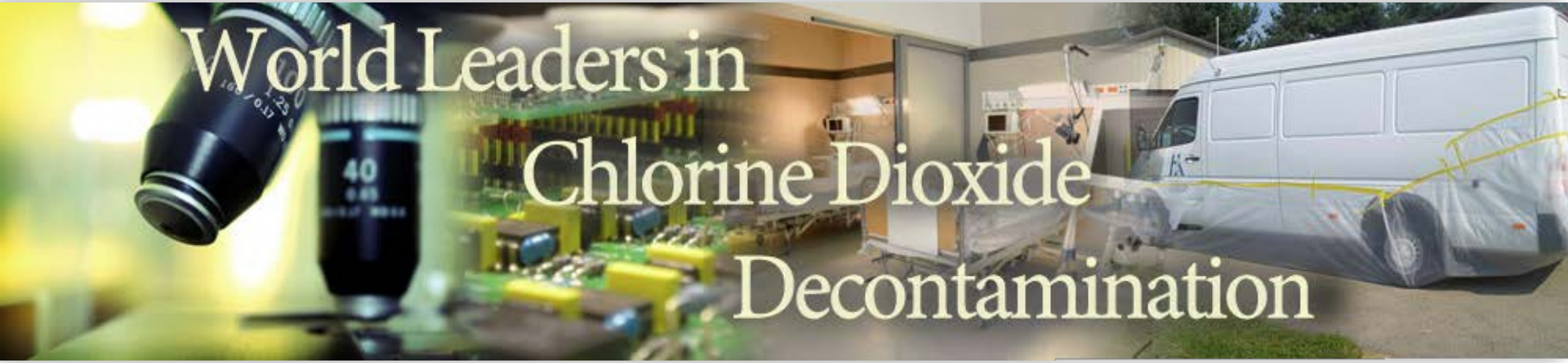
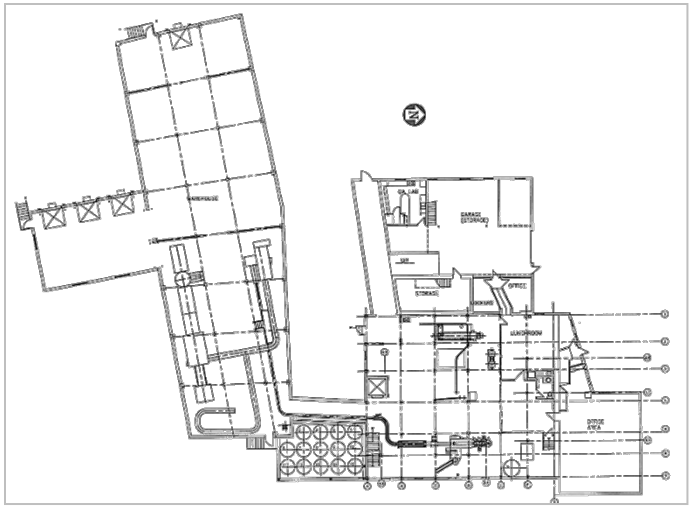
ClorDiSys





Principles of Chlorine Dioxide Gas as a Decontamination Method

Principles of Decontamination

In order for any decontamination method to be effective, the following points must be satisfied

The decontamination method must:

- ✓ **Be able to kill the organism in question**
- ✓ **Achieve good and complete distribution**
- ✓ **Achieve thorough and total penetration**
- ✓ **Achieve sufficient contact time at the correct concentration**

Traditional Sanitation Methods

Traditional sanitation methods can have difficulty guaranteeing that all organisms have been contacted / contacted with the proper dosage

The decontamination method must:

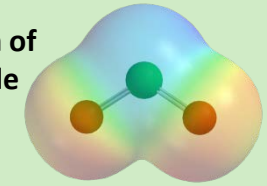
- ✓ **Be able to kill the organism in question**
- ? **Achieve good and complete distribution**
- ? **Achieve thorough and total penetration**
- ? **Achieve sufficient contact time at the correct concentration**

History of Chlorine Dioxide

A Brief Summary:

1912
Aqueous Germicide (Drinking Water Treatment Longest User)

1811
First Preparation of Chlorine Dioxide



1984
Chlorine Dioxide Recognized as a Gaseous Chemosterilizing Agent

1940
Bleaching Agent (Pulp & Paper Industry Largest User)

2001
ClorDiSys

1988
First Registered with the US-EPA for use as a sterilant

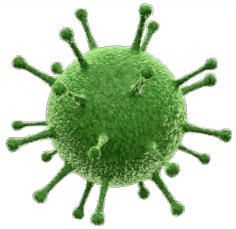
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Chlorine Dioxide Gas Process

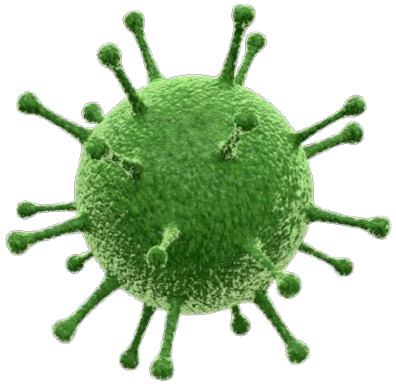
- **Pre-Conditioning**
  Raise relative humidity to 65-75%
- **Conditioning**
  Hold that humidity level for a short period of time
- **Charge**
  Inject CD Gas to a concentration of 1 - 5 mg/L
- **Exposure**
  Hold time at that CD Gas concentration
- **Aeration**
  Remove CD Gas

Antimicrobial Efficacy

	Chlorine Dioxide Gas
Registration	Sterilant



ClorDiSys' Chlorine dioxide gas is registered as a sterilant with the US EPA, which means it is capable of eliminating all viruses, bacteria, fungi and spores.



