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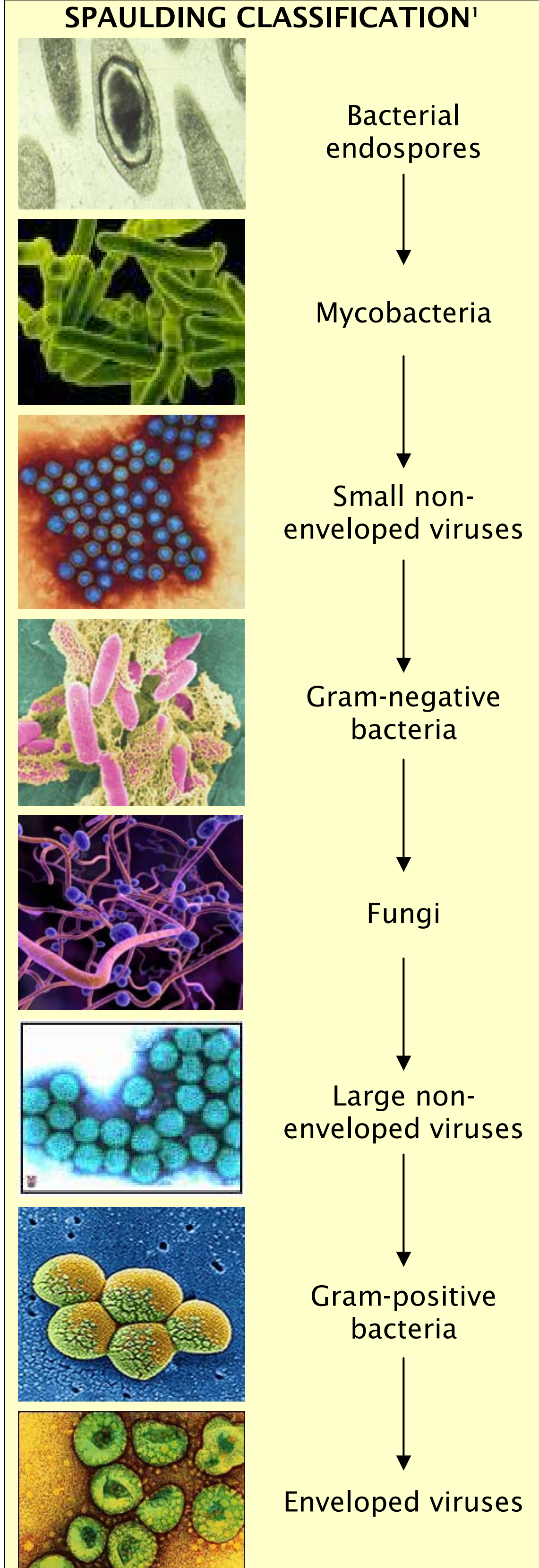
Hydrogen peroxide vapour biological efficacy



Hydrogen peroxide vapour (HPV) is well established as a bio-decontamination agent due to its "residue free" nature (the only residues are oxygen and water) and low temperature, vapour-phase application. HPV has been tested against many organisms and classes of organisms. However, because a great number of "common" micro-organisms exist, efficacy testing remains an ongoing process.

This document outlines the most significant current knowledge that can be attributed to known sources. This information can be used not only to look at specific organisms but also the efficacy of HPV against types and groups of organisms.

Figure one (left) shows a widely accepted classification of the resistance of various micro-organisms to sterilisation and disinfection procedures based on the pioneering work of E.H. Spaulding[1]. This classification can be used as a guide when forming a hypothesis about the efficacy of HPV against a particular micro-organism.

If a particular organism is not listed here, it does not mean there is no data available or that HPV is not effective against it. Therefore, if a specific organism, which is of particular importance is not listed here, please contact BIOQUELL to see if other data (analogous or specific) is available - or if further testing is required.

HPV has been shown to kill a wide range of micro-organisms including bacteria, viruses and fungi. The efficacy of HPV has been repeatedly demonstrated against bacterial endospores, which are typically the most resistant organism to any kind of bio-deactivation stress so as such are positioned at the top of the Spaulding classification.

