



“The Chlorine Dioxide People”

Application Note:

Chlorine Dioxide Gas Treatment by Dosage

Should the decontamination cycle be time based or dosage based? Previously, accurate measurement of other decontaminating agents was not consistent or reliable. Since chlorine dioxide gas has a visible color it is easily and accurately measured by a UV-VIS spectrophotometer. So the question comes up, can the cycle be based upon dosage (concentration–time, CT) or does it need to be based on time. To test this, ClorDiSys performed tests at different concentrations (0.3, 0.5, 1, 5, 10 & 20 mg/L) all with the same dosage (720ppm-hrs). These tests were based upon earlier studies, see table 1 & 2.

Objectives: Verify the linear relationship between concentration and contact time for achieving 6-log sporicidal kill with chlorine dioxide (CD) gas.

Method: 6-log biological indicators will be used to test the efficacy of chlorine dioxide gas when the overall dosage is held constant but the concentration and contact times are varied. Chlorine dioxide gas concentrations will range from 108 ppm up to 7200 ppm with the overall exposure dosage (CT) held steady at 720 ppm-hr.

Results: Data has shown that the concentration of chlorine dioxide gas used does not affect the overall efficacy of the sterilization cycle as long as the overall exposure dosage of 720 ppm-hr has been met. See Table 3 for results.

Conclusion: The overall exposure dosage is the determining factor of sterilization cycle efficacy when using chlorine dioxide gas. Any concentration of gas can be used as long as it is held for the proper amount of time to achieve the correct overall exposure dosage.

Outcomes: Applying these findings to applications, would allow for faster cycle times and/or lower cycle costs.

Equipment Used

- 1 Minidox-M CD Gas Generator with Control by PPM-Hrs
- 17 ft³ (0.5m³) Isolator
- NAMSA Spore Strips TCDS-06,
 - Tyvek wrapped paper carriers
 - *Geobacillus Stearotherophilus* (Lot # S94001, S86104, S84102)
- NAMSA Color Change Culturing Media (Lot # GM004986)
- Incubation at 57 Deg C for 36 hours
- BSC Scrubber (remove CD gas)

Table 1: The following table summarizes a previous dosage study using the same PPM-Hrs at various CD gas concentrations using *bacillus atrophaeus* spore strips.

ppm-hrs	mg/L	RH	Condition Time	Results
720	1	65	5	0/3, 0/3, 0/3
720	5	65	30	0/3, 0/3, 0/3
720	10	65	30	0/3, 0/3, 0/3
720	20	65	30	0/3, 0/3, 0/3

* Presented at 54th annual ABSA conference, 2011, *Effects of Relative Humidity, Concentration, and Exposure Time on the Efficacy of Chlorine Dioxide Gas Decontamination*, Mark A. Czarneski

Background Dosage / PPM-Hr Explanation

Dosage is described as an exposure at a concentration multiplied by an amount of time, typically hours (Hrs). For CD this is referred to as PPM-Hrs. To determine the PPM-Hrs the concentration in PPM is accumulated every minute. This accumulation then accrues PPM-Hrs.

NOTE: 1-For quick charging chambers, such as small isolators, a 30 minute condition time is required.

Standard sporicidal cycle parameters are: RH - 65%¹ with 5 minutes of condition time, CD Concentration - 1mg/L and CD Exposure time – 2 hrs.

PPM calculation for 1mg/L

PPM = (mg/M3) (24.45) / Molecular Weight

PPM = (mg/L) (1000) (24.45) / Molecular Weight

CD ppm = (1.0mg/L) (1000L/M3) (24.45) / 67.5

CD ppm = 362.2

Exposure Contact Time (CT)

Exposure CT = 362ppm * 2 hrs

Exposure CT = 724 ppm-hrs

24.45 = volume (liters) of a mole (gram molecular weight) of a gas at 1 atmosphere and at 25°C.

Discussion

During large facility decontamination, many times the target concentration cannot be reached due to loss, consumption, absorption or reaction with organic load. When this occurs the cycle can still be successful if this lower concentration is held for extended periods and therefore still have a successful cycle.

Experiments performed at various chlorine dioxide gas concentrations (0.3, 0.5, 1, 5, 10 & 20 mg/L) with BI's exposed to various exposure times with each cycle having a fixed target dosage of 720PPM-Hrs all exhibited complete decontamination. A dosage of 720 was sufficient to get effective results regardless of concentration.

The below figures show the cycle data for 0.3, 1, 5 and 20 mg/L runs.

Table 2: The following table documents the required dosage to achieve kill with 10⁶ *geobacillus stearothermophilus* spore strips.

Target ppm-hrs	Actual ppm-hrs	Target Concentration mg/L	Condition % RH	Condition Time Minutes	Biological Indicator Results (positive / total)																	
720	723	0.3	65	5	0/4																	
720	723	0.5	65	5	0/4																	
720	734	1	65	0/4	720	735	5	65	30	0/4	720	761	10	65	30	0/4	720	751	20	65	30	0/4
720	735	5	65	30	0/4																	
720	761	10	65	30	0/4																	
720	751	20	65	30	0/4																	

** ABSA 58th Annual Biological Safety Conference October 9-14, 2015, Providence, RI., LINEARITY OF THE RELATIONSHIP BETWEEN CONCENTRATION AND CONTACT TIME FOR STERILIZATION WITH CHLORINE DIOXIDE GAS (ID #8), Kevin Lorcheim & Erik Melgaard*

