



Dry Hydrogen Peroxide (DHP)

A Novel Solution for an Environmental Strategy

Contamination Threats Never Stop. Why Would Your Disinfection Technology?

Unlike vaporized agents, UV, UV-C, or ozone producing technologies that only provide short-lived or localized disinfection, DHP exists safely and effectively within the environment. DHP continually reaches difficult surface contaminants and airborne microbes.

Contaminated Environmental Surfaces

- Plays a critical role in transmission of pathogens.
- Research has shown as many as 50% of surfaces remain contaminated with pathogens, including multi-drug resistant organisms (MDRO) such as methicillin-resistant *Staphylococcus aureus* (MRSA) despite regular manual cleaning efforts.
- New emerging threatening organisms like CRE and *C.Auris* pose additional environmental challenges.



Chemaly RF, Simmons S, Dale C, et al. Infect Dis. 2014; 2(3-4): 79-90.

Pathogen	Survival Time
<i>S. aureus</i> (including MRSA)	7 days to >12 months
<i>Enterococcus</i> spp. (including VRE)	5 days to >46 months
<i>Acinetobacter</i> spp.	3 days to 11 months
<i>Clostridium difficile</i> (spores)	>5 months
Norovirus (and feline calicivirus)	8 hours to >2 weeks
<i>Pseudomonas aeruginosa</i>	6 hours to 16 months
<i>Klebsiella</i> spp.	2 hours to >30 months

Adapted from Hota B, et al. Clin Infect Dis 2004;39:1182-9 and Kramer A, et al. BMC Infectious Diseases 2006;6:130

Contaminated Environmental Surfaces

Factors contributing to environmental contamination:

- Multiple reservoirs for these pathogens within the healthcare setting: *i.e. shared patient equipment, contaminated medical devices, contaminated air and surfaces*
- Ability of these micro-organisms to survive in the air and on inanimate surfaces for extended periods of time.
- Inconsistent cleaning/disinfecting protocols.
- In a multisite study, Carling et. al reported an average rate of just 32% for cleaning thoroughness.

Chemaly RF, Simmons S, Dale C, et al. Infect Dis. 2014; 2(3-4): 79-90.
Carling PC, Huang SS. ICHE. 2013;34(05):507-13

Air Contamination

- Although traditionally the air is not a medium in which organisms grow, it plays as much of a role as contaminated surfaces do.
- The air itself is a vehicle or transport medium if you will of particulate matter, dust, spores and even harmful microorganisms like TB.
- Studies have shown that after flushing the toilet of a *C. diff* patient, the bacteria can be recovered from the air at heights around the toilet and can remain for up to 90 minutes. In addition these aerosolizations then fall and contaminate the surface environment.

Summary:

- Despite new disinfectants, checklists, focus on high touch surface areas and environmental monitoring, environmental and air contamination remains a current real risk in healthcare facilities contributing to transmission of pathogens.

Common Operating Room Airflow Pattern



Current systems, including laminar flow and positive pressure systems, do not deactivate pathogens, just displace pathogens. These pathogens are continuously being shed within the OR setting and contribute to the airborne pathogen concentration.

Increased Risk of SSI in Implant Procedures From Contaminated Air

- Procedures involving an implant pose the greatest risk of infection from the smallest inoculum.
- A foreign body such as an implant can reduce the number of organisms needed to cause an infection by a factor of 100,000.
- Organisms, typically skin flora, are dispersed in the operating room on squamous epithelial cells that can settle in the open incision and adhere to the implant.



Air Contamination and SSI: A Proven Relationship

Nearly a century of peer-reviewed literature supports the relationship between airborne pathogen levels and SSI.

Key SSI Risk Factors

- Number of people in the room
- Number of door openings
- Facility risk factors
- Length of procedure time
- Instrument tray exposure
- Procedural type

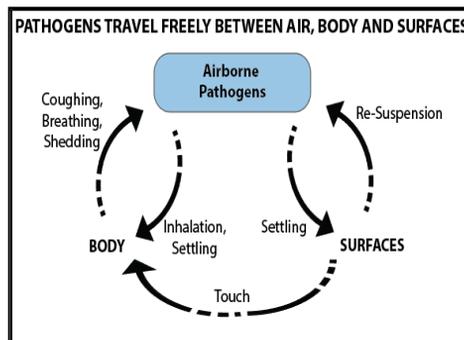


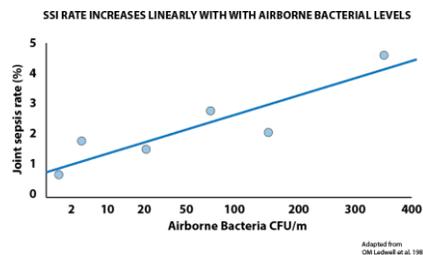
Figure. Schematic of airborne pathogen environmental cycle.

Elevated OR Air Bacterial Level Causes Increased Infection Rates



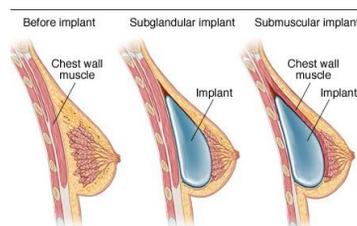
A prospective randomized multicenter study shows that joint replacements in rooms with over 50 CFU bacteria were 2.6 times as likely to have postoperative infection than those with 10-20 CFU.

- As airborne bacterial levels increase, infection rates increase.
- The relationship is linear.



Plastic Surgery Infections

- Clean cases that are complicated with an implant such as breast augmentation, have an increased risk of SSI.
- The SSI rate following breast cancer reconstructive surgery is relatively high (range, 6.3%-28%), based on a few reports in the literature.
- There is an increased surgical site infection rate in breast surgery without implants, compared to other clean cases.



OR Air Quality: How Clean is Clean Enough?

- Bacterial levels as high as 150 colony forming units (CFU)/m³ have been documented in ORs. Despite the risk of infection, there is no requirement for bacterial testing or particulate counts in US ORs.
- Air exchanges and positive air pressure are easily defeated by door openings and room traffic. Contamination arises largely from room personnel.
- Whyte and team showed that the incidence of joint SSI progressively declines as air contamination is reduced.

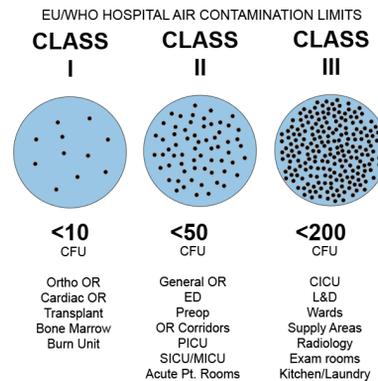


Figure 1. Representation of Typical EU/WHO air quality guidelines. Source: Charkowska (2008).

