination

Processing Rooms / Filing Lines

Necropsy Rooms

Buildings

Transport Van

BSL 1-4 Laboratories/Suites

Material Compatibility of Chlorine Dioxide Gas

Chlorine dioxide is an oxidizer, as is hydrogen peroxide, ozone, and oxygen among many other agents. However, chlorine dioxide gas is the gentlest on materials among those options, as seen by its lower oxidation potential. Oxidation / reduction potential is a measure of the tendency of a chemical species to gain electrons and oxidize other chemical species. A higher oxidation / reduction potential means that the species is more likely to gain electrons and is a stronger oxidizer. The stronger the oxidizer (higher the number), the more corrosive the agent is.

The table on the right shows several biocidal agents and their oxidation / reduction potentials. Chlorine dioxide has an oxidation / reduction potential of 0.95V, which is lower than other commonly known decontaminating agents such as hydrogen peroxide, as well as bleach. The reason that chlorine dioxide gas, scientifically less corrosive than hydrogen peroxide, has a worse reputation, is due to the link with liquid chlorine dioxide products. Liquid chlorine dioxides contain byproducts from their generation method which make them corrosive.

Biocidal Agent	Oxidation / Reduction Potential (V)
Ozone	2.07
Peracetic Acid	1.81
Hydrogen Peroxide	1.78
Sodium Hypochlorite	1.49
Chlorine Dioxide	0.95

Generation Method

The difference in generation methods of chlorine dioxide is where the difference in corrosiveness can be found. Many of the liquid methods are created by mixing an acid and a base which then forms an acidified chlorine dioxide solution. A common generation method for liquid chlorine dioxide is:

Mixture of Base + Water + Activator → Acidified Sodium Chlorite + Chlorous Acid + Chlorine Dioxide

Chlorine Dioxide Gas is less corrosive than hydrogen peroxide, bleach, and liquid chlorine dioxide products.

The production of two acidic components, acidified sodium chlorite and chlorous acid, is where the corrosive properties of liquid chlorine dioxide products come from. The pH of these solutions is typically around 3.

Pure chlorine dioxide, which can be generated as a gas, does not have the same effect on materials. Water injected with pure chlorine dioxide gas still has a pH of 7, meaning that the solution is neutral. A method of generating pure chlorine dioxide gas is below:

Reagent (gas) + Sodium Chlorite (solid) → Chlorine Dioxide (gas) + Salt (solid)

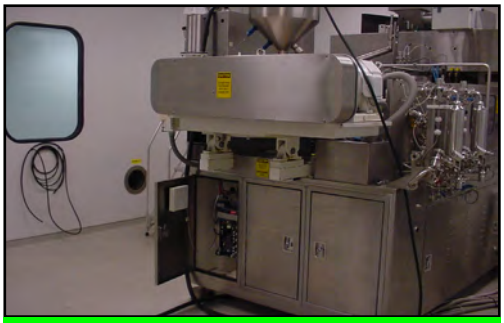
The solid salt product is retained within the system and not introduced into the space being decontaminated. Only the pure chlorine dioxide gas is introduce to the space. Chlorine dioxide gas does not leave a residue, so there is no worry of residual contact causing a negative effect on materials and components within the area being decontaminated.

We Don't Compare!

Our gaseous chlorine dioxide is pure, without the acidic byproducts which make many liquid CD solutions corrosive.

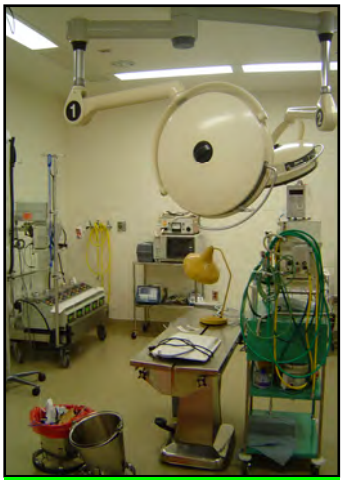
CD has recently been used to decontaminate the interior components of a $1 million Transmission Electron Microscope with no short-term adverse affect on the materials.

A picture is worth a thousand words:



Example 1: (Blow Fill Seal Machine)

In **Example 1**, a pharmaceutical Blow-Fill-Seal machine is shown. It has been decontaminated in the room shown on a regular basis since the late 1990's using our process. The machine is computer controlled with AC drives, motors, various electronic sensors, expensive tooling, and various gasket materials. Valued close to $1,000,000, it has shown no adverse effects.