The organisms listed in this document are divided into broad taxonomic categories (ie. bacteria, viruses and fungi) and grouped according to their microbiological characteristics. This division allows for an easy comparison of an untested organism with other related organisms that have been tested. The appendix includes the abstracts for the published journal articles.

1. Spaulding EH. Chemical disinfection and antisepsis in the hospital. *J Hosp Res* 1972;**9**:5-31.

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1. List of tested organisms which hydrogen peroxide vapour bio-deactivates and source references

1.1 Bacteria

Type of organism	Name of organism	Reference
Bacterial endospores Gram +ve rods	*Bacillus anthracis* var. *ames*	16
	Bacillus anthracis var. *sterne*	11,16,25
	Bacillus anthracis var. *vollum*	16
	Bacillus alvel	29
	Bacillus cereus[a]	9,29
	Bacillus circulans	9
	Bacillus firmus	9
	Bacillus licheniformis	29
	Bacillus megaterium	9,29
	Bacillus pumilus[a]	9,20,21,29
	Bacillus sphaericus	29
	Bacillus subtilis[a]	9,11,20,28
	Bacillus thuringiensis	16,29
	Clostridium botulinum	7
	Clostridium difficile	12,13
	Clostridium piliforme	31
	Clostridium sporogenes[a]	23,28
	Geobacillus stearothermophilus[a] (formerly *Bacillus stearothermophilus*)	3,4,7,8,9,11, 20,21,24,26
Gram +ve rods	*Mycobacterium smegmatis*[a]	20,21
	Mycobacterium tuberculosis	4,8
	Lactobacillus caesei[a]	20,21
Gram +ve cocci	*Enterococcus faecium/faecalis* (VRE)	12,13,19
	Methicillin-resistant *S.aureus* (MRSA)	3,6,13,19,24
	Staphylococcus epidermidis	24,26
Enterobacteriaceae Enteric Gram-ve rods	*Enterobacter cloacae*	22
	Escherichia coli (inc. O157:H7)[a]	10
	Klebsiella pneumoniae[a]	13
	Salmonella choleraesuis[a]	10
	Serratia marcescens[a]	1,20,21
Gram -ve rods	*Acinetobacter baumannii*	12,13,19
	Legionella pneumoniae[a]	10
	Pseudomonas aeruginosa[a]	17,20,21
Atypical bacteria	*Acholeplasma laidlawii* (Mycoplasma)	27

a. Complete bio-deactivation was successfully achieved even when the experiments were conducted in the presence of 5% serum.

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1.2 Viruses

Genome	D/RNA[a]	Family	Virus	Ref
DNA (Enveloped)	Double	Herpesviridae	Herpes simplex Type 1	21
			Pseudorabies virus	5
	Double	Iridoviridae	African swine fever virus	5
	Double	Poxviridae[b]	Vaccinia	5
DNA (Non-enveloped)	Double	Adenoviridae	Adenovirus	21,34
			Canine adenovirus	33
	Single	Parvoviridae	Canine parvovirus	33
			Feline parvovirus	33
			Parvovirus	18
RNA (Enveloped)	Single	Coronaviridae	Infectious bronchitis virus	10
	Single	Orthomyxoviridae	Influenza A2	21
			Avian influenza virus	5
	Single	Paramyxoviridae	Newcastle disease virus	5
	Single	Rhabdoviridae	Vesicular Stomatitis Virus	5
	Single	Flaviviridae	Dengue virus	32
			Hog Cholera Virus	5
RNA (Non-enveloped)	Single	Caliciviridae	Feline calicivirus	33
			Vesicular Exanthema Virus	5
	Single	Picornaviridae	Rhinovirus 14	21
			Polio Type 1	21
			Swine Vesicular Disease	5
	Double	Reoviridae	Bluetongue virus	5

a. single = single stranded genome, double = double stranded genome
b. some members of the Poxviridae are non-enveloped

1.3 Bacteriophage

Organism	Name	Reference
	Lactococcal bacteriophage	35

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1.4 Fungi

Type of organism	Name	Reference
	Alternaria sp.	29
	*Aspergillus niger**	17, 23
	Candida albicans[a]	23
	Candida parapsilosis[a]	20
	Coccidioides immitis	15
	Blastomyces dermatitidis	15
	Histoplasma capsulatum	15
	Penicillium sp.	29

a. Complete bio-deactivation was successfully achieved even when the experiments were repeated in the presence of 5% bovine serum.