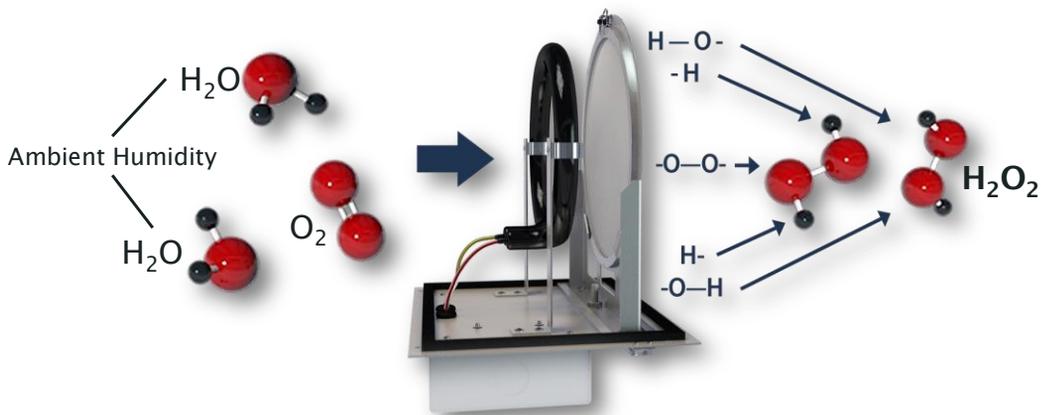
Compounding Pharmacies

- Unlike operating rooms, the pharmaceutical and computer industries enforce stringent air quality standard on their manufacturing processes.
- Currently no air quality standard (bacteria and particle limits) nor standard methodology for testing OR air quality, as there are in compounding pharmacies.
- Compounding pharmacies prepare sterile solutions to be introduced into the sterile vascular system. In OR, the majority of procedures involve entering a sterile organ space through an incision, which remains open to the OR air.





Dry Hydrogen Peroxide (DHP)



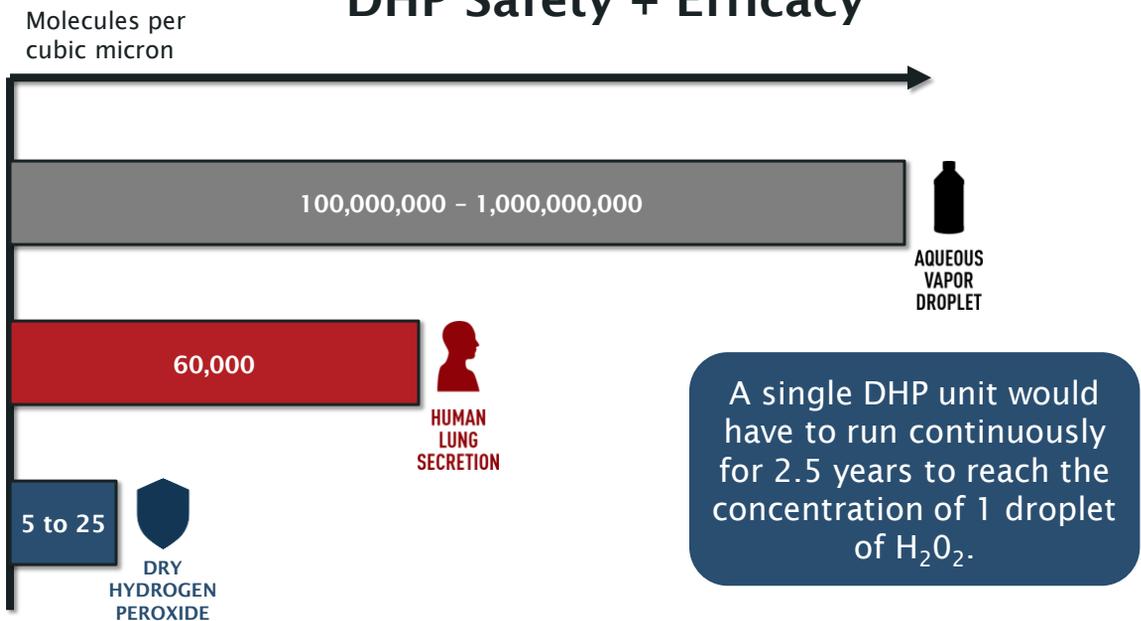
Safe, Green, Natural reduction of Viruses, Bacteria, Mold in the air and on surfaces.

Dry Hydrogen Peroxide (DHP) in a Typical Facility



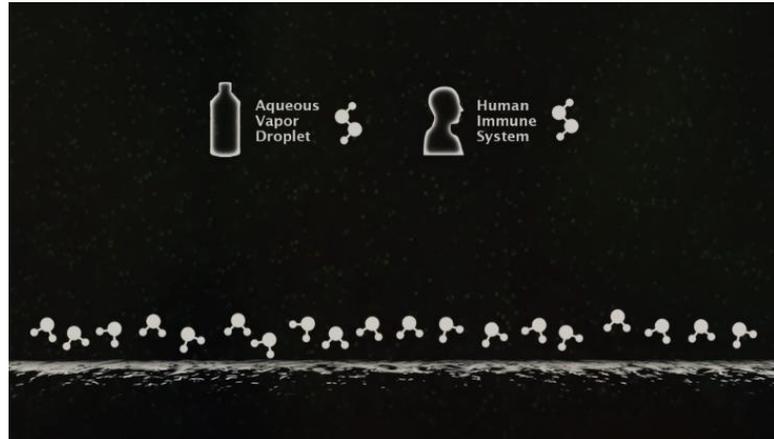
- 
 Airborne
Microbes
- 
 Surface
Contaminants
- 
 Pests
- 
 Odors
(VOC)
- 
 Cross
Contamination
- 
 HVAC
Distribution
- 
 Recontamination

DHP Safety + Efficacy



DHP vs. Aqueous Hydrogen Peroxide

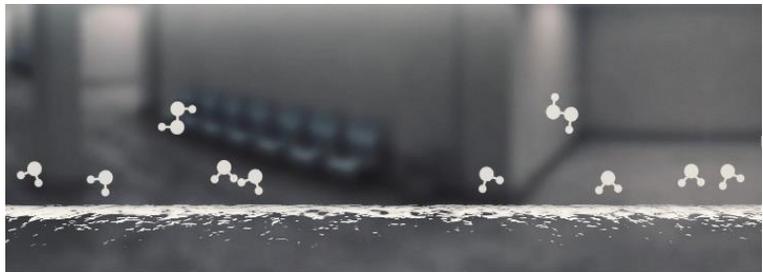
- For safety, aqueous hydrogen peroxide must be diluted with water.
- H_2O_2 competes with H_2O for access to the microbes receptors.



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Dry Hydrogen Peroxide (DHP)

- DHP is effective at such low concentrations because it is non-aqueous + non-aerosolized.
- H_2O_2 levels are that of a gaseous state, can easily access the microbes receptors.

