



“The Chlorine Dioxide People”

Providing you with gaseous chlorine dioxide solutions for your decontamination needs

## Chlorine Dioxide vs. “Vapor” Phase Hydrogen Peroxide (VPHP)

Chlorine Dioxide (CD) and formaldehyde are the only effective decontaminating agents that are used for the decontamination of buildings, rooms, isolators and bio-safety cabinets that are “true” gases. **NSF has approved** CD gas for biological safety cabinet (BSC) decontamination. VPHP is NOT approved for BSC decontamination. Hydrogen peroxide is a liquid at room temperature and requires boiling or vaporization to generate the vapor. The boiling point for 35% hydrogen peroxide is 228°F (109°C) while room temperature is only 70°F (21-22°C). A vapor is basically a super heated fluid that, when introduced into a room, wants to return to its original form, a liquid, as condensation. If the target chamber is a long distance from the generator (more than a few feet), heat tracing or insulation of hosing is required to REDUCE condensation in the hoses.

Gaseous CD does not require tight control of Dew Point temperatures as is required with VPHP (ie. difficult to obtain uniform condensation or lack of condensation in a real world application). Gaseous CD has **Quicker Aeration** due to minimal absorption and lack of condensation. Additionally, CD systems from CSI can include **integrated, accurate, and repeatable CD concentration measurement** and control. This means that while only an *injection rate* is selected with VPHP and the chamber concentration assumed, an *actual chamber concentration* is chosen and attained with CD. This greatly simplifies validation efforts and assures efficacy and repeatability. CD has been shown to be effective even with soiled loads while VPHP has been shown to be ineffective. **CD gas is also water soluble** and does not dissociate in water making it effective in applications which may have water (such as rack washers). VPHP does not penetrate water.

**CD gas is the safest fumigation** technology available. It is because of the odor detection below the 8hr threshold (VPHP has no odor) and CD gas has the fastest cycle times 3-4 hours for a typical room versus 6-12 hours for VPHP.

**Scalability:** One single ClorDiSys CD generator can decontaminate spaces from 1 to over 60,000 cubic feet as compared to multiple Hydrogen Peroxide generators (typically 1 generator for every 2000 cubic feet). Using VPHP injection rates need to be modified for room size and configuration with CD the injection rate does not change at all. CD can decontaminate a BSL-3 room or it can decontaminate the entire suite at once (not one room at a time). VPHP would decontaminate the suite one room at a time (requiring multiple days) or require multiple VPHP generators. This demonstrates the superiority of a true gas versus vapor phase.

**Material Compatibility:** Hydrogen Peroxide is 1.9 times more corrosive than CD based on its higher oxidation potential.

**Efficacy:** CD is **250% more efficient** than Hydrogen Peroxide due to CD’s higher oxidation capacity based on CD seeking 5 free electrons vs. 2.<sup>1</sup>

**Cycle Development:** No cycle development is necessary for CD, the cycles are set. Which VPHP cycles must be developed for each chamber or room. Equipment in the room blocks the flow of vapors requiring different cycles than cycles with empty rooms. Shape of the room can affect VPHP while the **shape or the room or equipment does not affect CD gas**.

**Quicker Cycles:** To further highlight the benefits of CD, the following documents example cycle times for both CD and VPHP.

| Isolator Decontamination | Volume   | Cycle Time                                 |
|--------------------------|----------|--|
| Steris VPHP              | ≈ 25 ft3 | 3-6 hours <sup>2</sup>                     |
| Bioquell Clarus          | ≈ 25 ft3 | 3-3.5 hours <sup>2</sup>                   |
| Chlorine Dioxide         | 31 ft3   | 1.3 hours <sup>3</sup>                     |
| Room Decontamination     | Volume   | Cycle Time                                 |
| Steris VPHP              | 300 ft3  | 7.5 hours <sup>4</sup>                     |
| Steris VPHP              | 760 ft3  | 4.25 hours+overnight aeration <sup>5</sup> |
| Bioquell Clarus          | 2500 ft3 | 10-11 hours <sup>6</sup>                   |
| Chlorine Dioxide         | 2700 ft3 | 3.5 hours <sup>7</sup>                     |

“Both gases (VHP and CD) are effective against biological agents and residual chemical agents, but destruction of some chemical agents is slow. **Chlorine dioxide was identified as the best available fumigant** for decontaminating parts of the Hart Senate Office Building, as well as for fumigating mail and packages” (SCIENCE Vol. 302 No. 21 November 2003 pp. 1350-1354).