1.5 Nematodes

Organism	Name	Reference
	Caenrohabditis elegans	14
	*Syphacia muris**	30

* The reference cited is a poster describing a study investigating the efficacy of hydrogen peroxide vapour (HPV) against *Syphacia muris* (pinworm) eggs. Microscopic destruction was noted on immature, but not on mature eggs. SCID (immuno-deficient) mice exposed to HPV-treated contaminated bedding did not developed pinworm infection whereas mice exposed to non-HPV-treated contaminated bedding did develop pinworm infection. Recent experiments by BIOQUELL have demonstrated that HPV-treated eggs are able to hatch in a specially formulated hatching medium, so it is possible that exposure to HPV, whilst not preventing *in vitro* hatching, renders pinworm eggs non-infective *in vivo*. Further research is required in this area.

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2 References

2.1 Peer reviewed journal article

1. Bates CJ, Pearse R. Use of hydrogen peroxide vapour for environmental control during a *Serratia* outbreak in a neonatal intensive care unit. *J Hosp Infect* 2005;**61**:364-366.

2. Fichet G, Comov E, Duval C, Antloga K, Dehen C, Charbonnier A, McDonnell G, Brown Pm Lasmezas CI, Deslys JP. Novel methods for disinfection of prion-contaminated medical devices. *Lancet* 2004;**364**:521-526.

3. French GL, Otter JA, Shannon KP, Adams NMT, Parks MJ, Watling D. Tacking contamination of the hospital environment by methicillin-resistant *Staphylococcus aureus* (MRSA): a comparison between conventional terminal cleaning and hydrogen peroxide vapour decontamination. *J Hosp Infect* 2004;**57**:31-37.

4. Hall L, Otter JA, Chewins J, Wengenack NL. Use of hydrogen peroxide vapour for deactivation of *Mycobacterium tuberculosis* in a biological safety cabinet and a room. *J Clin Microbiol* 2007;**45**:810-815.

5. Heckert RA, Best M, Jordan LT, Dulas GC, Eddington DL, Sterritt WG. Efficacy of vaporized hydrogen peroxide against exotic animal viruses. *Appl Environ Microbiol* 1997;**63:**3916-3918.

6. Jeanes A, Rao G, Osman M, Merrick P. Successful eradication of persistent environmental MRSA. *J Hosp Infect* 2005;**61**:85-86.

7. Johnston MD, Lawson S, Otter JA. Evaluation of hydrogen peroxide vapour as a method for the decontamination of surfaces contaminated with *Clostridium botulinum* spores. *J Microbiol Methods* 2005;**60**:403-411.

8. Kahnert A, Seiler P, Stein M, Aze B, McDonnell G, Kaufmann SH. Decontamination with vaporized hydrogen peroxide is effective against *Mycobacterium tuberculosis*. *Lett Appl Microbiol* 2005;**40:**448-452.

9. Kokubo M, Inoue T, Akers J. Resistance of common environmental spores of the genus *Bacillus* to vapor hydrogen peroxide. *PDA J Pharm Sci Technol* 1998;**52:**228-231.

10. McDonnell G, Grignol G, Antloga K. Vapour-phase hydrogen peroxide decontamination of food contact surfaces. *Dairy Food Environ Sanitat* 2002;**22:**868-873.

11. Rogers JV, Sabourin CL, Choi YW, Richter WR, Rudnicki DC, Riggs KB, Taylor ML, Chang J. Decontamination assessment of *Bacillus anthracis*, *Bacillus subtilis*, and *Geobacillus stearothermophilus* on indoor surfaces using a hydrogen peroxide gas generator. *J Appl Microbiol* 2005;**99**:739-748.