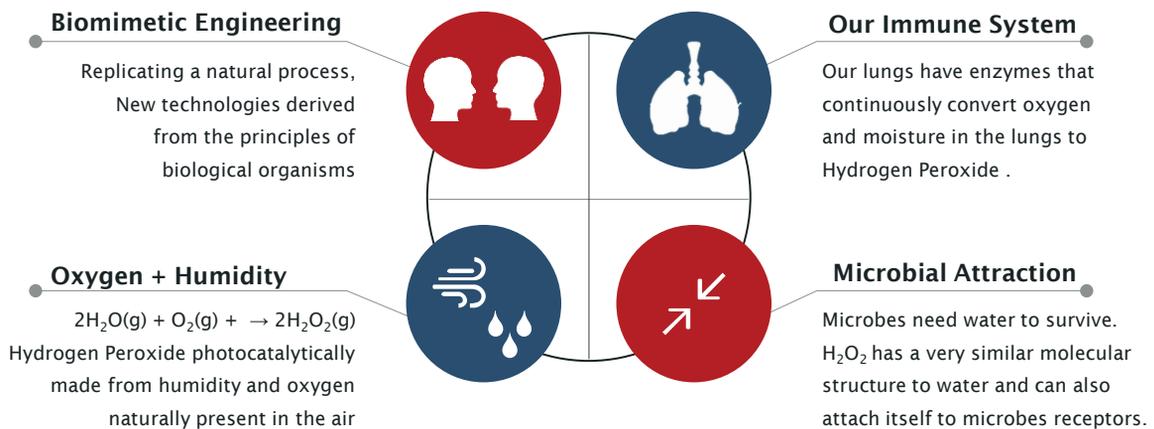


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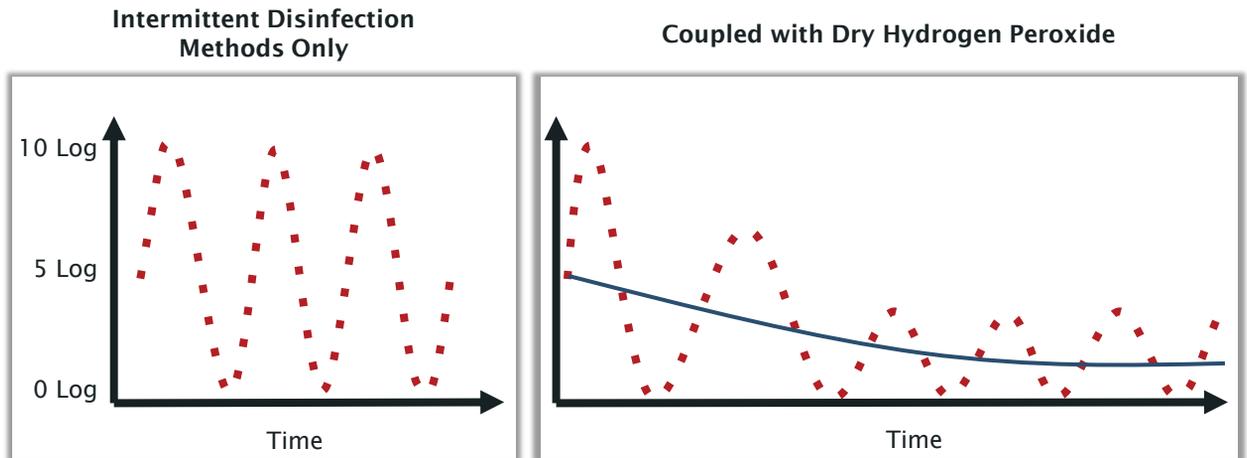
DHP Safety + Efficacy

- Dry Hydrogen Peroxide (DHP) is a gas.
- It is not a vapor from aqueous hydrogen peroxide solutions.
- Behaves like oxygen and nitrogen, diffusing through the air.
- DHP produces extremely effective microbial reduction at incredibly safe levels of H_2O_2 .

The Origins of Dry Hydrogen Peroxide (DHP)



A New Steady State



Microbial Colonization in the Hospital Setting

FIGURE ONE	CFU Count (per 100mm)			Pre-Cleaning to 187 hour	Post-Cleaning to 187 hour
	Pre-Cleaning	Post-Cleaning	187 Hours	Reduction (%)	Reduction (%)
Microbe					
S. Aureus	8	0	0	100%	NA
Alcaligenes Xylosoxidans	29	28	9	69%	68%
Mold	28	15	21	25%	-40%
Candida Parapsilosis	3	1	0	100%	100%
Pseudomonas Aeruginosa	25	20	1	96%	95%
Enterobacter	0	2	1	NA	50%
Pseudomonas Putida	2	0	0	100%	100%
Flavobacterium Meningosepticum	3	0	0	100%	100%
Pseudomonas Picketti	4	0	0	100%	100%
Citrobacter	23	11	0	100%	100%
Corynebacteria	0	9	0	NA	100%



Dilute Hydrogen Peroxide Technology for Reduction of Microbial Colonization in the Hospital Setting

Charles K. Herman, MD, FACS

American Journal of Infection Control
Volume 43, Issue 6, Pages S25-S26 (June 2015)

William Rutala
Award

2015

The DHP Difference

		Antimicrobial Surfaces	Cleaning Disinfectants	UV Light	Vaporized Agents	Dry Hydrogen Peroxide
Efficacy	Effective against viruses, bacteria, fungi	•	•	•	•	•
	Effective in out of reach areas				•	•
	Effective against airborne microbes			•	•	•
	Sustainable microbial reduction	•	•	•		•
	Wide area of effect					•
Cost	No labor commitment	•				•
	Low operating and labor cost	•				•
	No requirement to renew solution	•				•
Safety	Reduces risk of cross and recontamination					•
	Replicates a natural process					•
	Comfort and safety of occupants	•				•
	No odors, chemicals or solvents	•				•
	No bright lights	•	•			•
	Flexibility and ease of operation	•				•