Example 2: Surgical Suite

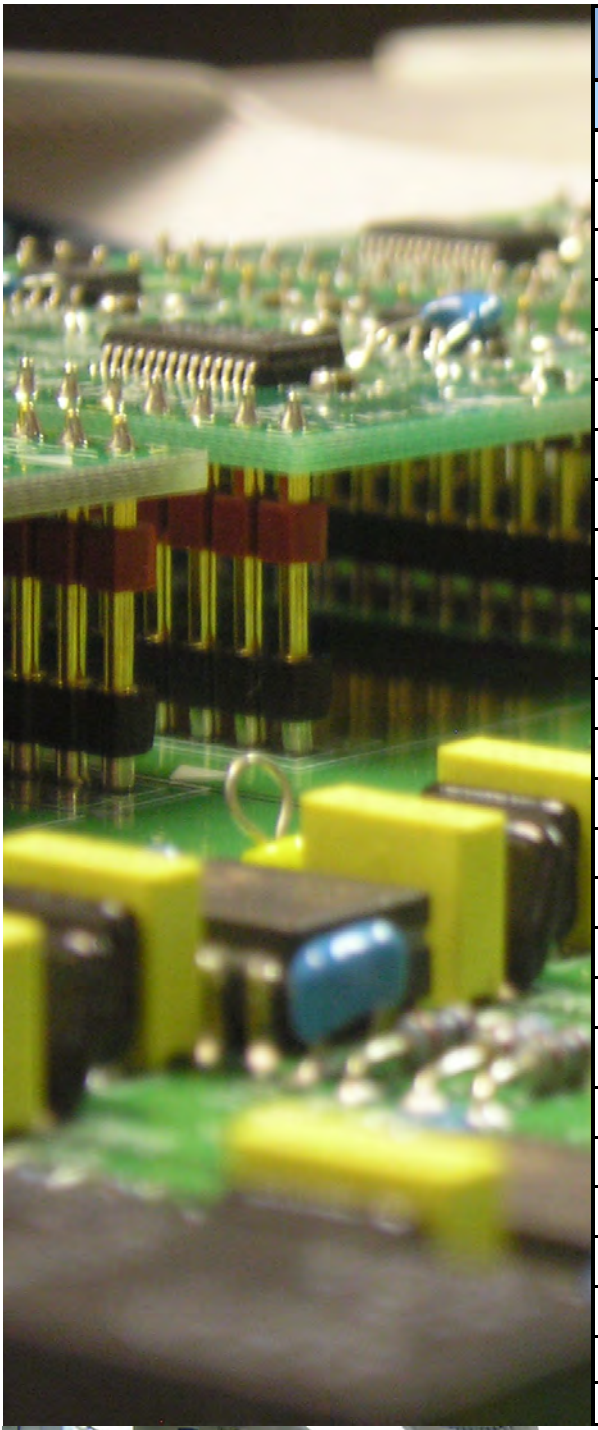
Example 2 is an operating room which contains X-ray equipment, various monitoring equipment, electronics, cabinets, lights, optics, computers, etc. This room is also decontaminated regularly with no adverse effects on any materials or components.

If you don't trust us, test us!

We offer free* material compatibility testing for items you are concerned about.

Call us to discuss and set up testing.

*Clordisys will expose your items/equipment to chlorine dioxide gas and return to you for observation and testing. Testing is free for small items/batches less S/H. For large items or extended testing, please call.



EQUIPMENT EXPOSED TO GASEOUS CHLORINE DIOXIDE WITH NO ADVERSE EFFECTS	
Equipment	**Results**
Computers – Laptop and Desktop	No Effect
GC's and HPLC's	No Effect
VCR's / VHS Tapes	No Effect
Scales / Balances	No Effect
Microscopes	No Effect
Cameras / Camcorders	No Effect
MRI Machines	No Effect
X-Ray Machines	No Effect
Refrigerators / Freezers	No Effect
Incubators	No Effect
Autoclaves	No Effect
Cage / Rack Washers	No Effect
Temperature / Pressure / Rh Probes	No Effect
HEPA Filters	No Effect
Sterilizing Filters	No Effect
Solenoid Valves	No Effect
Biological Safety Cabinets	No Effect
Rigid Plastic / Stainless Steel / Flexible Wall Isolators	No Effect
Polypropylene	No Effect
HVAC ductwork	No Effect
Engines	No Effect
Silocsane Gel	No Effect
Ultrasound Machines	No Effect
Xenogen IVIS 2001 Imaging System	No Effect
Anesthesia Systems	No Effect
Ventilators	No Effect

Decontamination Methods Comparison

The major methods for decontamination are: Gaseous chlorine dioxide, formaldehyde, and vapor phase hydrogen peroxide (VPHP). Chlorine dioxide gas (CD) is the newest method of the three, but is quickly becoming the industry's new gold standard as it becomes more widely used. By being a gas, like formaldehyde, CD naturally distributes uniformly and completely within the space being decontaminated, just like oxygen in the air. VPHP will start condensing back to the liquid state upon exiting the generator, and is distributed throughout the chamber/room through line of sight injection. As such, the back side, underside, and internal portions of components may not be contacted by VPHP for a long enough period of time, at the proper concentration, to achieve the correct level of kill. Ionized hydrogen peroxide (iHP) has been developed recently as a different method of decontamination. Creating a positively charged fine mist, iHP is repelled from positively charged materials within the space. Common materials which are positively charged are aluminum, glass, and air which may not receive an adequate concentration of iHP to provide decontamination. Plastics and rubbers strongly attract iHP, further drawing concentration away from nearby areas and creating an uneven distribution (and uneven decontamination) inside the room / chamber.

Decontamination Capacity

Clordisys' Minidox-M, Minidox-B, and Cloridox-GMP CD Generators can decontaminate areas from 1-70,000 ft^3 (1982 m^3). The Clordisys Minidox-L is designed for smaller applications, capable of decontaminating volumes from 1-300 ft^3 (8.5 m^3).

VPHP generators can realistically decontaminate areas from 1-2000 ft^3 (56.6 m^3). However due to a line of sight injection of hydrogen peroxide, multiple generators may be necessary if the area has a somewhat complex geometry, such as multiple rooms, or an "L" shape. Typically there is one VPHP generator used per room. VPHP generators typically are designed for specific volume ranges, incapable of decontaminating both large rooms and small chambers.

Cycle Times

Chlorine Dioxide Gas decontamination cycle times are quicker than those for both formaldehyde and VPHP. The reason is due to faster aeration times, as 12-15 air exchanges is sufficient to remove CD after a decontamination, generally 30-45 minutes for rooms. VPHP and formaldehyde cycles usually extend overnight, as VPHP needs extra time to aerate due to condensing onto surfaces, and formaldehyde needs lengthy exposure times and a neutralization step.