Antimicrobial Efficacy

Target Organism	Dosage Required using CD Gas
Salmonella	~100 ppm-hrs for 6-log kill
Listeria	~300 ppm-hrs for a 5-log kill
Spores	~600 ppm-hrs for 6-log kill
ClorDiSys Decon Cycle	720 ppm-hrs

Spores are considered the hardest organism to eliminate, compared to live viruses and bacteria which are considerably easier.

Humidity's Role Towards Efficacy

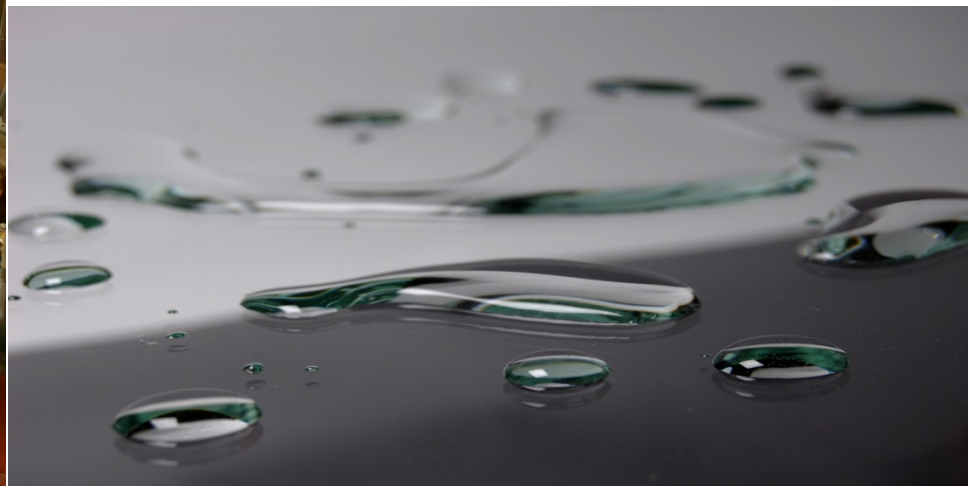
Chlorine dioxide has been validated to be effective at lower relative humidity, but requires a higher dosage

RH	Dosage Required for 6-log Spore Reduction
65%	~600 ppm-hrs
55%	~1000 ppm-hrs
45%	~1550 ppm-hrs

Wet Areas

As Chlorine Dioxide Gas is water soluble, it is able to maintain its efficacy within water, so areas do not have to be completely dry for the process to work.

As wash downs and manual cleaning traditionally occur prior to decontamination, using chlorine dioxide gas means that surfaces do not need to be completely dry prior to decontaminating.



Distribution

A chemical can't kill what it can't reach.

	Chlorine Dioxide Gas
Boiling Point	**51°F**
Natural State at Room Temperature	**Gas**

Gasses fill the space they are contained within evenly and completely.

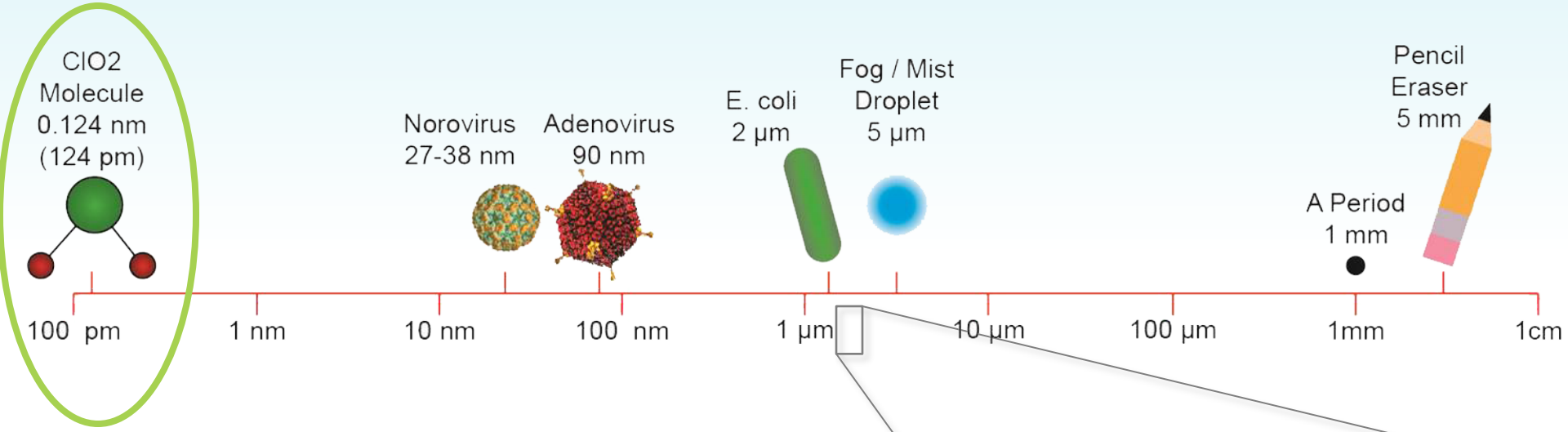
Chlorine Dioxide Gas is able to evenly fill the area it is decontaminating, no matter how large, tall or filled with equipment.

