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.

Rutala WA, Weber DJ. AJIC 2013;41:s36

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

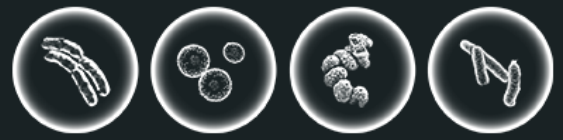
Summary:

- 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.

Challenges

Microbial Reduction
Safety of Occupants
Occupied Spaces

Microbial Threats



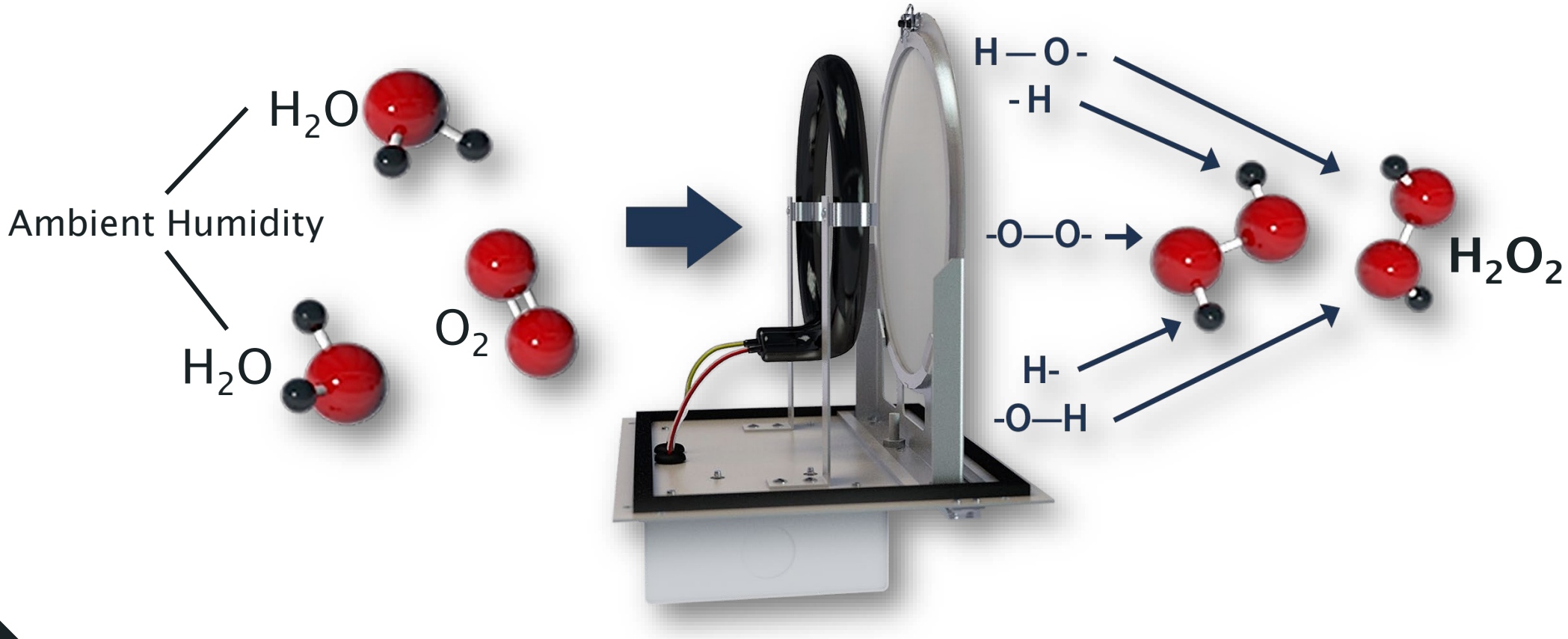
Viruses
Bacteria
Fungi

Challenges

Continuous Operation
Low Operational Cost
Ease of Use

Overview

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

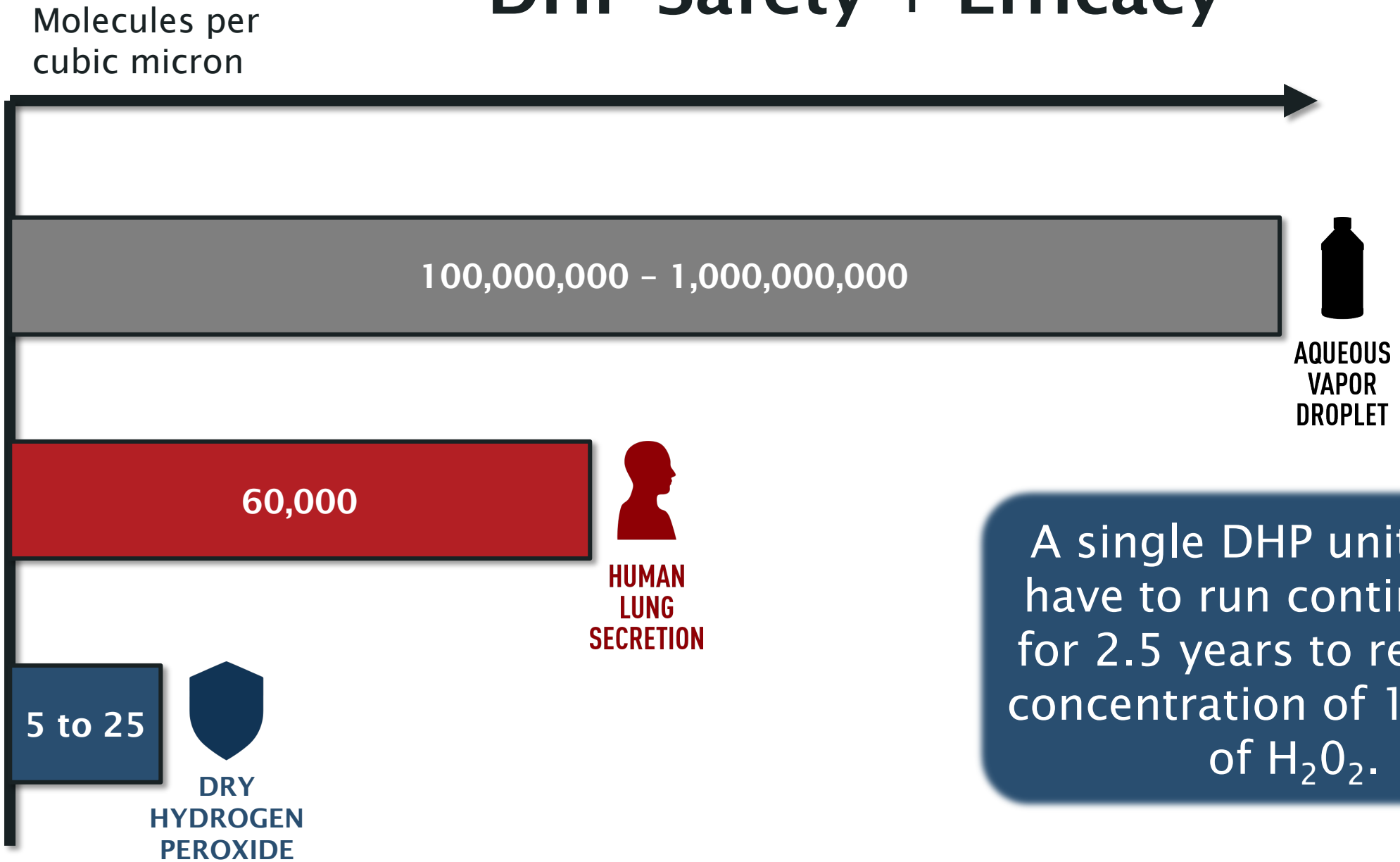
Odors (VOC)