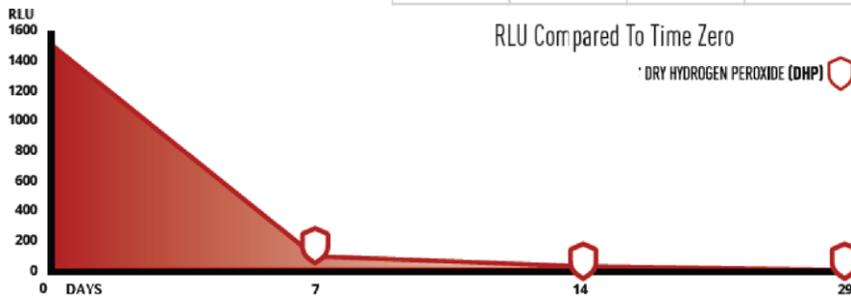


Pilot Study: 1101261-170929-1

SECTOR: Healthcare - Children's Specialty Care Facility

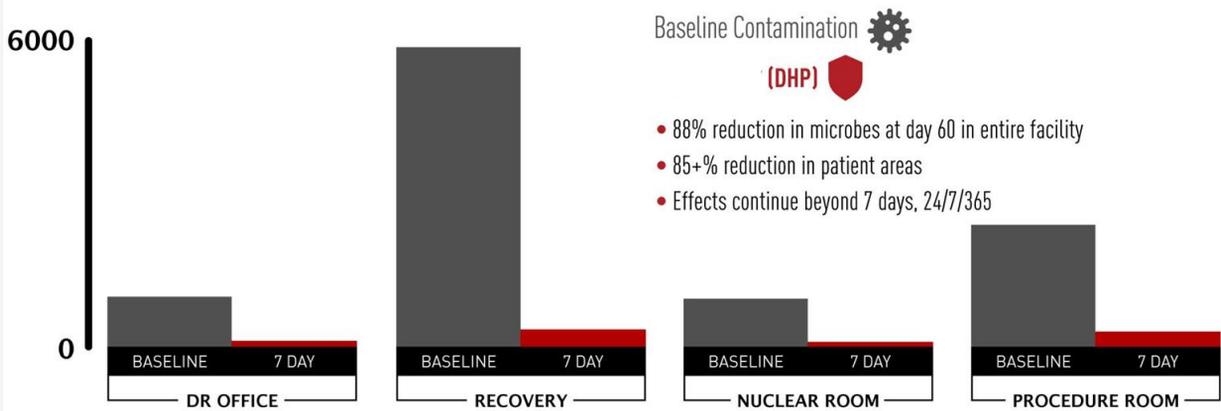


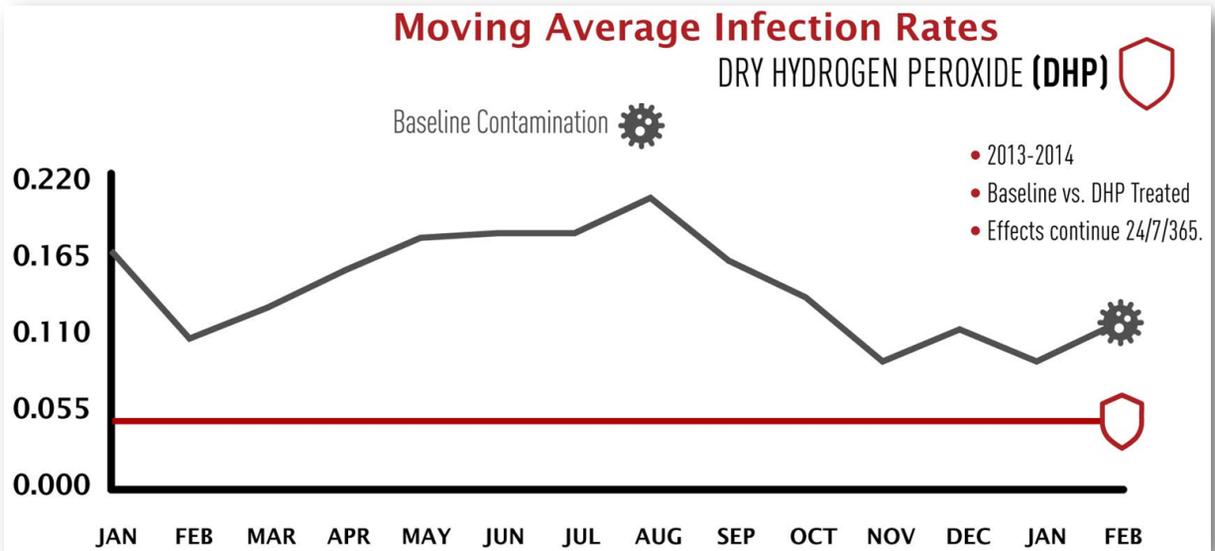
Baseline RLU Total	7 Day RLU Total	Percent Reduction Total	14 Day RLU Total	Percent Reduction Total	29 Day RLU Total	Percent Reduction Total
1.53E+03	1.16E+02	92.41%	4.80E+01	96.86%	2.10E+01	98.63%



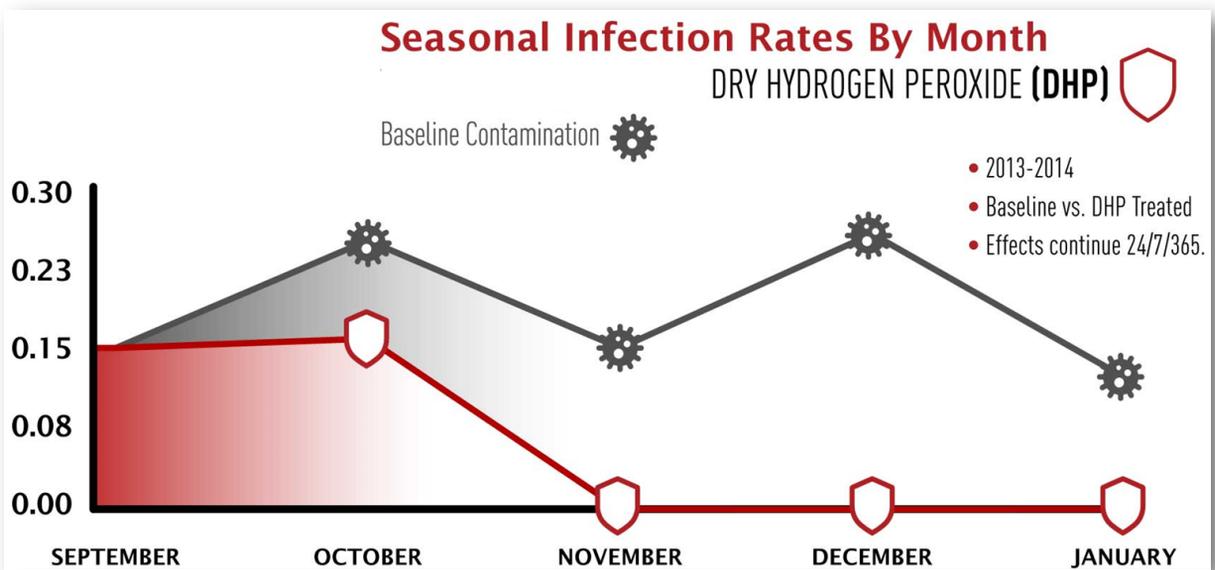
Cardiology Lab

DRY HYDROGEN PEROXIDE (DHP)