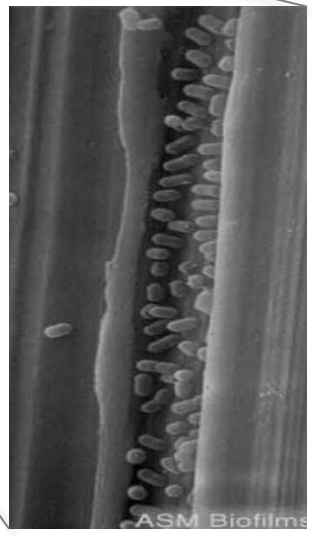
Distribution

Distribution

Penetration into Crevices

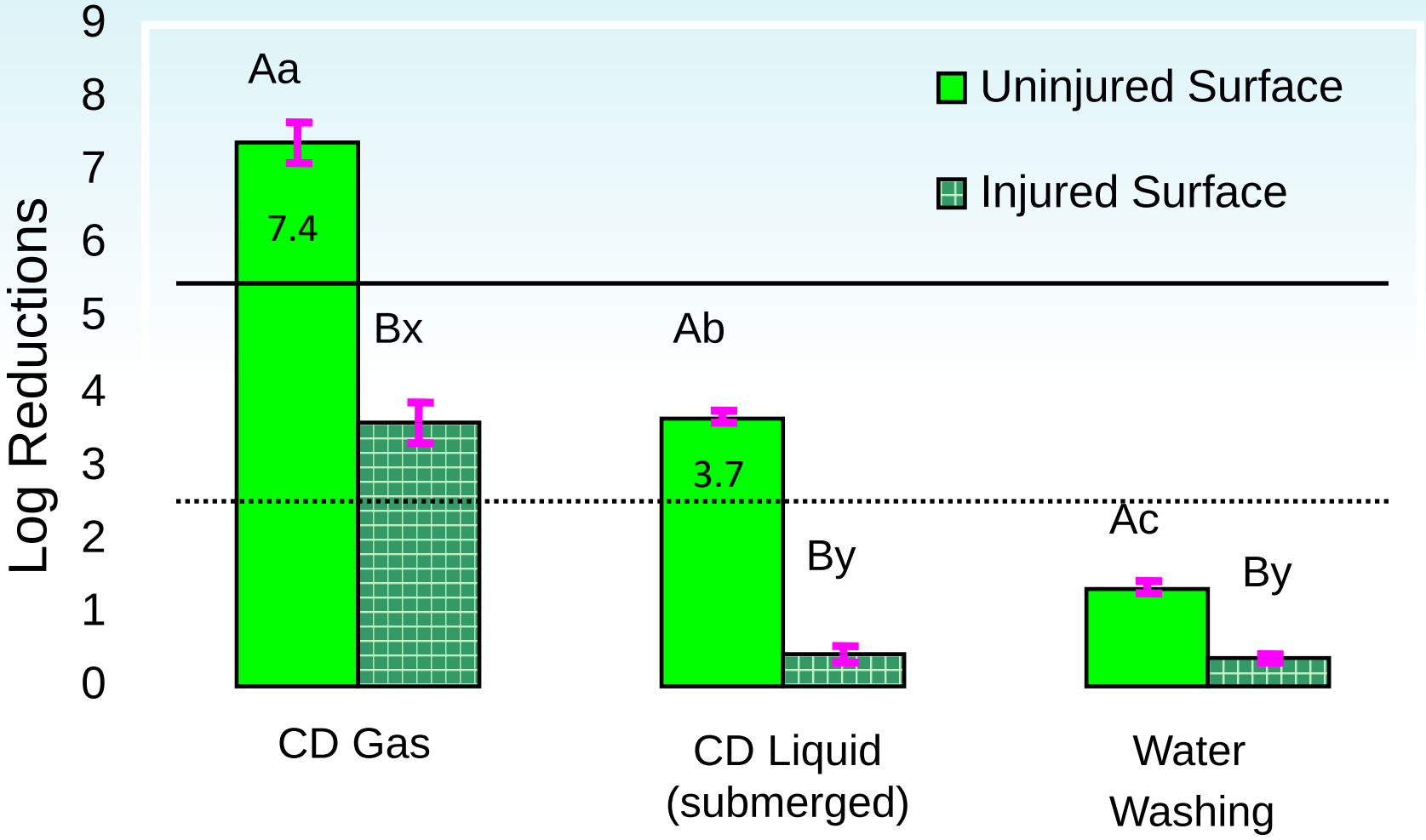
Organisms sizes vs ClO_2 molecule





Magnified scratch in stainless steel harboring bacteria

CD Gas vs. CD Liquid



Equal concentrations of CD Gas and Liquid used

All the treatments were for 10 min at 20°C

(Han, Y. et al, Reduction of Listeria monocytogenes on Green Peppers (Capsicum annuum L.) by Gaseous and Aqueoous Chlorine Dioxide and Water Washing and Its Growth at 7°C, Journal of *Food Protection, Vol 64, No 11, 2001 pages 1730-1738*)

Efficacy & Validation

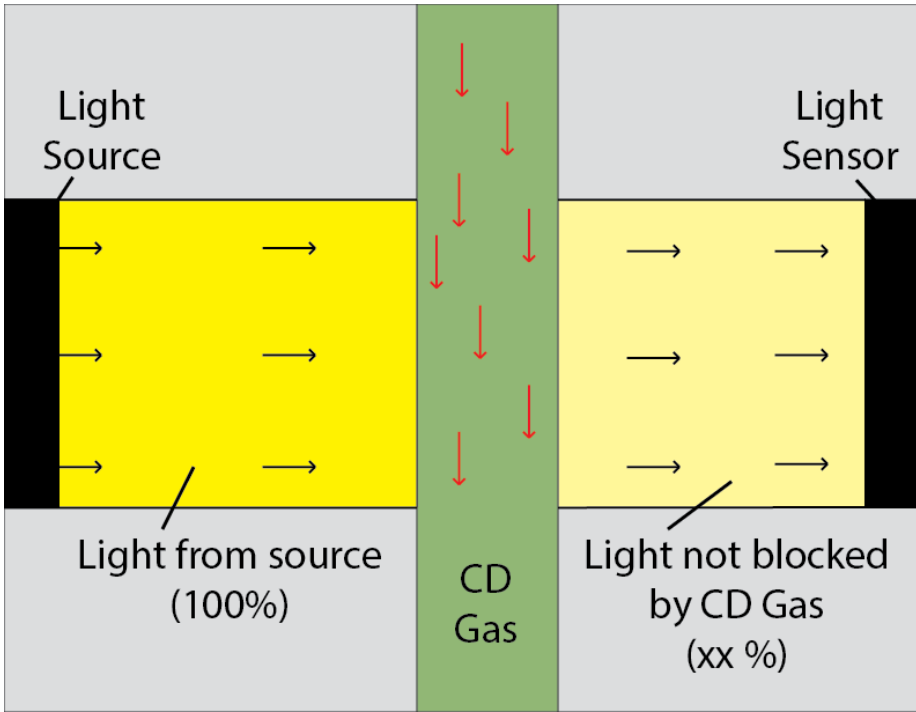
QA Method	Description
Concentration Monitor	Verifies the concentration of CD gas during a decontamination and overall cycle dosage
