







**Canadian Biosafety Symposium 2008**  
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**Selecting the Right Chemical  
Agent for Decontamination of  
Rooms and Chambers**

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## ***Effective Decontamination***

- All Decontamination methods can work based on the following:
  - Must reach ALL surfaces for a prescribed amount of time, which means you must have:
    1. Good and Complete Distribution
    2. Good and Total Penetration
    3. Sufficient Contact Time at specified concentration
- Any decontamination method requires a complete and through distribution of the sterilant or high level liquid disinfectant to get an effective decontamination

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## US EPA Definitions for Levels of Kill

**Sterilizers (Sporicides):** Used to destroy or eliminate all forms of microbial life including fungi, viruses, and all forms of bacteria and their spores.

**Disinfectants:** Used on hard inanimate surfaces and objects to destroy or irreversibly inactivate infectious fungi and bacteria but not necessarily their spores.

**Sanitizers:** Used to reduce, but not necessarily eliminate, microorganisms from the inanimate environment to levels considered safe as determined by public health codes or regulations.

**Antiseptics and Germicides:** Used to prevent infection and decay by inhibiting the growth of microorganisms.

[http://www.epa.gov/oppad001/ad\\_info.htm](http://www.epa.gov/oppad001/ad_info.htm)

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## Decontamination Complexity

- Concentration monitoring is important because:
  - Paper or cellulose based products react with most sterilants
  - Leaky dampers or rooms
  - Water absorbs some sterilants
- Not all sterilants penetrate water
- Materials degrade decontaminating agent concentrations
  - Galvanized metal breaks down HP
  - Temperature gradients effect vapor concentrations
  - Cold surfaces cause formaldehyde fall out
  - Direct sunlight causes chlorine dioxide to break down
- Room configuration, internal equipment and size are a issue

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## Decontamination Methods

1. Manual Spray / Wipe / Mop
2. Fogging
3. Formaldehyde Gas
4. Hydrogen Peroxide "Vapor"
5. Chlorine Dioxide Gas

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## Manual Spray / Wipe / Mop

- Manual spray and wipe method use high level liquid disinfectants
  - Decontaminating agent must be chosen based on level of decontamination required (germicide, sanitizer, disinfectant, sterilant)
  - Requires keeping the surface wet or submersed per EPA approved label requirements
- Difficult to spray and wet the following:
  - Under side of equipment
  - Under side of components
  - Behind equipment
  - Ceilings
  - Ventilation grills
  - Intricate components



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## Fogging

- Fogging is the mechanical spraying of high level liquid disinfectants
  - Removes the person from the process
  - Requires fogger to spray and wet all surfaces
  - Decontaminating agent must be chosen based on level of decontamination required (germicide, sanitizer, disinfectant, sterilant)
  - Requires keeping the surface wet per EPA approved label requirements
- Foggers create small droplets that are affected by gravity
- Droplets do not reach:
  - Under side of equipment
  - Under side of components
  - Behind equipment
  - Ceilings
  - Ventilation grills
  - Intricate components



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## Formaldehyde

- True Gas
- Long Contact times (6-12 hours)
- Listed as carcinogenic\*
- Must be neutralized at end of exposure
- Neutralization byproduct must be cleaned prior to room usage
- Formaldehyde “falls out” upon contact with cold surfaces
- Requires high concentrations to achieve sporicidal effects (8000-10,000 ppm)
- Heat up Paraformaldehyde in hot plate to release gas
- Does not penetrate water
- Easily Scalable (just add more hot plates 1000cu ft / hot plate)
- Inexpensive consumables and equipment
- Penetrates HEPA filters

\*As of June 2004 the International Agency for Research on Cancer classified formaldehyde as carcinogenic to humans, Retrieved June 30, 2004, from:  
[http://www.iarc.fr/ENG/Press\\_Releases/archives/pr153a.html](http://www.iarc.fr/ENG/Press_Releases/archives/pr153a.html)

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## Formaldehyde Cleanup

- Formaldehyde neutralization is done using ammonia bicarbonate
- Too little causes more formaldehyde residuals
- Too much causes a lot of bicarbonate residual cleanup
- Must try to balance the two, not wanting formaldehyde residuals and also not wanting to cause too cleanup
- If balance is not correct then there will be residuals
  - Residuals can affect work performed in decontaminated area
  - Residuals add more load to HEPA filters
  - Residuals can affect worker safety (tearing, coughing, breathing issues...)
- Large space decontamination is troublesome due to cleanup required, can all surfaces be realistically wiped to remove all residues

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## “Vapor” Hydrogen Peroxide (VHP)

