

Chlorine Dioxide Gas Decontamination of a 65,000 Cubic Foot Surgical Barrier Facility

Paul Lorcheim

When an animal facility flooded due to a burst pipe, it was important to decontaminate to ensure sterility after repairs.

INTRODUCTION

Surgical barrier facilities are by necessity highly controlled to maintain sterility. Any breach of containment can introduce contaminants which could potentially find their way into the animals being operated on. As such, personnel undergo stringent gowning and entry procedures, quarantines if they visit other animal facilities and various other operating procedures to minimise the possibility of bringing in contamination. Similarly, the facility is controlled through a number of mechanical and procedural means to limit potential contamination. Regardless of the quantity and quality of the levels of precaution employed by a facility, it is impossible to fully eliminate the risk of contamination as witnessed by a commercial breeder's surgical barrier facility. A pipe burst overnight, causing damage to a facility and flooding a majority of it with water. There was much concern over the sterility of the facility as there was a possibility of moulds and other organisms originating from the standing water. Repairs to the plumbing and to the facility itself would need to be performed, further exposing the barrier to possible sources of contamination as the required construction crew would not be entering or working under normal gowning and personal protective equipment (PPE). To bring the facility back to a sterile state, decontamination using chlorine dioxide gas was performed after all repairs had occurred. Biological indicators and swab samples confirmed that the decontamination was successful and the barrier facility was reopened in a sterile state.

CHLORINE DIOXIDE GAS

Chlorine dioxide (CD) is a greenish-yellow gas and is a single-electron-transfer oxidising agent with a chlorine-like odour. Pure CD is an unstable gas and therefore is generated as needed. Although CD has "chlorine" in its name, its chemistry is radically different from that of chlorine. CD oxygenates products rather than chlorinating them and thus trihalomethane (THM) formation does not occur¹. Therefore, unlike chlorine, CD does not produce environmentally undesirable organic compounds containing chlorine.

Chlorine dioxide is a true gas at normal use temperatures and therefore is not susceptible to condensation issues and temperature gradients such as vapours. It has a yellowish-green colour, which allows its concentration to be precisely monitored and controlled by a UV-VIS spectrophotometer. This allows tight process control from beginning to end of a decontamination cycle.

Chlorine dioxide (CD) has been recognised since the beginning of the century for its

disinfecting properties. Gaseous CD has been shown to be more effective than liquid CD when applied in equal concentrations and times². Chlorine dioxide in both gaseous and aqueous phase is a strong oxidising agent and has about 2.5 times the oxidation capacity of chlorine³. Both gaseous and aqueous phase CD has been shown to be an effective sanitising agent that has broad and high biocidal effectiveness.

PHYSICAL SITE

The surgical barrier facility is approximately 1,840.6 m³ (65,000 ft³) and consists of a main corridor with rooms branching off either side. The facility has two animal holding rooms, two surgery rooms, a pre/post operation holding room, three offices, clean/dirty cage wash, a passthrough room and a mechanical space. The barrier has a separate air handling system which consists of two HEPA filtered air intakes on the ground floor and three exhaust stacks on the roof. Surrounding the facility on two sides and the floor above were offices, laboratories and mechanical spaces.

SITE PREPARATION

Decontamination personnel arrived on-site after all repair work was completed. All equipment and components were left inside the facility to be decontaminated, including computers, microscopes, surgical instruments and other electronics. This saved the facility time as equipment, tools and instruments would not need to be autoclaved into the facility afterward. The air handling units were shut down upon arrival of the decontamination team so that the air supplies and exhausts could be sealed at their termination points. While the facility was being sealed, gas injection and gas sampling tubing was run to various places within the facility. The gas sample tubing allowed for real-time chlorine dioxide gas concentration monitoring such that the exposure levels at various locations within the barrier could be monitored. Gas injection and gas sampling tubing were located apart from one another to guarantee accurate concentration readings. Sealing the facility proved to be the most time-consuming and labour-intensive part of the project as all vents, external doors and openings along the exterior of the barrier had to be sealed using combinations of duct tape, adhesive films and putty. Fans and blowers were distributed throughout the facility to expedite the natural circulation of the humidity and gas. Gauges to measure relative humidity were placed throughout the facility, allowing the internal conditions to be monitored during the decontamination.