Biological Indicators	Verifies that the decontamination cycle achieved 6-log sporicidal reduction
Swab Testing	… you know this one.

Concentration Monitoring

	Chlorine Dioxide Gas
Color	Yellow-Green
Concentration Monitoring	uv-vis spectrophotometer

Thanks to its yellow-green color, chlorine dioxide is able to be accurately monitored using a photometer.

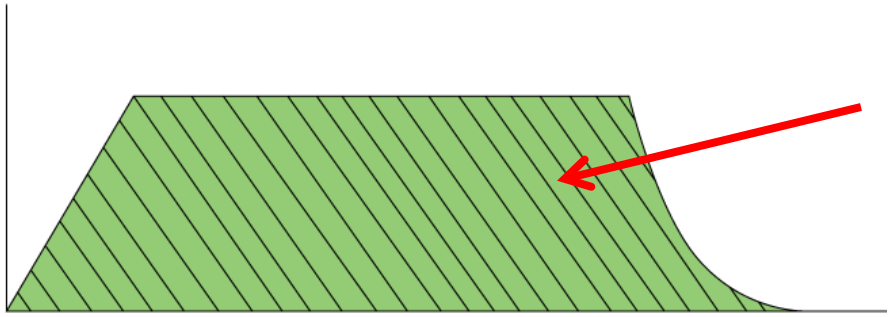
The higher the concentration of gas, the deeper (darker) the color gets. The photometer measures the depth of color of the gas and converts it to a highly-accurate concentration reading.



Contact Time and Dosage

	Chlorine Dioxide Gas
Concentration Monitoring	Highly Accurate

You can hold the true concentration for the contact time necessary to achieve the dosage required for a complete decontamination.