Room Decontamination	Volume	Cycle Time
Steris VPHP	300 ft^3 (8.5m^3)	7.5 hours (empty room), 8.5 hrs (room with equip.)
Steris VPHP	760 ft^3 (21.5m^3)	4.25 hours + overnight aeration
Bioquell Clarus	2500 ft^3 (70.8m^3)	10-11 hours
Chlorine Dioxide	2700 ft^3(76.5m^3)	3.5 hours

Carcinogenicity

Formaldehyde is classified as a "suspected human carcinogen" according to the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH designates VPHP as an A3, Confirmed Animal Carcinogen with Unknown Relevance to Humans. Chlorine Dioxide Gas is not considered to be carcinogenic and the ACGIH does not list CD as a carcinogen of any kind. Chlorine dioxide gas is used to treat fruits, vegetables, poultry, and other foods. Chlorine dioxide has also been used in the treatment of drinking water since the 1920's.

Material Compatibility

VPHP and CD are both oxidizers. VPHP is a scientifically more corrosive than CD, with an oxidation potential 1.9 times that of CD. Some major liquid chlorine dioxide solutions are generated with acidic byproducts, making them corrosive. Clordisys' CD Gas generation method generates a pure chlorine dioxide, which is gentler than VPHP, and much more gentle than the leading liquid chlorine dioxide solutions. CD has been used to decontaminate many delicate and expensive instruments, including a $1 million Transmission Electron Microscope.

Post Exposure Residue

Neither Chlorine Dioxide Gas nor VPHP leaves a residue after decontamination. Formaldehyde does leave a residue that needs to be cleaned up afterwards. This proves to be difficult when dealing with intricate components or areas hard to access.

EPA Registration

Clordisys Solutions, Inc's chlorine dioxide gas is registered with the US EPA to sterilize "manufacturing and laboratory equipment, environmental surfaces and implements such as: manufacturing vessels; beakers, test tubes and laboratory glassware; rooms; sterility testing isolators and pharmaceutical isolators."

NSF Approval

Chlorine dioxide gas was approved for BSC decontamination by NSF International in 2008. Chlorine dioxide gas and formaldehyde are currently the only approved methods for BSC decontamination. See ANSI / NSF 49 Annex G for details.

Chlorine dioxide gas is the only decontamination method that is both EPA registered and NSF approved.

Cycle Development

What Factors Affect Cycle Development for each Decontamination Method?							
	Volume	Room Shape	Shadow Areas / Loading of Space	Temperature	Starting Relative Humidity	Injection Rate	Wet Surfaces
Chlorine Dioxide Gas	**No**	**No**	**No**	**No**	**No**	**No**	**No**
Hydrogen Peroxide Vapor	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Volume

Chlorine Dioxide - Volumes up to 70,000 ft^3 (1982 m^3) are achievable with one generator.

Hydrogen Peroxide - VPHP Generators have volume capacities between 8,000-12,000 ft^3 (226.5-339.9 m^3) with realistic capacities around 2000 ft^3 (56.6 m^3).

Room Shape

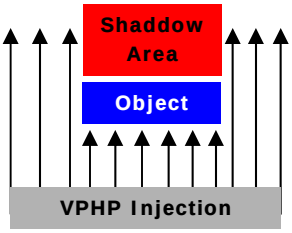
Chlorine Dioxide - Room shapes do not affect the cycle for CD. As a true gas at room temperatures, CD naturally disperses everywhere.

Hydrogen Peroxide - VPHP is injected into the room and distributes in a line-of-sight fashion. Whatever cannot "be seen" by the generator cannot be contacted directly by VPHP from the generator, which may not receive sufficient concentration to achieve full decontamination.

Shadow Areas / Loading Within a Space /

Chlorine Dioxide - The amount of equipment and its location within a space does not affect a CD cycle. Gases get everywhere.

Hydrogen Peroxide - The amount of equipment and its location within a space DOES affect a VPHP cycle. Equipment and items in the room can act as barriers to the VPHP distribution, blocking the line-of sight between other surfaces and the generator, as seen on the right. As such, cycles must be developed and validated whenever the amount or location of equipment changes to ensure proper decontamination.



Temperature:

Chlorine Dioxide - CD exists as a gas at temperatures above 52° F (11° C). At temperatures above this, CD is a gas and gets great distribution. No affect on cycle development.

Hydrogen Peroxide - Hydrogen peroxide has a boiling point of 228° F (109° C). At temperatures below this, hydrogen peroxide returns to the liquid state. It does this through condensation, which limits its movement throughout a space and causes non-uniform distribution throughout a room or chamber. This also causes non-uniform concentration throughout the space, with the possibility of some areas not getting enough VPHP to achieve full decontamination, since colder areas and surfaces scavenge VPHP from warmer surfaces and areas. This non-uniform concentration clouds the repeatability of VPHP cycles, as the concentration monitor cannot sense the many levels of concentration within the space.

Starting Relative Humidity Level: (note: All decontamination methods need increased Rh for spore log kill)

Chlorine Dioxide - Starting Rh level does not affect the cycle. No affect on cycle development.

Hydrogen Peroxide - The humidity level affects the dew point and condensation of VPHP. Starting a cycle at different Rh levels can cause different amounts of condensation within the room / chamber, which causes a different distribution of the concentration than before, and different overall level of decontamination throughout the space. The higher the initial Rh, the less VPHP will be generated to achieve condensation generating VPHP levels that might not provide efficacy to some areas.

Injection Rate:

Chlorine Dioxide - Cycles always use the same injection rate. No affect on cycle development.

Hydrogen Peroxide - Room geometry, room volume, and the amount of equipment within the room / chamber affect the injection rate used in a cycle. The proper injection rate needs to be determined through testing and validation runs which must be performed for each room and every time the amount and location of equipment changes.