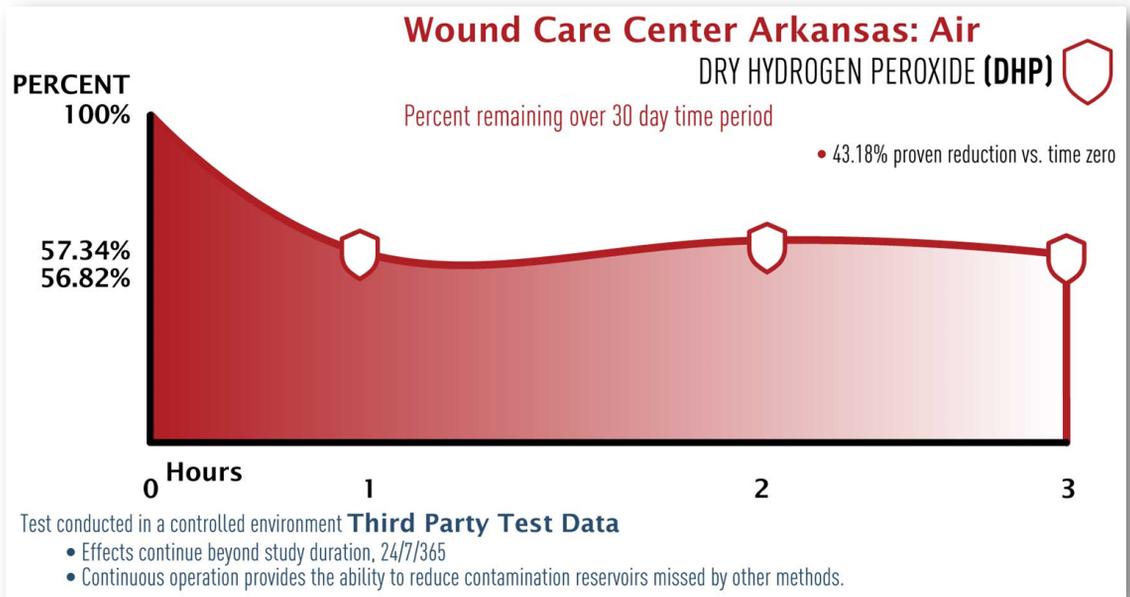




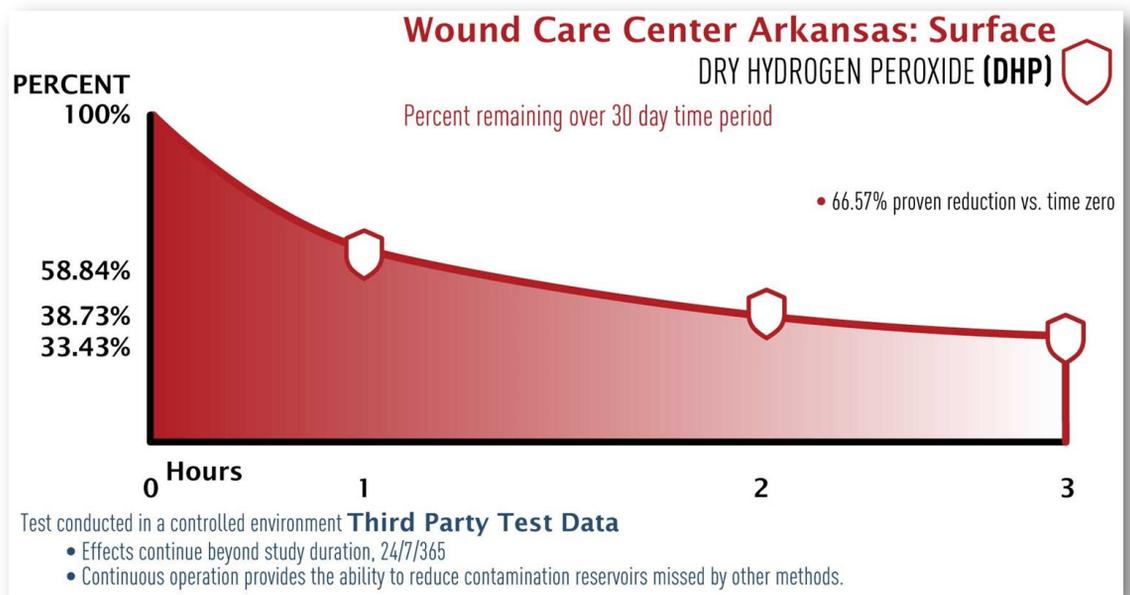
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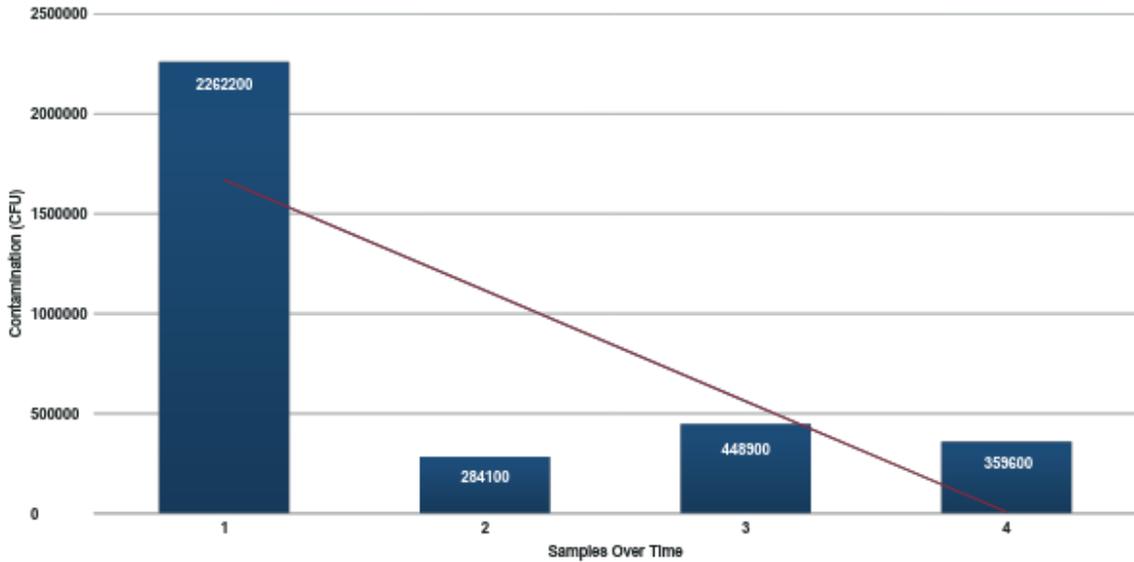


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The Elliott Community

Long Term Care Facility

Microbial Monitoring Report



Our Studies

Multi-Center Study

Intervention Arm – Synexis Biodefense System installed. Normal environmental services providing disinfection continue.

Control Arm – Normal environmental services providing disinfection process with no Synexis Biodefense System installed.

- 690-bed Las Vegas Acute Care Hospital
- Pediatric ICU (24 Beds)
- Pediatric ER (22 Beds)
- Adult Oncology Services (23 Beds)
- Cardiovascular Trauma Unit (22 Beds)



Our Studies

Veterans Affairs Study

Randomized crossover study in a Community Living Center to determine bioburden levels of high-touch surfaces while in the presence of a Synexis Biodefense System.