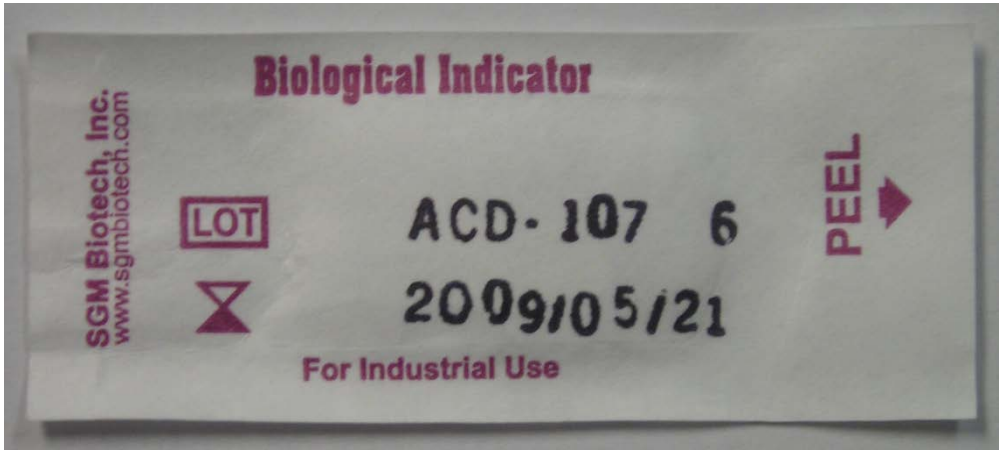
Area under the curve is a highly accurate dosage measurement.

Decontamination Dosage

The decontamination is not considered to be complete until all concentration monitoring locations exceed the proper dosage.

Biological Indicators

Biological indicators consist of a semi-permeable outer packaging and a interior carrier impregnated with bacterial spores. For sterilization, BI's contain over 1 million bacterial spores, providing the ability to prove a 6-log (99.9999%) sporicidal reduction.

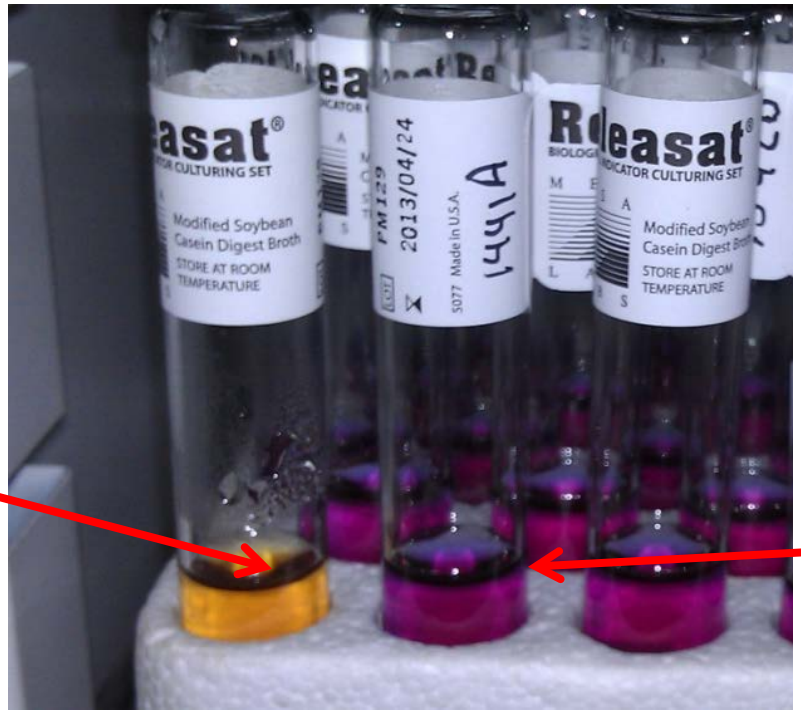


BI Analysis

After the decontamination process is complete, BI's are collected and aseptically dropped into growth media tubes and incubated. If any spores were not killed in the BI, they will grow and the bacteria will multiply causing turbidity (cloudiness) or a color change within the media tube. Each BI/media combination has a validated incubation time which is how long you must wait before taking a final reading on the BI for growth. CD gas has a 36-48 hr incubation time depending on BI manufacturer.

Positive for growth

(Decon unsuccessful)