Wet Surfaces in Chamber / Room:

Chlorine Dioxide - CD can penetrate water and decontaminate it and the surface beneath it. No affect on cycle development.

Hydrogen Peroxide - VPHP dilutes and breaks down in water and is unable to decontaminate it.

Chlorine Dioxide Gas: The Safest Fumigant

This highlights some of the reasons why gaseous chlorine dioxide (CD) is the safest of all the gas or vapor decontamination agents. To be clear, all decontamination agents are deadly. This is their function.

Safety Warnings (Self Alerting)

The best safety feature with CD is that it is self-alerting. CD has an odor threshold at or below the 8 hour Time Weighted Average (TWA), so the user is self alerted to exposure at a low level and the reliance on external equipment is not as imperative as with VPHP. This alone makes CD safer since the user is self-alerted before unsafe levels are achieved. With VPHP, odor does not provide a warning of exposure. This dangerous trait is why natural gas is given a sulfur-like odor additive, to act as an alert of exposure. The VPHP user becomes aware of a harmful exposure only when choking occurs and ***must*** rely on external equipment to alert of possible exposure. This makes it extremely important to place personal safety detection devices all around the area when using VPHP. With CD, this reliance upon external equipment is not a necessity because of it's odor. Minimal area monitors are required when using CD.

Shorter Cycle Times

Chlorine dioxide is the fastest acting decontaminating gas or vapor. For the various decontaminating agents the cycle times can range from 3-1/2 hours to over 12 hours in decontaminating a 2500 ft^3 room (70.8 m^3). With normal aeration exhaust rates, a CD cycle would be about 3-1/2 hours or less, formaldehyde would be about 12-1/2 hours, and VPHP could be 10 to 12 hours when you include the aeration times. This means that a potentially unsafe condition exists for a far shorter time when using chlorine dioxide for room decontamination.

VPHP has long cycles because of the longer aeration times due to vapor condensation and absorption issues that do not apply with a true gas. Formaldehyde has long cycles because of long exposure times and the neutralization time.

Lower Concentration Levels

Chlorine dioxide is typically used at lower concentrations for room decontamination. VPHP concentrations are typically 750-1500 ppm. Formaldehyde concentration is typically 10,000 ppm. CD concentration is typically only 360 ppm. If something goes wrong, the higher concentration of formaldehyde and VPHP poses a greater risk due to the higher concentrations in the room.

Equipment Located Outside the Target Chamber

The CD generating equipment is located outside the decontamination target chamber. If equipment is inside the chamber and some issue occurs, the user may have to enter the chamber with a decontamination agent present to shutdown the equipment. Since CD generation equipment is located outside the chamber and if some issue occurs the equipment can easily be shutdown by hitting the stop button located on the generator or even by pulling the plug.

Quicker Emergency Aeration

Chlorine dioxide is quicker to aerate down to the 8-hour TWA compared to VPHP and formaldehyde so the room returns to a safe condition quicker when CD is used. If something goes wrong during the CD cycle, aeration can be started and in 30-45 minutes there will be no CD left (below the 0.1ppm TWA). If something goes wrong with VPHP cycle, then the catalytic conversion starts and this can take hours (typically 12 hours). If direct aeration is utilized, this also takes hours to remove the VPHP from the room (typically 6 hours). The reason for the long aeration times with VPHP is that it is a vapor with condensation and absorption issues and not a true gas. If something goes wrong during the formaldehyde cycle, aeration can be started and in 50-75 minutes there will be safe formaldehyde levels (below the 2ppm TWA) except for subsequent off-gassing. If neutralization is required, aeration can be approximately 120 minutes. Therefore the unsafe levels of a sterilant are present for much longer with VPHP than CD and provide a greater risk due to having hazardous concentrations present longer. CD can be down to safe levels much faster than VPHP. In fact, based on the 6 hours VPHP aeration, CD can be removed from the room 12 times faster that VPHP. Another way of describing this is that it will take hours for VPHP to aerate from a room to reach safe levels. For example, it takes 4 hours for VPHP to be reduced from 300 ppm to 1.0 ppm. As a contrast it takes 45 minutes to aerate CD from 300 ppm to 0.1 ppm. So even though the TWA for CD is 0.1 vs. 1.0 for VPHP, CD gets to the safe levels much quicker and therefore is much safer.

Non-carcinogenic

Chlorine dioxide gas is non-carcinogenic. It is used to treat fruits, vegetables, poultry, and other foods. Chlorine dioxide has also been used in the treatment of drinking water since the 1920's.

Complete Decontamination

Chlorine dioxide gas and formaldehyde are gasses and gasses reach and penetrate all areas that vapors have trouble reaching. As the only decontaminating agent able to penetrate water, chlorine dioxide gas decontaminates the water and the surface beneath it. Other methods would not be able to decontaminate either the water or the surface beneath, allowing any organism present to survive. If the decontaminating agent cannot reach ALL of the dangerous organisms in a BSL-3/4 facility, at the proper concentration, for the prescribed amount of time, then a complete decontamination will not occur and worker safety is compromised.

Portable Chlorine Dioxide Gas Generators

The Clordisys family of portable chlorine dioxide gas generators all automatically control the decontamination process. They have the capability to interface with nearly any chamber or room, as well as building management systems. The generators are manufactured using industrial components and feature HMIs that are password protected and have recipe management systems with real time trending. Easy to learn and easy to use, our portable CD Generators are perfect for routine decontamination.