- Hydrogen peroxide is a liquid at room temperatures
- Hydrogen peroxide (35%) boiling point 109°C
- Short Contact Times 1- 4 hours
- Non-carcinogenic
- No post exposure cleanup required
  - Catalytically converted or direct vented
- Low typical concentrations (700-1500ppm)
- Vapor generated by boiling or vaporizing liquid hydrogen peroxide then delivered to target chamber
- Must insulate or heat trace injection hoses to maximize concentration delivered to the chamber
- Does not penetrate water

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## ***“Vapor” Hydrogen Peroxide (VHP)***

- 1 Generator for approximately 10,000 cu ft.
- Currently 2 camps of thought for VHP, Wet and Dry
  - Dry - wants no amount of condensation (below dew point)
  - Wet - wants “micro-condensation” (above dew point)
- Difficult to maintain as vapor - returns to normal state of liquid as condensation
- Must constantly inject vapor due to condensation which causes concentration drop in room
- Long Aeration Times (due to condensation)
- Some plastics absorb HP
- Trouble penetrating some HEPA filters
- Condensation causes corrosion. <sup>1 2</sup>

1. Anders Malmborg, Maria Wingren, Philippe Bonfield and Gerald McDonnell (Steris), “ VHP takes its Place in Room Decontamination”, Clean Rooms Volume: 15 Issue: 11 November 2001 .

2. Carl Hultman, Aaron Hill and Gerald McDonnell, “The Physical Chemistry of Decontamination with Gaseous <sup>11</sup> Hydrogen Peroxide”, Pharmaceutical Engineering, Vol. 27, No. 1, Jan/Feb 2007.

## ***Chlorine Dioxide***

- True Gas (boiling point 11°C)
- Short Contact times (0.5-2 hours)
- Fast overall cycle times (fast aeration)
- Non - carcinogenic
- Water Soluble (only decontaminating agent to sterilize water)
- Non - Flammable
- No post exposure cleanup required
  - Direct vented or scrubbed at end of exposure
- Low typical concentrations (360-1800 ppm)

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## Chlorine Dioxide

- **Generation Method**  
Reagent (G) + Sodium Chlorite (S) = Chlorine Dioxide (G) + Salt (S)
- **Penetrates water**
- **Scalable by adding a generator for every 60,000 cubic feet**
- **Inexpensive consumables**
- **Penetrates HEPA filters**
- **Photometric sterilant concentration monitoring**

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## Summary

Issue	Spray / Wipe /Mop	Fogging	Formaldehyde Gas	Hydrogen Peroxide Vapor	Chlorine Dioxide Gas
Equipment Cost	Low	Low	Low	High	Moderate
Labor Costs	High	High	High	Low	Low
Consumable Costs	Low	Low	Low	Low	Low
Facility Downtime Costs (cycle time costs)	High	High	High	High	Low
Corrosiveness	Low-High (agent specific)	Low-High (agent specific)	Low	Low (unless condensation)	Low
Total Cycle Time	1-2 days	1-2 days	9 to 15 hours + clean up	4 hours (small) 12 hours (large)	1.5 hrs (small) 5 hrs (large)
Residues	High	High	High	Low	Low
Concentration Monitoring	No	No	No	Yes (not integrated to equipment)	Yes
EPA approvals	Yes (agent specific)	Yes (agent specific)	No	Yes (Steris)	Yes
Scalability	Yes??	Yes	Yes	Yes??	Yes

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## Conclusions

- For complete decontamination, the agent of choice **MUST** have
  - Total penetration
  - Complete distribution
  - *Contact the organism for approved amount of time*
- If effective and absolute decontamination is required then
  - gaseous methods are best
- If equipment costs are an issue and disinfection is required then
  - spray and wipe or fogging are the methods to use
- If equipment costs are an issue (and cancer is not a concern) then
  - formaldehyde is the method to use
- If your room is very leaky (drop ceilings) then
  - spray and wipe or fogging are the methods to use

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### ***Oxidation Potential of Several Biocidal Agents***

<b>Biocidal Agent</b>	<b>Oxidation Potential (volts)</b>	<b>Oxidation Capacity (electrons)</b>	<b><sup>1</sup></b>
O <sub>3</sub> (ozone)	2.07	2e <sup>-</sup>	
CH <sub>3</sub> COOOH (peracetic acid)	1.81	2e <sup>-</sup>	
H <sub>2</sub> O <sub>2</sub> (peroxide)	1.78	2e <sup>-</sup>	
NaOCl (sodium hypochlorite)	1.49	2e <sup>-</sup>	
ClO <sub>2</sub> (chlorine dioxide)	0.95	5e <sup>-</sup>	

The above table summarizes key properties of oxidizing biocides.

1. Barry Wintner, Anthony Contino, Gary O'Neill, Chlorine Dioxide, Part 1 A Versatile, High-Value Sterilant for the Biopharmaceutical Industry, *BioProcess International* DECEMBER 2005

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