2.2 Conference presentations

12. Boyce JM, Havill NL, Otter JA, McDonald LC, Adams NM, Thompson A, Wiggs L, Noble-Wang J. Impact of Hydrogen Peroxide Vapor Room Bio-Decontamination on Environmental Contamination and Nosocomial Transmission of *Clostridium difficile*. 16th Annual Meeting of the Society for Healthcare Epidemiology of America (SHEA), Chicago, Illinois, 2006. Abstract 155.

13. French GL, Otter JA, Shannon KP. Survival of nosocomial bacteria dried in air and killing by hydrogen peroxide vapour (HPV). Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC), Washington DC, 2004.

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14. Gustin EJ, McDonnell GE, Mullen G, Gordon BE. The efficacy of vapour phase hydrogen peroxide against nematode infestation: the *Caenorhabditis elegans* model. American Association for Laboratory Animal Science (AALAS), Annual meeting, San Antonio, TX. October, 2002.

15. Hall L, Otter JA, Chewins J, Wengenack NL. Deactivation of dimorphic fungi using Hydrogen Peroxide Vapour. 16th Congress of the International Society for Human and Animal Mycology (ISHAM), Paris. June 2006.

16. Harper B, Larson L. Laboratory validation of chlorine dioxide / hydrogen peroxide gas decontamination. DECON 2002, San Diego. September 2002.

17. Klapes AN. New Applications of Chemical Germicides: Hydrogen Peroxide. ASM International Symposium on Chemical Germicides, Atlanta, GA. July1990.

18. McDonnell G, Belete B, Fritz C, Hartling J. Room decontamination with vapour hydrogen peroxide VHP for environmental control of parvovirus. American Association for Laboratory Animal Science (AALAS), Annual meeting, Baltimore, MD. October 2001.

19. Otter JA, Cummins M, Ahmad F, van Tonder C, Drabu Y. O19 Assessing the biological efficacy and rate of recontamination following hydrogen peroxide vapour decontamination. *Int J Antimicrob Agents* 2007;**29** Suppl. 2:S4.

20. Rickloff JR, Oreliski, PA. Resistance of various micro-organisms to vaporized hydrogen peroxide in prototype tabletop sterilizer, 89th General Meeting of the American Society for Microbiology (ASM), New Orleans. May 1989.

21. Rickloff JR. Use of Vapourized Hydrogen Peroxide for the Bio-decontamination of Enclosed Areas. Interphex USA Conference, New York. 1990.

22. Schouten M, Otter JA, van Zanten A, Houmes-Zielman G, Nohlmans-Paulssen M. P1692 Environmental decontamination of an intensive care unit to control outbreaks of multidrug-resistant Gram-negative rods using hydrogen peroxide vapour. *Int J Antimicrob Agents* 2007;**29** Suppl. 2:S479.

2.3 Independent reports commissioned by BIOQUELL

23. Cabinet bio-decontamination trial. Centre for Applied Microbiology and Research (CAMR, now HPA), Porton Down. March 1995.

24. Determination of the effectiveness of VPHP against methicillin-resistant *Staphylococcus aureus, Staphylococcus epidermidis* and *Bacillus stearothermophilus*. CAMR (now HPA), Porton Down, UK. March 2001.

25. *Bacillus anthracis* (Anthrax) deactivation investigation. Dstl, Porton Down. June 2002.

26. Assessment of the efficacy of vapour phase hydrogen peroxide as a room disinfectant. CAMR (now HPA), Porton Down. April 2003.

27. Inactivation of Mycoplasma using vapourised hydrogen peroxide. Mycoplasma Experience Ltd. Sept 2003.

28. AOAC Sporicidal Test. Reading Scientific Services Ltd. (RSSL) / Wickham Laboratories, 2005.

2.4 Other sources

29. Information supplied with kind permission of Eli Lilly and Company, Indianapolis, Indiana.

30. Krause J, Riedesel H. Elimination of Pinworm Eggs from Caging Equipment with Vapourised Hydrogen Peroxide. Report from the Max-Planck-Institute for Experimental Medicine.

31. Case study from a room bio-decontamination at Imperial College School of Medicine. April 2003. Contact BIOQUELL for further details.

32. Investigation into the efficacy of hydrogen peroxide vapour in the bio-deactivation of Dengue virus. August 2003. Trials conducted in commercial confidence. Contact BIOQUELL for further details.