Cloridox-GMP

The Cloridox-GMP Sterilization System can be used on any room/chamber sized between 1-70,000 ft^3 (1982 m^3). In addition the system can be attached to most vacuum chambers to provide a method for component or product sterilization as well. The Cloridox-GMP Sterilization System comes standard with an accurate, real time concentration monitor, which allows for tight process control, easy validation, and great repeatability. A run record is produced that contains the date, cycle time, cycle steps, as well as temperature, pressure, and chlorine dioxide concentration. The HMI system features a password protected, recipe management system with real time trending.

Ideal application: GMP facilities or facilities where vacuum cycles need to be conducted in addition to the decontamination of rooms, isolators, equipment, or supplies.

Minidox-M

The Minidox-M Sterilization System can be used on any room/chamber sized between 1-70,000 ft^3 (1982 m^3). Comes standard with an accurate, real time concentration monitor, which allows for tight process control, easy validation, and great repeatability. A run record is produced that contains the date, cycle time, cycle steps, as well as temperature, pressure, and chlorine dioxide concentration. The HMI system features a password protected, recipe management system with real time trending.

Ideal application: Any facility looking to decontaminate rooms, isolators, equipment, or supplies.

Minidox-B

The Minidox-B Sterilization System can be used on any room/chamber sized between 1-70,000 ft^3 (1982 m^3). The Minidox-B does not contain a concentration monitoring system, instead relying on injection of chlorine dioxide gas through calculation. The HMI system features a password protected, recipe management system.

Ideal application: Any facility looking to decontaminate ambient rooms/chambers without concentration monitoring (comparable to VPHP generators)

Minidox-L

The Minidox - L Decontamination System is a smaller, more economical chlorine dioxide gas generation system designed for use in any chamber under 300 ft^3 (8.5 m^3) such as an isolator, incubator, HEPA housing, or a Biological Safety Cabinet (BSC). It provides a rapid and highly effective method to decontaminate a target chamber. It includes a BSC interface plate, carbon-based scrubber for removal of CD gas, and required tubing.

Ideal application: Facilities looking to decontaminate small chambers such as pass-throughs, incubators, or BSCs but not rooms.

Fixed Equipment

Equipment Decontamination Chamber

The Equipment Decontamination Chamber is designed for use with any Clordisys CD Generator. For many applications, the Equipment Decontamination Chamber can effectively replace a bulk autoclave inside a facility. It provides the ability to rapidly and effectively sterilize computers, electronics, medical devices, sterile products, instruments, and components at ambient temperatures. It can be used to decontaminate components entering a "sterile" or "clean" facility at room temperatures. Items can also be decontaminated before removal from a dirty area into a clean area without the concern for cross contaminations.

The equipment is available in a variety of sizes to meet your facility's needs and constraints.

Ideal application: Decontaminating incoming products, equipment, or supplies into a research or production area.

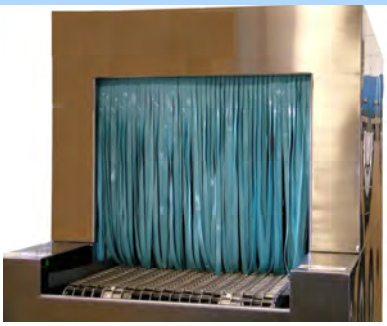
Steridox-VP & Steridox-AP Sterilizers

The Steridox-VP Chlorine Dioxide Gas Vacuum Sterilizer and Steridox-AP atmospheric pressure sterilizer provide a rapid and highly effective method to sterilize medical devices, sterile products, instruments, and components at ambient temperatures. Both include a highly accurate sterilant monitoring system making them highly repeatable and easily validatable. A run record is produced that contains: date, cycle time, cycle steps, as well as temperature, pressure, and chlorine dioxide gas concentration.

The sterilizers are available in a variety of sizes to meet your processing needs. Automated sliding doors are also available. The VP chamber and doors are constructed of 316L stainless steel to provide an exceptionally long life. The unit is enclosed in easily removable stainless steel panels.

Ideal application: Products or components unable to be sterilized under ambient pressure.

Decontamination Spray Tunnel



Get an easy, quick and cost effective way to sanitize the outside of feed and bedding bags. A Chlorine Dioxide Decontamination Spray Tunnel provides a cost effective method to decontaminate feed and bedding bags, components, parts, supplies, and equipment entering a "sterile" or "clean" facility at room temperatures.

Some items which can be sanitized in the Decontamination Spray Tunnel include feed and bedding bags, animal cages, trays, components, supplies, etc. The controls are simple start/stop and speed control for the conveyor speed to match your sanitization and throughput requirements.

Ideal application: Incoming feed and bedding bags to research facilities.

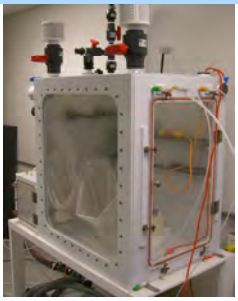
Equipment Decontamination Room Door

The Equipment Decontamination Room Door allows you to turn any room into a sterilization/ decontamination room. This provides a cost effective method to decontaminate components, parts, supplies, and equipment entering a "sterile" or "clean" facility at room temperatures and without the need for a specialized chamber. It can also be used as an exit chamber for a BSL area.

The door utilizes a rugged, non-inflatable gasket so that sealing a door using tape is not required. An optional interlock and control system is available. The door is available in a variety of sizes to meet your facility needs.

Ideal application: Facilities looking to decontaminate components, parts, supplies or equipment entering a clean facility or exiting a BSL facility.

Isolators and Pass-Through Chambers



Clordisys offers custom isolators and pass-through chambers for your facility. They provide a simple and effective chamber complete with decontamination ports and HEPA filters. They can be fabricated using either Stainless Steel or polypropylene depending on your facility's needs and applications. The isolators are fitted with glove ports for manipulating items inside. The pass-through chambers are fitted with two sealed doors and can be fabricated to any size.