THE DECONTAMINATION EVENT

Once the facility was sealed except for one last entry/exit point, the relative humidity level was raised to approximately 65%. This humidification step is necessary for all spore reduction as spores swell and crack under elevated relative humidity. This gives the sterilant an opening large enough to penetrate into and inactivate the spore. When the barrier reached 65% relative humidity, the decontamination team removed the humidifiers and performed a final walkthrough of the facility. During this walkthrough, final checks were made and a security sweep was performed to ensure that the barrier facility was clear of all people. At that point, the final door was sealed and all personnel were notified that the gas decontamination was about to begin. The chlorine dioxide gas generators were then started and gas began to enter the facility. For rooms and facilities, a concentration of 1 mg/L (362 ppm) is targeted. Concentration was monitored throughout the

decontamination to evaluate its progress and ensure that the proper exposure levels were met. To achieve a six-log sterilisation level kill with chlorine dioxide gas, a 720 ppm-hr exposure level is targeted. Exposure level is calculated by multiplying the current concentration by the amount of time it is held for (i.e. 360 ppm concentration held for one hour would give a 360 ppm-hr cumulative exposure). The concentration monitor calculates the total exposure level throughout the decontamination, and displays the totals per sample location. Once all sample locations reached a cumulative exposure of 720 ppm-hrs, the decontamination step was complete and aeration of the gas began. The supply and exhaust vents were unsealed and the air handling system was remotely activated and turned on. Aeration takes between 12–15 air exchanges for facilities to return to safe levels inside, which were monitored by the decontamination team through a low-level sensor. After approximately one hour of aeration, the low-level sensor showed 0.0 ppm within the barrier, allowing for safe entry. Once gowned up, all tubing, fans and biological indicators were removed through the pass-through decon room. At this point, the barrier was now in operational condition and surgery could be safely performed.

RESULTS

The target exposure as described above was 720 ppm hours to achieve a greater than 6-log reduction. The actual cumulative exposure levels were between 875 and 1,000 ppm-hrs. A total of 14 biological indicators (*Geobacillus stearothermophilus*) were placed throughout the building to validate the gaseous CD decontamination. Biological indicators were placed in challenging locations such as underneath laptops, underneath syringe packages, inside water bottles and inside cabinet drawers. None exhibited growth after incubation in media tubes.

CONCLUSIONS

The decontamination process using chlorine dioxide gas was determined to be a success. Biological indicator results were all negative for growth, and swab samples taken after the decontamination also produced no positives. As chlorine dioxide does not leave a residue, no further cleaning was necessary. Additionally there was no visible indication of material degradation on any of the equipment that had been left within the building including the scales, computers, microscopes, incubators, centrifuges, racks and cages. All mechanical and electrical items that had been present within the barrier during the decontamination continued to be functional after the decontamination. Most importantly, the barrier was free of all molds, bacteria and spores, making it safe for sterile surgeries to take place again.

REFERENCES

1. Long, B.W., Miller, R.F. and Rosenblatt, A.A. Pilot Study: The Use of High Purity, Chlorine-Free Chlorine Dioxide to Minimize Trihalomethane Formation. From: www.clo2.com/reading/drinking/pilot.html [1].
2. Han, Y. et al, Reduction of *Listeria monocytogenes* on green peppers (*Capsicum annuum*) by gaseous and aqueous chlorine dioxide and water washing, and its growth at 7°C, *J. Food Protection*, 64, 1730, 2001a.
3. Benarde, M. A., Israel, B. M., Oliveri, V. P., and Granstrom, M. L., Efficiency of

Chlorine Dioxide Gas Decontamination of a 65,000 Cubic Foot Surgical Barr

Published on ALN (<http://www.alnmag.com>)

chlorine dioxide as a bactericide, J. Appl. Microbiol, 13, 776, 1967.

Paul Lorcheim, PE, is Director of Operations at ClorDiSys Solutions, Inc., PO Box 549 Lebanon, NJ, 08833 USA; +1 908-236-4100, www.clordisys.com [2], paullorcheim@clordisys.com [3].

Source URL (retrieved on 12/09/2013 - 3:37pm):

<http://www.alnmag.com/articles/2013/12/chlorine-dioxide-gas-decontamination-65000-cubic-foot-surgical-barrier-facility>

Links:

- [1] <http://www.clo2.com/reading/drinking/pilot.html>
- [2] <http://www.clordisys.com>
- [3] <mailto:paullorcheim@clordisys.com>