33. Viral deactivation trials. Oct 2002. Conducted in commercial confidence. Contact BIOQUELL for further details.

34. Adenovirus deactivation trials. Sept 2003. Conducted in commercial confidence. Contact BIOQUELL for further details.

35. Study to determine the effectiveness of hydrogen peroxide vapour for the decontamination of bacteriophage. Undisclosed Pharmaceutical Company, 2005. Contact BIOQUELL for further details.

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3 Appendix – Abstracts / Summaries

Peer reviewed journal articles:

This section includes abstracts from published journal articles. Please contact BIOQUELL for full copies of these articles and for copies of the other documents that are referenced in this document.

1. **Bates CJ, Pearse R. Use of hydrogen peroxide vapour for environmental control during a *Serratia* outbreak in a neonatal intensive care unit. *J Hosp Infect* 2005 Aug 11; Epub ahead of print.**

Department of Medical Microbiology, Royal Hallamshire Hospital, Sheffield, UK.

The use of hydrogen peroxide vapour (HPV) for environmental control of nosocomial pathogens is receiving much attention. We describe the use of the BIOQUELL HPV system, combined with other infection control measures, to eradicate *Serratia marcescens* from the neonatal intensive care unit (NICU) at our hospital.

2. **Fichet G, Comov E, Duval C, Antloga K, Dehen C, Charbonnier A, McDonnell G, Brown Pm Lasmezas CI, Deslys JP. Novel methods for disinfection of prion-contaminated medical devices. *Lancet* 2004;364:521-526.**

CEA/DSV/DRM/GIDTIP, Route du Panorama, 92265 Fontenay-aux-Roses, France.

BACKGROUND: The unique resistance of prions to classic methods of decontamination, and evidence that prion diseases can be transmitted iatrogenically by medical devices pose a serious infection control challenge to health-care facilities. In view of the widespread tissue distribution of the variant Creutzfeldt-Jakob disease agent in human beings, new practicable decontamination procedures are urgently needed. **METHODS:** We adapted an in-vivo method using stainless steel wires contaminated with prions to the hamster-adapted scrapie strain 263K. A new in-vitro protocol of surface contamination compatible with subsequent biochemical detection of PrP(res) (protease-resistant form of the prion protein) from the treated surface was developed to explore the mechanisms of action of methods of decontamination under test. These models were used to investigate the effectiveness of innovative physical and chemical methods of prion inactivation. **FINDINGS:** Standard chemical decontamination methods (NaOH 1N, NaOCl 20000 ppm) and autoclaving in water at 134 degrees C reduced infectivity by >5.6 log10 lethal doses; autoclaving without immersion was somewhat less effective (4-4.5 log reduction). Three milder treatments, including a phenolic disinfectant, an alkaline cleaner, and the combination of an enzymatic cleaner and vaporised hydrogen peroxide (VHP) were also effective. VHP alone, which can be compatible with electronic components, achieved an approximately 4.5 log reduction in infectivity (equivalent to autoclaving without water immersion). **INTERPRETATION:** New decontamination procedures are proposed to ensure the safety of medical and surgical instruments as well as surfaces that cannot withstand the currently recommended prion inactivation procedures.

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3. French GL, Otter JA, Shannon KP, Adams NMT, Parks MJ, Watling D. Tacking contamination of the hospital environment by methicillin-resistant *Staphylococcus aureus* (MRSA): a comparison between conventional terminal cleaning and hydrogen peroxide vapour decontamination. *J Hosp Infect* 2004;57:31-37.

Department of Infection, King's College London, 5th Floor, North Wing, St Thomas' Hospital, Lambeth Palace Road, London SE1 7EH, UK.