Additional benefits can be seen in the following table:

|                                   | “Vapor” Hydrogen Peroxide   | Chlorine Dioxide  |
|-----------------------------------|---|---|
| <b>Safety</b>                     | <ul style="list-style-type: none"> <li>Not Carcinogenic</li> <li>Mucus membrane irritant</li> <li>No decontamination needed upon exiting facility</li> <li>People entering area need to be in self contained breathing apparatus (SCBA)</li> <li>EPA Acute toxicity category I (danger) for skin and category I (danger) for eye</li> </ul>   | <ul style="list-style-type: none"> <li>Not Carcinogenic</li> <li>Mucus membrane irritant</li> <li>No decontamination needed upon exiting facility</li> <li>People entering area need to be in self contained breathing apparatus (SCBA)</li> <li>EPA Acute toxicity category II (warning) for skin and category III (caution) for eye</li> </ul>  |
| <b>Current uses</b>               | <ul style="list-style-type: none"> <li>Pharmaceutical and Medical Device Equipment and Components</li> <li>Medical Device Sterilization</li> <li>Hospital</li> <li>NOT NSF approved for BSC decontamination</li> </ul>  | <ul style="list-style-type: none"> <li>Bio-remediation (Anthrax- Hart Building, Trenton Post Office, AMI building)</li> <li>Pharmaceutical and Medical Device Equipment and Components</li> <li>Medical Device Sterilization</li> <li>BSC decontamination (NSF Approved)</li> <li>Removal of biofilms</li> <li>Water treatment</li> <li>Food sanitization (Meats and Produce)</li> <li>Drinking water</li> </ul>  |
| <b>Regulatory status</b>          | <ul style="list-style-type: none"> <li>Only Steris Vaprox is EPA registered for sterilization/decontamination, List A: EPA's Registered Antimicrobial Products as Sterilizers</li> </ul>  | <ul style="list-style-type: none"> <li>ClorDiSys Solutions, Inc. is EPA registered for sterilization/decontamination (Including rooms) , List A: EPA's Registered Antimicrobial Products as Sterilizers</li> </ul>  |
| <b>Biocidal Activity</b>          | <ul style="list-style-type: none"> <li>Broad Spectrum</li> <li>Good sporicidal activity</li> </ul>  | <ul style="list-style-type: none"> <li>Broad Spectrum</li> <li>Good sporicidal activity</li> </ul>  |
| <b>Mode of action</b>             | <ul style="list-style-type: none"> <li>Oxidation (oxidation potential of 1.78)</li> <li>Oxidation Capacity of only 2e-</li> </ul>   | <ul style="list-style-type: none"> <li>Oxidation (oxidation potential of 0.95)</li> <li>Oxidation Capacity of 5e-</li> <li>Free radical monomer</li> <li>Does not Chlorinate</li> </ul>   |
| <b>Functional Conditions</b>      | <ul style="list-style-type: none"> <li>Typical Use concentrations 750-1500ppm</li> <li>Need very low humidity levels prior to starting cycle</li> <li>Concentration based on loss in mass</li> <li>Ideal temp &gt; 35°C (to reduce condensation)</li> <li>Boiling/Vaporization of liquid</li> <li>Typical cycle time 10 hours (2500 ft<sup>3</sup> chamber)</li> </ul>  | <ul style="list-style-type: none"> <li>Use concentrations used typically 108-1800ppm</li> <li>Need &gt; 65% RH (hydration critical to sporicidal properties)</li> <li>Effective at ambient temperatures (15-40°C)</li> <li>In situ generation</li> <li>Typical cycle time 3.5 hours (2700 ft<sup>3</sup> chamber)</li> </ul>  |
| <b>Advantages / Disadvantages</b> | <ul style="list-style-type: none"> <li>Broad Spectrum biocidal properties</li> <li>Good sporicidal activity</li> <li>Does not have effect on wide range of plastics</li> <li>Does not have effect on stainless steel surfaces</li> <li>Vapors have poor penetrating ability</li> <li>Vapors have poor distribution ability</li> <li>Typically 1 generator for every 2000 cu ft</li> <li>Oxidation Capacity of only 2e-</li> <li>More corrosive effects due to higher oxidation potential</li> <li>Need higher operating temperatures in chamber to reduce hydrogen peroxide condensation</li> <li>Cannot take into account loss of vapor concentration due to condensation</li> <li>Long cycle times</li> <li>If generator is a long distance from chamber (&gt;5ft) insulation and heat tracing of hoses required to reduce condensation</li> <li>Can be corrosive to uncoated ferrous metals at higher concentrations</li> <li>Galvanized steel (duct work) and aluminum catalytically breaks down hydrogen peroxide</li> <li>Does not obtain kill on cement block</li> <li>Does NOT penetrate water</li> </ul> | <ul style="list-style-type: none"> <li>Broad Spectrum biocidal properties</li> <li>Good sporicidal activity</li> <li>Does not have effect on wide range of plastics</li> <li>Does not have effect on stainless steel surfaces</li> <li>Chlorine Dioxide is a true gas (Boiling point 11°C)</li> <li>Gasses have excellent penetration ability</li> <li>Gasses have excellent distribution ability</li> <li>1 generator for over 60,000 cu ft</li> <li>More efficient due to Oxidation Capacity of 5e-</li> <li>Gas concentration is continuously monitored during process</li> <li>No neutralization of the gas is needed</li> <li>Can vent to atmosphere or scrub</li> <li>Gas penetrates dead legs and hard to reach places</li> <li>Used to sanitize equipment in food industry</li> <li>Novartis validated filling line using Chlorine Dioxide</li> <li>Does not Chlorinate environment and equipment</li> <li>Does not have effect on anodized aluminum</li> <li>Can be corrosive to uncoated ferrous metals at higher concentrations</li> <li>Penetrates water</li> </ul> |

**References:**

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