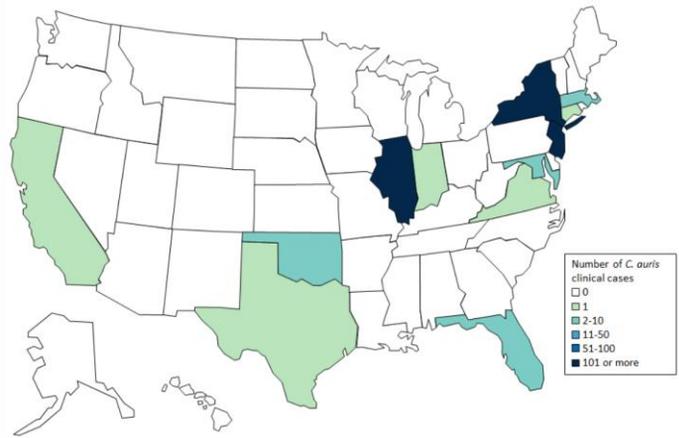
Part of current intermittent strategy to reduce HAIs

- Two hospital wings (one treated with DHP, one control)
- Focus on high touch areas
- Specific tests for ABC (aerobic bacterial colonies), MRSA and C. diff will be conducted.



Tracking *Candida auris*

U.S. Map: Clinical cases of *Candida auris* reported by state, United States, as of December 31, 2018

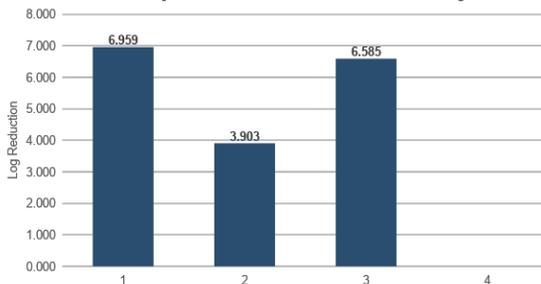


- *C. auris* is an emerging fungus that presents a serious global health threat.
- *C. auris* can cause severe invasive illness in hospitalized patients
- Up to 60% of patients with *C. auris* infections have died.
- *C. auris* is Multi-drug Resistant, resistant to typical anti-fungal therapies.
- Unlike other *Candida* species, has persistent viability on the skin and in the environment leading to horizontal transmission.
- Resistant to standard quantary disinfection products

Source: Centers for Disease Control and Prevention

Candida auris Exposure to Dry Hydrogen Peroxide

DHP Exposed *C. auris* Chamber Study



The following study tested the efficacy of Dry Hydrogen Peroxide (DHP) on *Candida auris*. This specific fungal pathogen is approaching epidemic levels in New York healthcare facilities.

The chart and table below show a 3.06 log reduction after Day 1 (T=1) and a subsequent 6.58 log reduction after Day 2 (T=2).

Time point (days)		10 ⁻¹		10 ⁻²		10 ⁻³		10 ⁻⁴		Plate Average	Log Transformed	Log Reduction
		A	B	A	B	A	B	A	B			
T=0	Control							146	152	149	7.17	
T=1	Control							94	87	91	6.96	3.06
	DHP	32	16	2	1					24	3.90	
T=2	Control					39	38			39	6.59	6.58
	DHP									0	0.00	

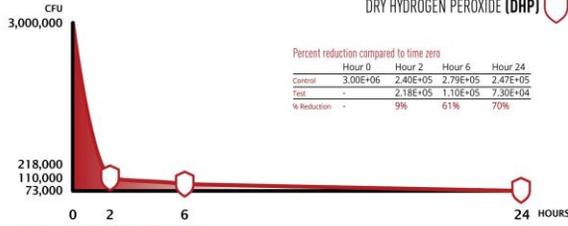


A strain of *Candida auris* cultured in a petri dish at CDC.

C. diff

Clostridium difficile (C. diff)

DRY HYDROGEN PEROXIDE (DHP)



Test conducted in a controlled environment ATIS Labs

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

171214

Clostridium difficile (C. diff) (With Soil Load)

DRY HYDROGEN PEROXIDE (DHP)



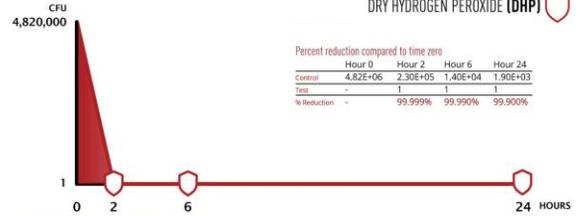
Test conducted in a controlled environment ATL Labs (accredited)

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

E. faecalis

Enterococcus faecalis

DRY HYDROGEN PEROXIDE (DHP)



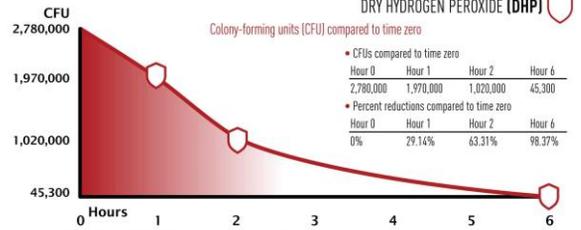
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171214

Enterococcus faecalis

DRY HYDROGEN PEROXIDE (DHP)



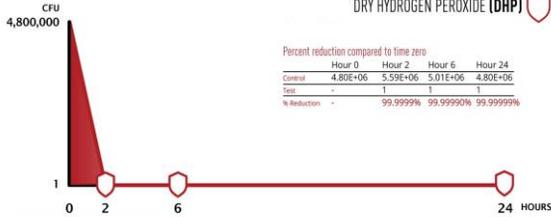
Test conducted in a controlled environment Microchem (accredited)

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

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Methicillin-resistant Staphylococcus aureus (MRSA)

DRY HYDROGEN PEROXIDE (DHP)



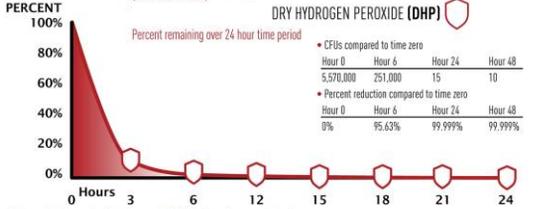
Test conducted in a controlled environment ATIS Labs

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

171214

Methicillin-resistant Staphylococcus aureus (MRSA) (With Soil Load)

DRY HYDROGEN PEROXIDE (DHP)



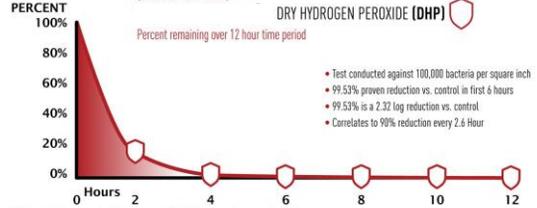
Test conducted in a controlled environment ATL Labs (accredited)