The hospital environment can sometimes harbour methicillin-resistant Staphylococcus aureus (MRSA) but is not generally regarded as a major source of MRSA infection. We conducted a prospective study in surgical wards of a London teaching hospital affected by MRSA, and compared the effectiveness of standard cleaning with a new method of hydrogen peroxide vapour decontamination. MRSA contamination, measured by surface swabbing was compared before and after terminal cleaning that complied with UK national standards, or hydrogen peroxide vapour decontamination. All isolation rooms, ward bays and bathrooms tested were contaminated with MRSA and several antibiogram types were identified. MRSA was common in sites that might transfer organisms to the hands of staff and was isolated from areas and bed frames used by non-MRSA patients. Seventy-four percent of 359 swabs taken before cleaning yielded MRSA, 70% by direct plating. After cleaning, all areas remained contaminated, with 66% of 124 swabs yielding MRSA, 74% by direct plating. In contrast, after exposing six rooms to hydrogen peroxide vapour, only one of 85 (1.2%) swabs yielded MRSA, by enrichment culture only. The hospital environment can become extensively contaminated with MRSA that is not eliminated by standard cleaning methods. In contrast, hydrogen peroxide vapour decontamination is a highly effective method of eradicating MRSA from rooms, furniture and equipment. Further work is needed to determine the importance of environmental contamination with MRSA and the effect on hospital infection rates of effective decontamination.

4. Hall L, Otter JA, Chewins J, Wengenack NL. Use of hydrogen peroxide vapour for deactivation of *Mycobacterium tuberculosis* in a biological safety cabinet and a room. *J Clin Microbiol* 2007;45:810-815.

Mayo Clinic, Rochester, MN 55905, USA.

Mycobacterium tuberculosis is an important human pathogen that is routinely cultured in clinical and research laboratories. *M. tuberculosis* can contaminate surfaces and is highly resistant to disinfection. We investigated whether hydrogen peroxide vapor (HPV) is effective for the deactivation of *M. tuberculosis* on experimentally contaminated surfaces in a biological safety cabinet (BSC) and a room. Biological indicators (BIs) consisting of an approximately 3-log(10) inoculum of *M. tuberculosis* on stainless steel discs and a 6-log(10) inoculum of *Geobacillus stearothermophilus* were exposed to HPV in BSC time course experiments and at 10 locations during room experiments. In three separate BSC experiments, *M. tuberculosis* BIs were transferred to growth media at 15-min intervals during a 180-min HPV exposure period. No *M. tuberculosis* BIs grew following 30 min of HPV exposure. In three separate room experiments, *M. tuberculosis* and *G. stearothermophilus* BIs were exposed to HPV for 90, 120, and 150 min, respectively. BIs for both microorganisms were deactivated in all 10 locations following 90 min of HPV exposure. HPV provides an alternative to traditional decontamination methods, such as formaldehyde fumigation, for laboratories and other areas contaminated with *M. tuberculosis*.

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5. Heckert RA, Best M, Jordan LT, Dulas GC, Eddington DL, Sterritt WG. Efficacy of vaporized hydrogen peroxide against exotic animal viruses. *Appl Environ Microbiol* 1997;63:3916-3918.

Animal Diseases Research Institute, Canadian Food Inspection Agency, Nepean, Ontario, Canada.

The efficacy of vapor-phase hydrogen peroxide in a pass-through box for the decontamination of equipment and inanimate materials potentially contaminated with exotic animal viruses was evaluated. Tests were conducted with a variety of viral agents, which included representatives of several virus families (Orthomyxoviridae, Reoviridae, Flaviviridae, Paramyxoviridae, Herpesviridae, Picornaviridae, Caliciviridae, and Rhabdoviridae) from both avian and mammalian species, with particular emphasis on animal viruses exotic to Canada. The effects of the gas on a variety of laboratory equipment were also studied. Virus suspensions in cell culture media, egg fluid, or blood were dried onto glass and stainless steel. Virus viability was assessed after exposure to vaporphase hydrogen peroxide for 30 min. For all viruses tested and under all conditions (except one), the decontamination process reduced the virus titer to 0 embryo-lethal doses for the avian viruses (avian influenza and Newcastle disease viruses) or less than 10 tissue culture infective doses for the mammalian viruses (African swine fever, bluetongue, hog cholera, pseudorabies, swine vesicular disease, vesicular exanthema, and vesicular stomatitis viruses). The laboratory equipment exposed to the gas appeared to suffer no adverse effects. Vaporphase hydrogen peroxide decontamination can be recommended as a safe and efficacious way of removing potentially virus-contaminated objects from biocontainment level III laboratories in which exotic animal disease virus agents are handled.