Ideal application: They offer an easy way to decontaminate most items so that they can de safely be brought into a clean facility or removed from a hazardous environment.

ClorDiSys Connection Plates

Multi-Room Distribution System - Distribution Plate

The Distribution Plate is part of the Multi-Room Distribution System. The Distribution Plate is located where the CD Gas Generator is operated, either mounted in the ceiling or in the wall. Each target room to be decontaminated houses a Ceiling Plate. Tubing and electrical cables are run above the ceiling between the Distribution Plate and each Ceiling Plate, allowing the CD Generator to connect up to each target room from the same location. This allows for the CD Gas Generator to be stationed in one place and be able to decontaminate any room connected to the system from that location.

Ideal application: For use in a facility that has rooms in both unrestricted and restricted (barrier or BSL) areas to decontaminate, such that the CD Generator can stay outside the restricted area and connect to rooms both inside and outside the restricted area.

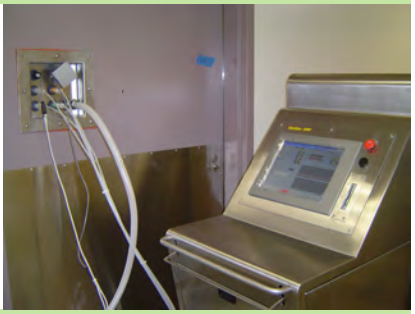
Used in conjunction with Ceiling Plates

Multi-Room Distribution System - Ceiling Plate

The Ceiling Plate is also part of the Multi-Room Distribution System. The Ceiling Plate is located inside the rooms to be decontaminated, and is connected to the distribution plate via tubing and signal cables.

Ideal application: For use in a facility that has rooms in both unrestricted and restricted (barrier or BSL area) areas to decontaminate, such that the CD Generator can stay outside the restricted area and connect to rooms both inside and outside the restricted area.

Door Plate



The Door Plate is used as an interface between the CD Generator and a room. It also allows for a quick and easy connection to the room via valved tubing connectors.

Ideal application: Installed into rooms that will be decontaminated often, creating an easier interface for connecting the generator to the room.

Wall Plate

The Wall Plate is used as an interface between the CD Generator and a room. It also allows for a quick and easy connection to the room via valved tubing connectors.

Sized to replace a mason block, the wall plate is available for stud walls as well.

Ideal application: Installed into rooms that will be decontaminated often, creating an easier interface for connecting the generator to the room.

Under Door Plate

The Under Door Plate is used as an interface between the CD Generator and a room. It provides for an easier surface to seal against than if just sealing around tubing separately. It also allows for a quick and easy connection to the room via valved tubing connectors.

Ideal application: A facility with many different rooms that they wish to decontaminate, as one Under Door Plate can be used throughout the facility.

Saving Energy & Money
Using a Decontamination Chamber vs. a Bulk Autoclave

With individuals and institutions becoming more conscious of their environmental impact, new methods and products for achieving needs have come about. One of the newest ways for your facility to lower it's energy usage and costs is to consider Decontamination Chambers. Decontamination Chambers offer a completely sealed chamber for the decontamination of equipment or materials entering / leaving a barrier facility, or for decontaminating equipment inside of the facility. Decontamination Chambers can save energy and money compared to bulk autoclaves in terms of steam usage, water usage, electricity usage, maintenance costs, replacement costs, cost of capital equipment, and footprint.

Area of Savings	Cost Savings Per Year*
Steam	$27,755
Water Savings	$9,216
Electricity Savings	$828
Gasket Savings	$2500 - $5500
Potential Cage Savings	$35,000 - $70,000
Consumable Costs	($19,695)
Potential Yearly Savings	**$55,604 - $93,604**
Potential Lifetime Savings (25 –yrs)	**$1,390,100 - $2,340,100**

*Assumption of 5 cycles per day for 300 days on a 300 ft^3 chamber.

Bulk Autoclaves require an abundance of water and steam during a decontamination cycle. Steam is used for sterilizing the contents, and water is used for cooling the waste steam to appropriate temperatures for drainage, and may be used in the vacuum pump as well. An average 300 ft^3 (8.5 m^3) bulk autoclave can use over 3050 lbs of steam per day, and over 2400 gallons of water per day. (Amounts vary depending on manufacturer, values given are averaged from multiple manufacturers)

Decontamination chambers also require less maintenance as there is less wear and tear by eliminating the frequent heating and cooling which can strains gaskets and components within the autoclave.

Replacement costs for caging is also a potential for cost savings for the same reason. The heating / cooling / steam can create fissures in the caging, lowering a cage's lifespan and potentially increasing replacement schedule and budget.

As many facilities have multiple Autoclaves, the simplest and easiest decision might be to implement both an Autoclave and a Decon Chamber to fulfill all of your facility's needs.

Chlorine Dioxide Gas decontamination chambers essentially eliminate both water and steam usage, saving facilities both energy and money, potentially around $100,000 per year. To help decide whether implementing a chlorine dioxide gas decontamination chamber, one must look at the items their facility needs to decontaminate. Chlorine Dioxide Gas is capable of decontaminating electronics, racks, cages, HEPA filters, plastics, and the outsides of bedding/feed bags. Autoclaves are still the best suited to decontaminate dense organic materials such as bedding and feed.