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

MRSA

Methicillin-resistant Staphylococcus aureus (MRSA) (Without Soil Load)

DRY HYDROGEN PEROXIDE (DHP)



Test conducted in a controlled environment ATL Labs (accredited)

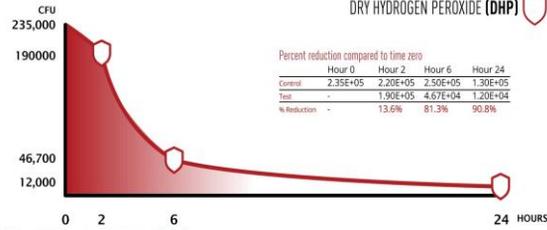
- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

4

Aspergillus niger (A. niger)

Vegetative *Aspergillus niger* (A. niger)

DRY HYDROGEN PEROXIDE (DHP)



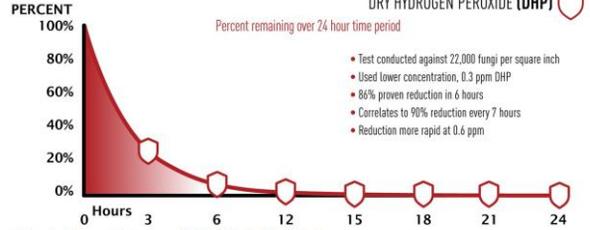
Test conducted in a controlled environment ATS Labs

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

171214

Vegetative *Aspergillus niger* (A. niger)

DRY HYDROGEN PEROXIDE (DHP)



Test conducted in a controlled environment Third Party Test Data

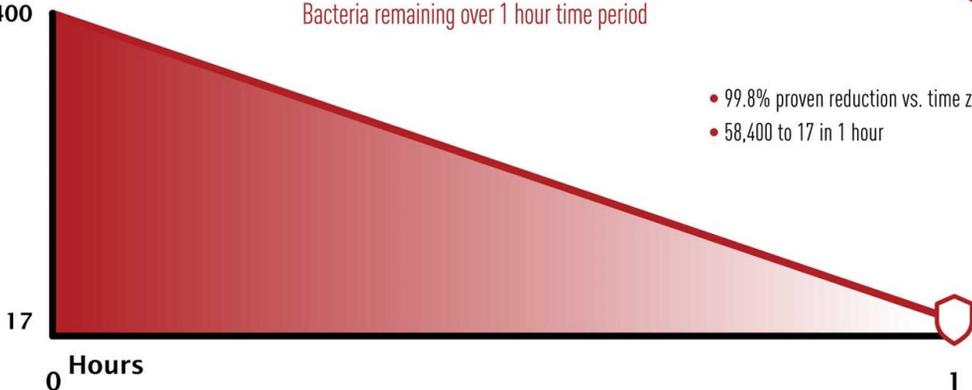
- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

Airborne *Escherichia coli* bacteriophage MS2

DRY HYDROGEN PEROXIDE (DHP)

BACTERIA
58,400

Bacteria remaining over 1 hour time period

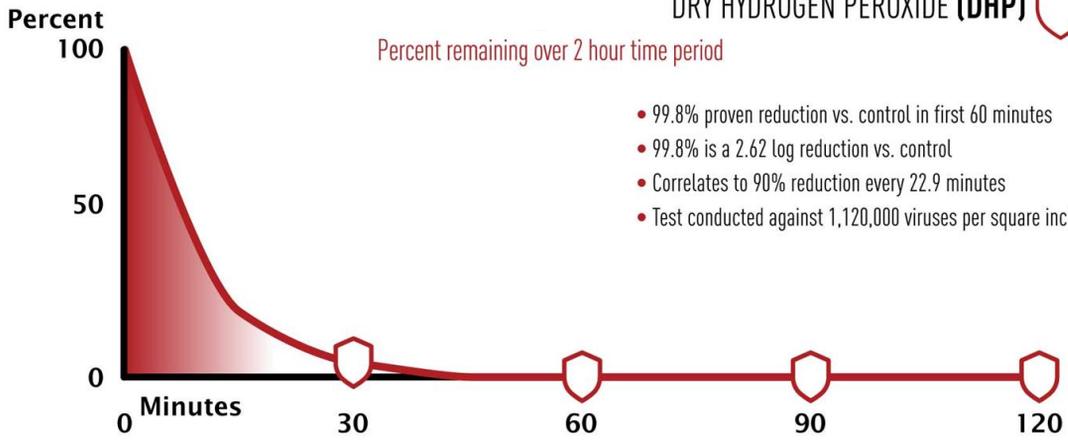


Test conducted in a controlled environment Microchem (accredited)

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

Influenza

DRY HYDROGEN PEROXIDE (DHP)



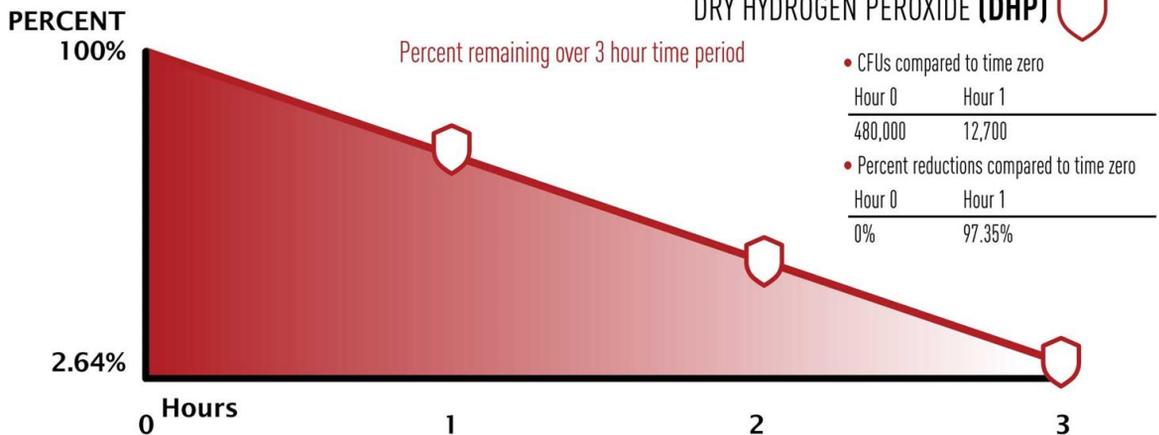
Test conducted in a controlled environment **ATL Labs (accredited)**

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

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Listeria monocytogenes

DRY HYDROGEN PEROXIDE (DHP)