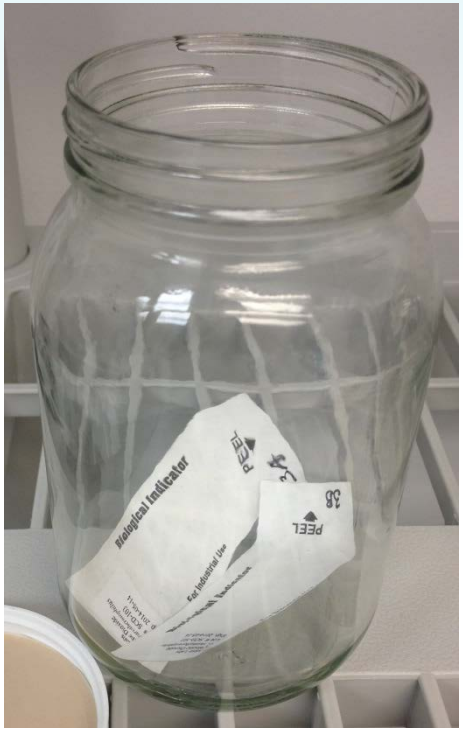
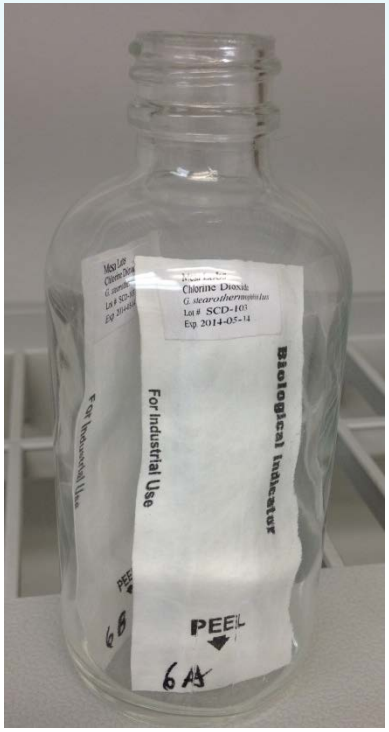
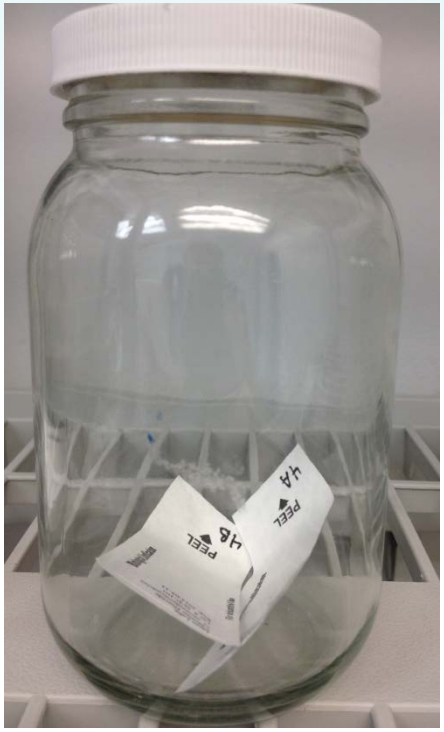


Negative for growth

(Decon successful)

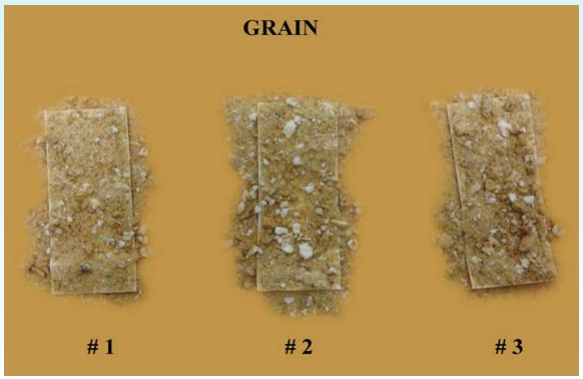
Penetration into Open and Closed Cabinets

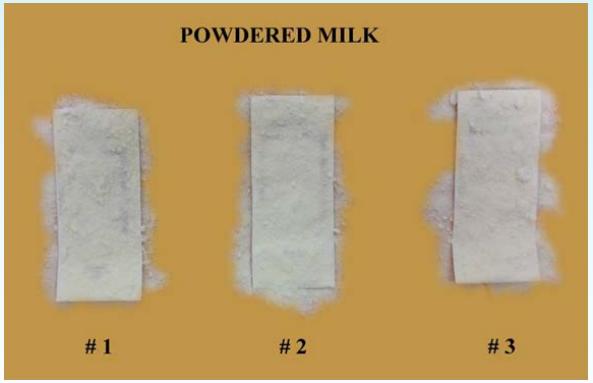
Penetration Inside Jars

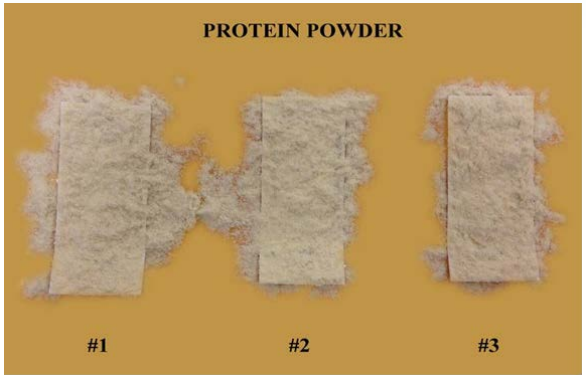
BIs Killed	BIs Killed	BIs Killed	BIs NOT Killed
			