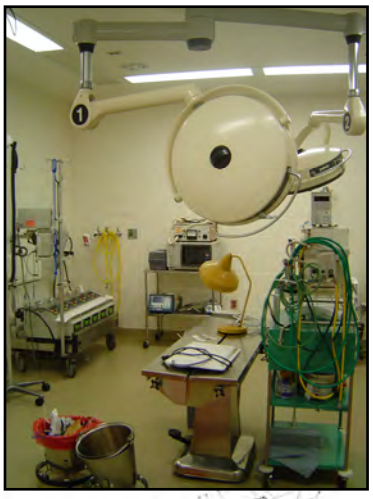
What Can They Be Used To Decon?

	Autoclave	CD Decon Chamber
Bedding	Yes	No
Bedding Bags	Yes	Yes
Feed	Yes	No
Feed Bags	Yes	Yes
Liquids	Yes	No
Waste	Yes	No
Racks	Yes / No	Yes
Cages	Yes	Yes
HEPA Filters	No	Yes
Plastics	Yes / No	Yes
Electronics	No	Yes

The Minidox-M connects to a combination Decontamination Chamber / Rack Washer. This option offers the greatest flexibility, allowing the user to use the same chamber for both decontamination methods. Energy savings are possible here as the user can run a chlorine dioxide gas cycle when there are no items within the chamber that necessitate an autoclave cycle. Such items can be seen in the table above.

Room, Facility & Building Decontamination Service

ClorDiSys Solutions, Inc. provides completely turnkey decontamination services for all types of facilities and applications. If you have contamination issues or are interested in overall facility decontamination prior to move-in CSI can help you. CSI's method of using chlorine dioxide gas allows us to completely decontaminate your facility all at once with minimal equipment and minimal downtime. Gaseous systems provide the ability to get a thorough distribution and complete penetration when compared to any other method (vapors, mists or fogs).



Clordisys Solutions, Inc has the capabilities to decontaminate areas over 1,000,000 ft^3 (28,316 m^3). The ability to decontaminate as a single unit allows for a more effective result with no transition areas. When decontaminating using vapor systems, large amounts of generators are required and the facility must be separated into smaller areas causing more costs for equipment and time to setup. Additionally, separating the facility to smaller areas causes issues with cross contamination when breaking down one area to decontaminate the next area.

Only gaseous decontaminating agents offer effective decontamination against life threatening organisms in a non-ideal setting. These are the only decontaminating agents that are truly effective in areas that are difficult to reach such as floor drains, HVAC grills, beneath furniture and components, the inside of cabinets, hinges, instruments and components, and other difficult-to-reach areas. CD is non-carcinogenic, does not require neutralization, leaves no residues, and provides an extremely fast method for decontamination.

Decontamination service contracts are also available for monthly, bi-monthly, quarterly or yearly occurrences and can comply with facility shut-down events.

What?

- **Rooms**
- **BSL Suites**
- **Entire Facilities**
- **HVAC Ductwork**
- **Processing / Holding Tanks**

When

- **New Construction**
- **Renovations**
- **Contaminations**
- **Decommissioning**
- **Between laboratory populations**

Biological Efficacy of Chlorine Dioxide

Clordisys' Chlorine Dioxide Gas is registered with the United States Environmental Protection Agency as a sterilizer. The U.S. EPA defines a sterilizer as able "to destroy or eliminate all forms of microbial life including fungi, viruses, and all forms of bacteria and their spores. With this classification from the EPA, it can be considered that Chlorine Dioxide Gas will eliminate all viruses, bacteria, fungi, and their spores. Below is a table of some of the more commonly seen organisms that chlorine dioxide has been proven to eliminate. Testing has been done using Chlorine Dioxide on a multitude of specific organisms, and a more complete list is available on our website. To date, no organism tested against Chlorine Dioxide Gas has proved resistant.

Product: CSI CD CARTRIDGE

EPA Reg#: 80802-1

Registrant: CLORDISYS SOLUTIONS, INC

Approval Date: 02/25//2005

Active Ingredients: Sodium chlorite 72.8%

Bacteria:	Ref.
Blakeslea trispora	28
Bordetella bronchiseptica	8
Brucella suis	30
Burkholderia mallei	36
Burkholderia pseudomallei	36
Campylobacter jejuni	39
Clostridium botulinum	32
Clostridium dificile	44
Corynebacterium bovis	8
Coxiella burneti (Q-fever)	35
E. coli ATCC 11229	3
E. coli ATCC 51739	1
E. coli K12	1
E. coli O157:H7 13B88	1
E. coli O157:H7 204P	1
E. coli O157:H7 ATCC 43895	1
E. coli O157:H7 EDL933	13
E. coli O157:H7 G5303	1
E. coli O157:H7 C7927	1
Erwinia carotovora (soft rot)	21
Franscicella tularensis	30
Fusarium sambucinum (dry rot)	21
Fusarium solani var. coeruleum (dry rot)	21
Helicobacter pylori	8
Helminthosporium solani (silver scurf)	21
Klebsiella pneumonia	3
Lactobacillus acidophilus NRRL B1910	1
Lactobacillus brevis	1
Lactobacillus buchneri	1
Lactobacillus plantarum	5
Legionella	38

Bacteria:	Ref.
Legionella pneumophila	42
Leuconostoc citreum TPB85	1
Leuconostoc mesenteroides	5
Listeria innocua ATCC 33090	1
Listeria monocytogenes F4248	1
Listeria monocytogenes F5069	19
Listeria monocytogenes LCDC-81-861	1
Listeria monocytogenes LCDC-81-886	19
Listeria monocytogenes Scott A	1
Methicillin-resistant Staphylococcus aureus (MRSA)	3
Multiple Drug Resistant Salmonella typhi-murium (MDRS)	3
Mycobacterium bovis	8
Mycobacterium fortuitum	42
Pediococcus acidilactici PH3	1
Pseudomonas aeruginosa	3
Pseudomonas aeruginosa	8
Salmonella	1
Salmonella spp.	2
Salmonella Agona	1
Salmonella Anatum Group E	1
Salmonella Choleraesins ATCC 13076	1
Salmonella choleraesuis	8
Salmonella Enterica (PT30) BAA-1045	1
Salmonella Enterica S. Enteritidis	13
Salmonella Enterica S. Javiana	13
Salmonella Enterica S. Montevideo	13
Salmonella Enteritidis E190-88	1
Salmonella Javiana	1
Salmonella newport	4