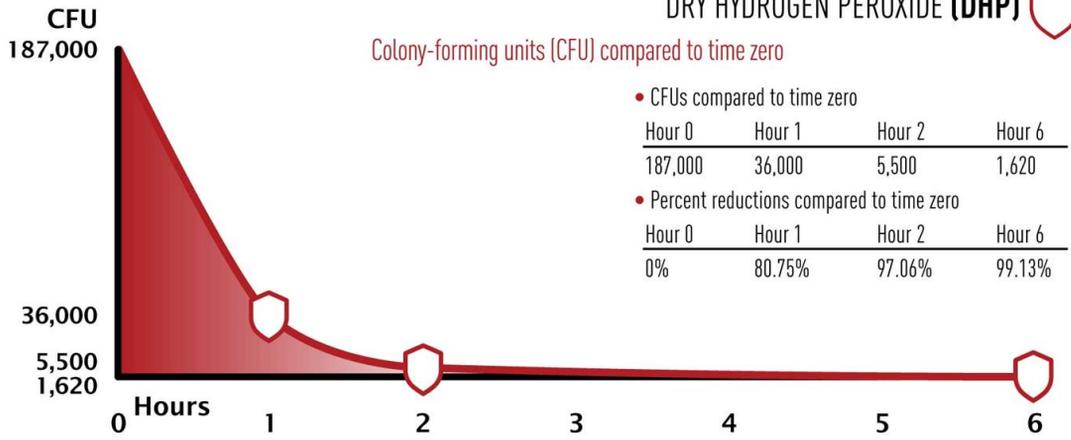
Test conducted in a controlled environment **Microchem (accredited)**

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

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Salmonella Enteritidis

DRY HYDROGEN PEROXIDE (DHP)



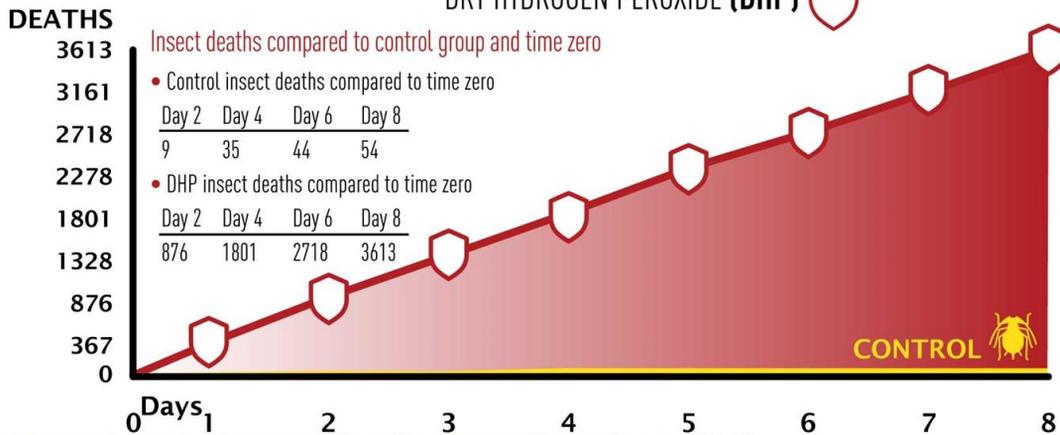
Test conducted in a controlled environment **Microchem (accredited)**

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

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Green Peach Aphids (*Myzus persicae*)

DRY HYDROGEN PEROXIDE (DHP)



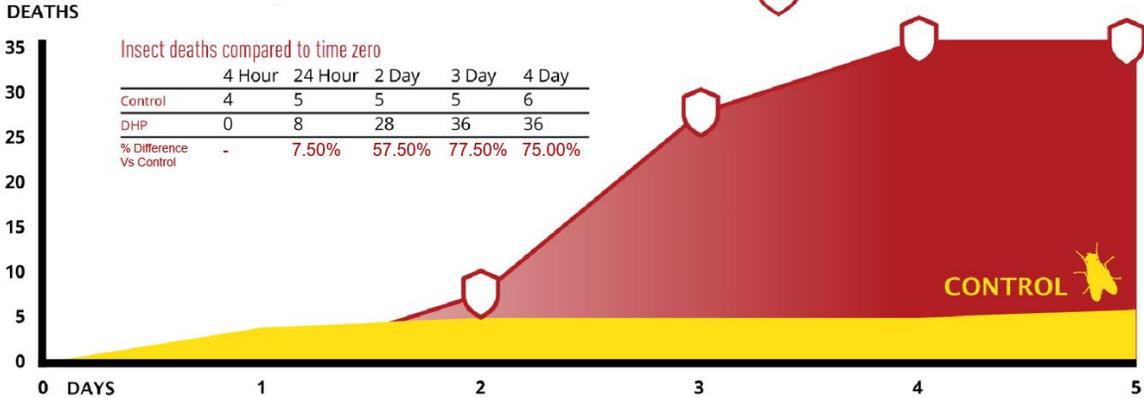
Test conducted in a controlled environment **Eurofins Agroscience (accredited)**

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce insect population missed by other methods.

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House Fly Mortality

DRY HYDROGEN PEROXIDE (DHP)

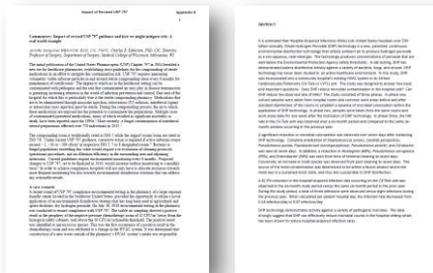


Test conducted in a controlled environment:

- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce insect population missed by other methods.

Soon to Be Published

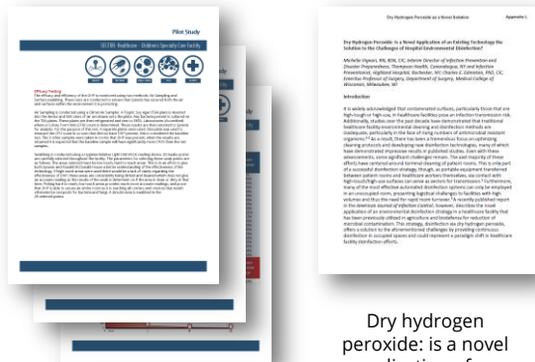
Peer reviewed publications



Commentary: impact of revised USP 797 guidance and how [DHP] might mitigate risk: a real world example

Dilute hydrogen peroxide technology for continuous reduction of microbial colonization and healthcare associated infections in an acute care hospital.

Non-peer reviewed publication



Utilizing dry hydrogen peroxide for continuous environmental disinfection: the Ronald McDonald House story

Dry hydrogen peroxide: is a novel application of an existing technology the solution to the challenge of hospital environmental disinfection?



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BIODEFENSE SYSTEMS

An active immune system for occupied spaces.

- Healthcare
- Animal Health
- Agriculture
- Government
- Food Services
- Hospitality



HVAC
DEVICE



STANDALONE
DEVICE

Dry Hydrogen Peroxide (DHP) is generally effective against any organism that is susceptible to other forms of Hydrogen Peroxide.

If your organization is interested in performing tests against a specific microbe or environmental condition, please contact us at:

rstephens@synexis.com