Open jar	Open jar	Lid placed on top of jar	Lid sealed on jar

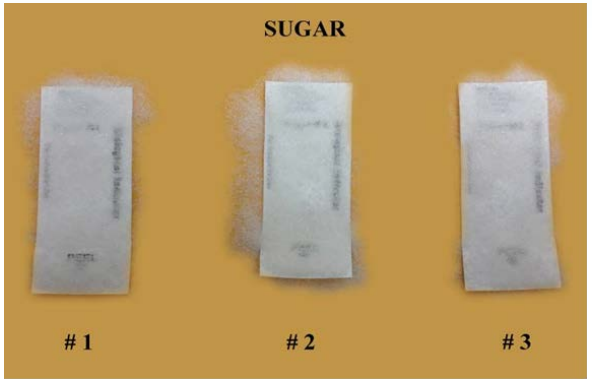
Penetration into Grain, Powdered Milk, Protein Powder, Sugar, Flour, Baby Formula

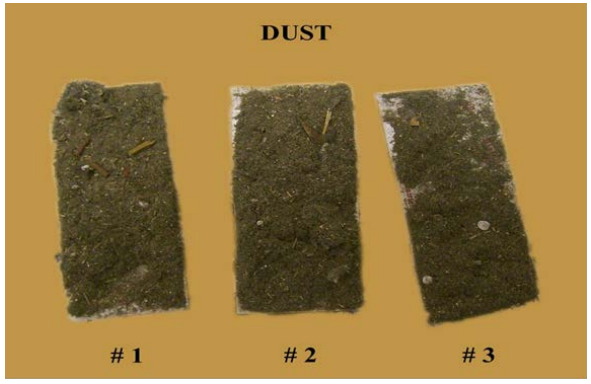
ALL BIs Killed

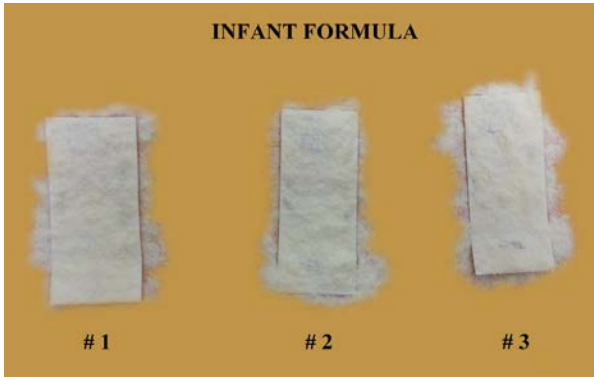












Cycle Flexibility

	Chlorine Dioxide Gas
Temperature	Not a factor above 52 F
Starting Relative Humidity	Not a factor
Equipment Within Space	Not a factor, gas gets everywhere
Room Shape / Size	Not a factor, gas gets everywhere
Injection Point Location	Not a factor, gas gets everywhere

Efficacy Summary

Chlorine Dioxide Gas is able to achieve the requirements for a successful decontamination naturally due to its chemical properties.

The decontamination method must:

- ✓ **Be able to kill the organism in question**
- ✓ **Achieve good and complete distribution**
- ✓ **Achieve thorough and total penetration**
- ✓ **Achieve sufficient contact time**

  at the correct concentration

Material Compatibility

Oxidation Potential

Biocidal Agent	Oxidation Potential (volts)	Oxidation Capacity (electrons)
Ozone	2.07	2e-
Peracetic acid	1.81	2e-
Hydrogen Peroxide	1.78	2e-
Bleach	1.49	2e-
Chlorine Dioxide	**0.95**	**5e-**

Chlorine Dioxide is scientifically gentler on materials than these other sterilant methods.

Chlorine Dioxide vs Chlorine Dioxide

Better Ingredients, Better Chlorine Dioxide

Chlorine dioxide does not last long enough to be bottled and shipped, so it must be generated on demand. Depending on the method in which chlorine dioxide is generated, the end product can vary greatly.

ClorDiSys generates pure chlorine dioxide for decontamination

(4% Chlorine Dioxide – 96% Nitrogen)

Other methods of generating chlorine dioxide (liquid or gas) generate acidic byproducts along with the chlorine dioxide

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

No Residue

ClorDiSys CD Gas has no residues

One of the first commercial uses for ClorDiSys' (Then J&J's) chlorine dioxide gas was to sterilize implantable contact lenses. It was proven to the FDA that this sterilization method left no measurable residuals.

We are starting to receive FDA approvals for treating food products with our chlorine dioxide gas as well. Each approval requires residual testing to prove that the food is safe to eat.

Material Compatibility

CD gas is safe on:

Stainless steel

Galvanized metals

Anodized aluminum

Painted / coated metals

Plastics

Epoxy Paints / Coatings

Electronics

CD can affect:

Unpainted ferrous metals

Urethane Foam

Some Natural Rubbers

Safety

How to Decontaminate Safely

The key component to decontaminating a space safely is to contain it within the area you are treating. This can be done through the following steps:

- Sealing all penetrations leading in / out of the space (such as pipes)
- Sealing off the HVAC system handling the space (where applicable)
- Sealing off the doors and entry points to the space

Chlorine Dioxide is Non-carcinogenic

Current Uses:

- Over 700 municipalities use chlorine dioxide to disinfect their public drinking water.
- Used in poultry processing rinse water
- Used in fruit and vegetable rinse water
- Listed as an allowed substance on its National Organic Program's National List of Allowed and Prohibited Substances

Chlorine Dioxide is not classified as a carcinogen by any health agency

Odor Threshold

	C D
OSHA 8 hr TWA	0.1 ppm
Typical Concentrations	360 ppm
Odor Detection	**YES** **At 8 hour safety level**

The smell of CD is distinguishable from, but similar to the smell of chlorine. This is beneficial as chlorine's odor is widely known and recognized, so there is no learning curve for personnel in recognizing when there is CD present. While one's nose is not meant to be used as a primary means of odor detection due to the variance in sensitivity to smell that personnel have, it provides an extra layer of personal protection.