Bacteria:	Ref.
Salmonella Typhimurium C133117	1
Salmonella Anatum Group E	1
Shigella	38
Staphylococcus aureus	23
Staphylococcus aureus ATCC 25923	1
Staphylococcus faecalis ATCC 344	1
Tuberculosis	3
Vancomycin-resistant Enterococcus faecalis (VRE)	3
Vibrio strain Da-2	37
Vibrio strain Sr-3	37
Yersinia enterocolitica	40
Yersinia pestis	30
Yersinia ruckerii ATCC 29473	31

Viruses:	Ref
Adenovirus Type 40	6
Calicivirus	42
Canine Parvovirus	8
Coronavirus	3
Feline Calici Virus	3
Foot and Mouth disease	8
Hantavirus	8
Hepatitis A Virus	3
Hepatitis B & C Viruses	8
Human coronavirus	8
Human Immunodeficiency Virus	3
Human Rotavirus type 2 (HRV)	15
Influenza A	22
Minute Virus of Mouse (Parovirus)(MVM-i)	8
Minute Virus of Mouse (Parovirus)(MVM-p)	8
Mouse Hepatitis Virus (MHV-A59)	8
Mouse Hepatitis Virus (MHV-JHM)	8
Mouse Parvovirus type 1 (MPV-1)	8
Murine Parainfluenza Virus Type 1 (Sendai)	8
Newcastle Disease Virus	8
Norwalk Virus	8
Poliovirus	20
Rotavirus	3
Severe Acute Respiratory Syndrome (SARS)	43
Sialodscryoadenitis Virus (Coronavirus)(SDAV)	8
Simian rotavirus SA-11	15
Theiler's Mouse Encephalomyelitis Virus (TMEV)	8
Vaccinia Virus	10

Algae/Fungi/Mold/Yeast:	Ref.
Alternaria alternata	26
Aspergillus aeneus	28
Aspergillus aurolatus	28
Aspergillus brunneo-uniseriatus	28
Aspergillus caespitosus	28
Aspergillus cervinus	28
Aspergillus clavatonanicus	28
Aspergillus clavatus	28
Aspergillus egyptiacus	28
Aspergillus elongatus	28
Aspergillus fischeri	28
Aspergillus fumigatus	28
Aspergillus giganteus	28
Aspergillus longivesica	28
Aspergillus niger	12
Aspergillus ochraceus	28
Aspergillus parvathecius	28
Aspergillus sydowii	28
Aspergillus unguis	28
Aspergillus ustus	28
Aspergillus versicolor	28
Botrytis species	3
Candida spp.	5
Candida albicans	28
Candida dubliniensis	28
Candida maltosa	28
Candida parapsilosis	28
Candida sake	28
Candida sojae	28
Candida spp.	5
Candida tropicalis	28
Candida viswanathil	28
Chaetomium globosum	7
Cladosporium cladosporioides	7
Debaryomyces etchellsii	28
Eurotium spp.	5
Fusarium solani	3
Lodderomyces elongisporus	28
Mucor circinelloides	28
Mucor flavus	28
Mucor indicus	28
Mucor mucedo	28
Mucor rademosus	28
Mucor ramosissimus	28

Algae/Fungi/Mold/Yeast:	Ref.
Mucor saturnus	28
Penicillium chrysogenum	7
Penicillium digitatum	3
Penicillium herquei	28
Penicillium spp.	5
Phormidium boneri	3
Pichia pastoris	3
Poitrasia circinans	28
Rhizopus oryzae	28
Roridin A	33
Saccharomyces cerevisiae	3
Stachybotrys chartarum	7
T-mentag (athlete's foot fungus)	3
Verrucarin A	33

Bacterial Spores:	Ref.
Alicyclobacillus acidoterrestris	17
Bacillus coagulans	12
Bacillus anthracis	10
Bacillus anthracis Ames	30
Bacillus atrophaeus	14
Bacillus atrophaeus ATCC 49337	31
Bacillus megaterium	12
Bacillus polymyxa	12
Bacillus pumilus ATCC 27142	12
Bacillus pumilus ATCC 27147	11
Bacillus subtillis (globigii) ATCC 9372	11
Bacillus subtillis ATCC 19659	31
Bacillus subtillis 5230	12
Clostridium. sporogenes ATCC 19404	12
Geobacillus stearothermophilus ATCC 12980	11
Geobacillus stearothermophilus ATCC 7953	31
Geobacillus stearothermophilus VPHP	11
Bacillus thuringiensis	18

Beta Lactams:	Ref.
Amoxicillin	29
Amplicillin	29
Cefadroxil	29
Cefazolin	29
Cephalexin	29
Imipenem	29
Penicillin G	29
Penicillin V	29

Protozoa:	Ref.
Chironomid larvae	27
Cryptosporidium	34
Cryptosporidium parvum Oocysts	9
Cyclospora cayetanensis oocysts	41
Giardia	34

Microsporidia:	Ref.
Encephalitozoon intestinalis	41

Chemical Decontamination:	Ref.
Mustard Gas	
Ricin Toxin	10
dihydronicotinamide adenine dinucleotide	24
microcystin-LR (MC-LR)	25
cylindrospermopsin (CYN)	25

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