6. Jeanes A, Rao G, Osman M, Merrick P. Successful eradication of persistent environmental MRSA. *J Hosp Infect* 2005;61:85-86.

Infection Control and Microbiolgoy Department, University Hospital Lewisham, London SE13 6LH, UK.

Clinical areas used to care for patients infected or colonized with methicillin-resistant *Staphylococcus aureus* (MRSA) become contaminated, and there is evidence that conventional cleaning methods do not eradicate MRSA. However, environmental hygiene is important for the control of MRSA and other nosocomial pathogens. Here we describe the use of hydrogen peroxide vapour (HPV) decontamination to eradicate MRSA environmental contamination following admissions of MRSA patients and subsequent cross-infection in a surgical ward.

7. Johnston MD, Lawson S, Otter JA. Evaluation of hydrogen peroxide vapour as a method for the decontamination of surfaces contaminated with *Clostridium botulinum* spores. *J Microbiol Methods* 2005;60:403-411.

Safety and Environmental Assurance Centre, Unilever Colworth, Sharnbrook, Beds, MK44 1LQ, UK.

The aim of this study was to evaluate the efficacy of hydrogen peroxide vapour (HPV) against spores of *Clostridium botulinum*, for use as a method for decontaminating environments where this pathogen has been handled. Spores were dried onto stainless steel slides and exposed to HPV in a sealed glovebox enclosure, transferred to a quenching agent at timed intervals during the exposure period, before survivors were cultured and enumerated. D-values were calculated from graphs of log10 survivors plotted against time and were found to range from 1.41 to 4.38 min. HPV was found to be effective at deactivating spores of toxigenic *Cl. botulinum*, non-toxigenic Clostridium spp. and Geobacillus stearothermophilus dried onto stainless

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steel surfaces. HPV could be used to decontaminate cabinets and rooms where *Cl. botulinum* has been handled. The cycle parameters should be based on studies carried out with relevant spores of this organism, rather than based on inactivation data for *G. stearothermophilus* spores, which have been used in the past as a standard biological challenge for disinfection and sterilisation procedures. HPV could provide an attractive alternative to other decontamination methods, as it was rapid, residue-free and did not give rise to the health and safety concerns associated with other gaseous decontamination systems.

8. Kahnert A, Seiler P, Stein M, Aze B, McDonnell G, Kaufmann SH. Decontamination with vaporized hydrogen peroxide is effective against *Mycobacterium tuberculosis*. *Lett Appl Microbiol* 2005;40:448-452.

Max-Planck Institute for Infection Biology, Berlin, Germany.

AIMS: To determine the efficacy of room fumigation with vaporized hydrogen peroxide (VHP) in decontamination of viable *Mycobacterium tuberculosis*. **METHODS AND RESULTS:** About 8 x 10(4)-2.3 x 10(6) CFU of M. tuberculosis H37Rv and *M. tuberculosis* Beijing were dried in 10-microl drops in tissue culture plates, placed in steam-permeable Tyvek pouches and distributed on laboratory surfaces. The room was exposed to VHP delivered by air conditioning. Different exposure conditions were tested. Exposure to VHP resulted in sterilization of the bacterial samples in three different test runs. **CONCLUSIONS:** VHP treatment is an effective means of reducing and eliminating room contaminations of *M. tuberculosis*. **SIGNIFICANCE AND IMPACT OF THE STUDY:** Fumigation with VHP represents an alternative to formaldehyde fumigation, particularly for decontamination of animal rooms in tuberculosis research laboratories.

9. Kokubo M, Inoue T, Akers J. Resistance of common environmental spores of the genus Bacillus to vapor hydrogen peroxide. *PDA J Pharm Sci Technol* 1998;52:228-231.

Shibuya Kogyo Company LTD/Process Engineering Organization Kanazawa, Japan.