Chlorine Dioxide Gas

The chemical properties of chlorine dioxide make it well suited for space decontamination.

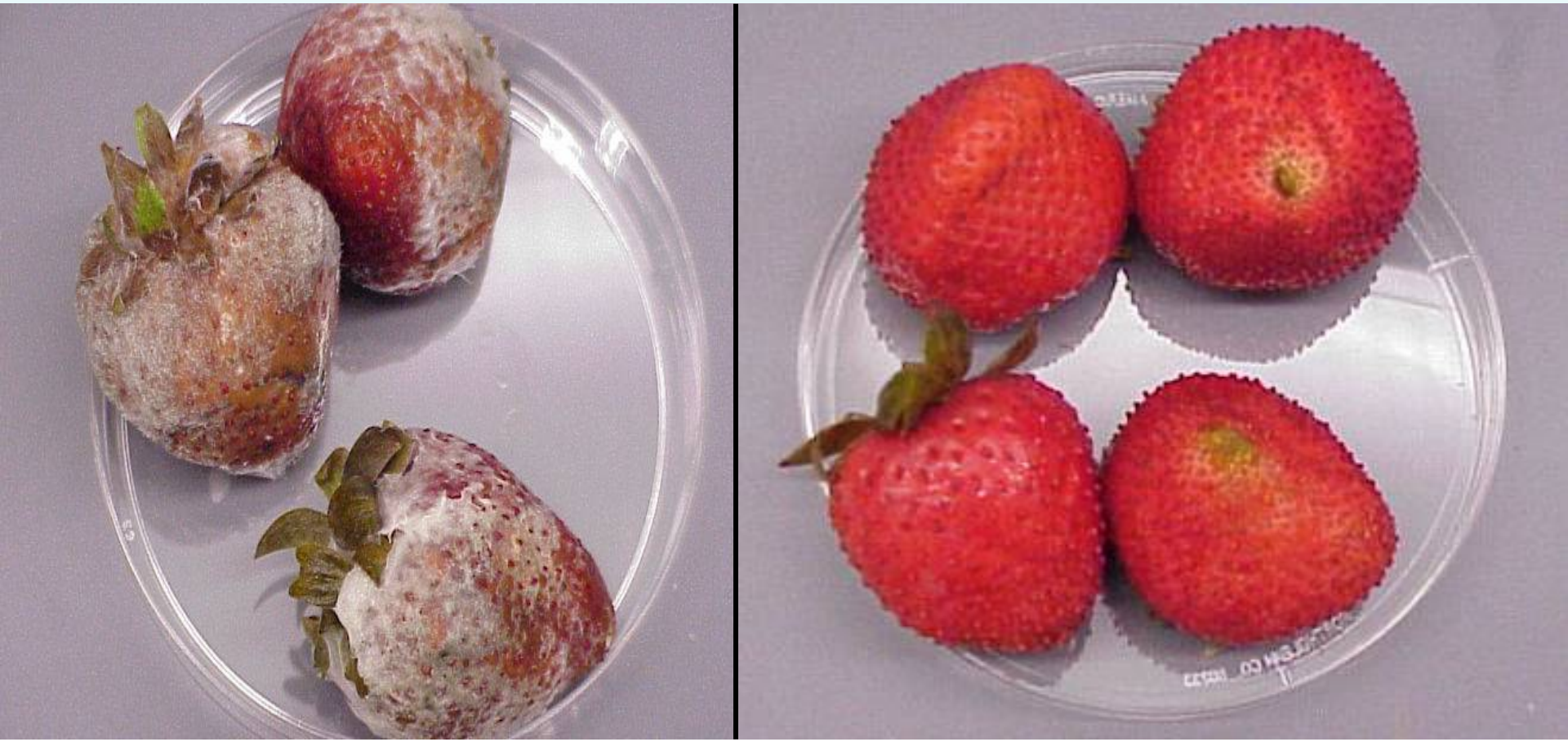
Chlorine dioxide gas is able to achieve a complete 6-log sporicidal decontamination of all surfaces within a space, including hard-to-reach areas such as crevices.

This allows it to successfully treat large areas all at once without missing any organisms.

Shelf Life Extension

Untreated and stored for 6 weeks at 4°C

Treated with 10 mg/l Chlorine dioxide gas for 10 min and stored for 6 weeks at 4°C



Han Y., Linton, R.H., and Nelson, P.E., Inactivation of *Escherichia coli* O157: H7 and *Listeria monocytogenes* on strawberry by chlorine dioxide gas, annual meeting of Institute of Food Technologists, Anaheim, CA, 2002.