The use of hydrogen peroxide as an antimicrobial agent has a long history in infection control and contamination prevention. It has long been known that hydrogen peroxide can efficiently and rapidly destroy even highly resistant bacterial spores. In recent years, vapour hydrogen peroxide (VHP), commonly called VHP, has come into wide use as a decontaminating or sterilizing agent in the pharmaceutical industry. The most commonly used biological indicator for VHP sterilization has been *B. stearothermophilus* ATCC #12980. Published studies have indicated that *B. stearothermophilus* is the most resistant organism to VHP. At present, several types of commercial biological indicators BIs designed specifically for the evaluation of VHP processes are available from vendors. BIs for VHP can be purchased as enveloped packages on various substrates, and as suspension cultures for inoculation onto a carrier or substrate of the user's choice. The purpose of this article is to evaluate and compare the resistance of environmental isolates of wild type organisms of the genus *Bacillus* to that of commercially available biological indicators. Significantly, when a typical spore suspension of *B. stearothermophilus* ATCC #12980 marketed for use in validating VHP processes was tested under identical conditions and on the same substrate it's D value was found to exceed that of the most resistant wild type of our "bioburden" organism tested by more than a factor of 10.

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10. McDonnell G, Grignol G, Antloga K. Vapour-phase hydrogen peroxide decontamination of food contact surfaces. ***Dairy Food Environ Sanitat*** **2002;22:868-873.**

Steris, 5960 Heisley Road, Mentor, OH 44060, USA.

Decontamination of food contact surfaces, equipment and general work areas is important for the prevention of transmission of foodborne microorganisms. Many liquid-based disinfectants that are widely used for this purpose may not be appropriate for electrical equipment and for relatively large areas. Fumigation with vapour phase hydrogen peroxide (VPHP) is an option in these cases and is discussed in this report. VPHP is a dry and rapidly effective antimicrobial vapour. A typical decontamination cycle consists of four phases in a one-step process that is documented and can be validated for a given application. VPHP has been shown to have potent antimicrobial activity against bacteria, viruses, fungi and bacterial spores. Recently, efficacy has been confirmed against known foodborne pathogens, including *Listeria monocytogenes* and *E. coli* O157:H7. Because the VPHP process is dry, it is compatible with many materials, including electronics. IN the case study presented, VPHP was shown to be effective in decontaminating a simulative room, including an electrical appliance, in an automated, validated process. VPHP is a possible alternative to liquid-based disinfectants for decontamination of food contact surfaces and equipment.

11. Rogers JV, Sabourin CL, Choi YW, Richter WR, Rudnicki DC, Riggs KB, Taylor ML, Chang J. Decontamination assessment of *Bacillus anthracis*, *Bacillus subtilis*, and *Geobacillus stearothermophilus* on indoor surfaces using a hydrogen peroxide gas generator. ***J Appl Microbiol*** **2005;99:739-748.**

Battelle Memorial Institute, Columbus, OH, OH 43201, USA.

AIMS: To evaluate the decontamination of *Bacillus anthracis, Bacillus subtilis, and Geobacillus stearothermophilus* spores on indoor surface materials using hydrogen peroxide gas. **METHODS AND RESULTS:** *Bacillus anthracis, B. subtilis, and G. stearothermophilus* spores were dried on seven types of indoor surfaces and exposed to > or =1000 ppm hydrogen peroxide gas for 20 min. Hydrogen peroxide exposure significantly decreased viable *B. anthracis, B. subtilis*, and *G. stearothermophilus* spores on all test materials except *G. stearothermophilus* on industrial carpet. Significant differences were observed when comparing the reduction in viable spores of *B. anthracis* with both surrogates. The effectiveness of gaseous hydrogen peroxide on the growth of biological indicators and spore strips was evaluated in parallel as a qualitative assessment of decontamination. At 1 and 7 days postexposure, decontaminated biological indicators and spore strips exhibited no growth, while the nondecontaminated samples displayed growth. **CONCLUSIONS:** Significant differences in decontamination efficacy of hydrogen peroxide gas on porous and nonporous surfaces were observed when comparing the mean log reduction in *B. anthracis* spores with *B. subtilis* and *G. stearothermophilus* spores. **SIGNIFICANCE AND IMPACT OF THE STUDY:** These results provide comparative information for the decontamination of *B. anthracis* spores with surrogates on indoor surfaces using hydrogen peroxide gas.

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