Cross Contamination

HVAC Distribution

Recontamination

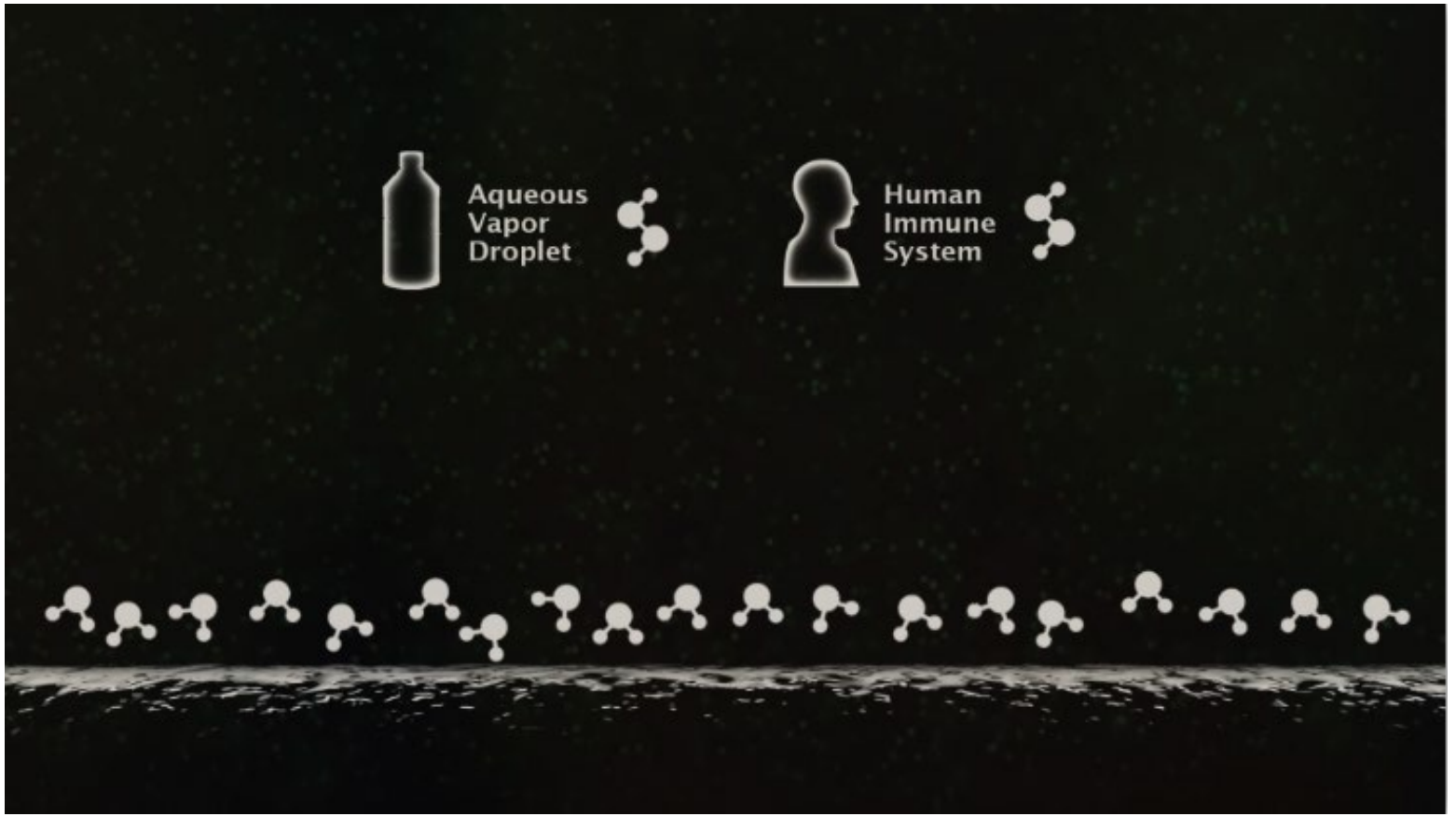
DHP Safety + Efficacy



A single DHP unit would have to run continuously for 2.5 years to reach the concentration of 1 droplet of H_2O_2.

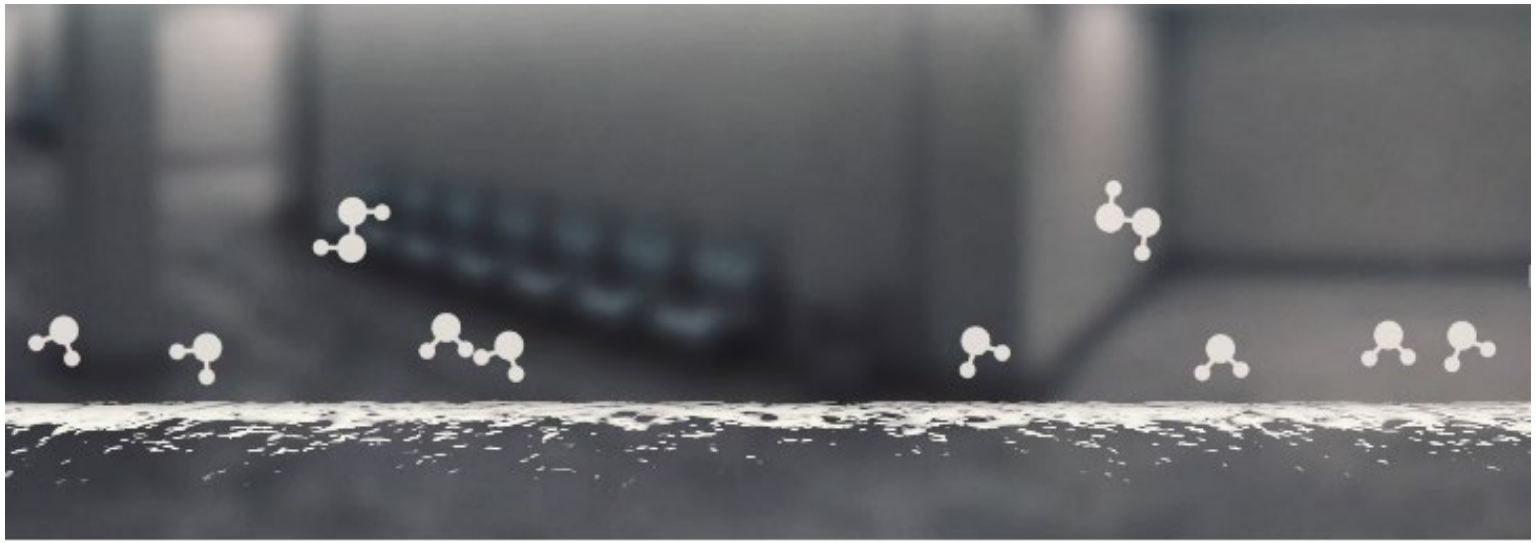
DHP vs. Aqueous Hydrogen Peroxide

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



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.



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.

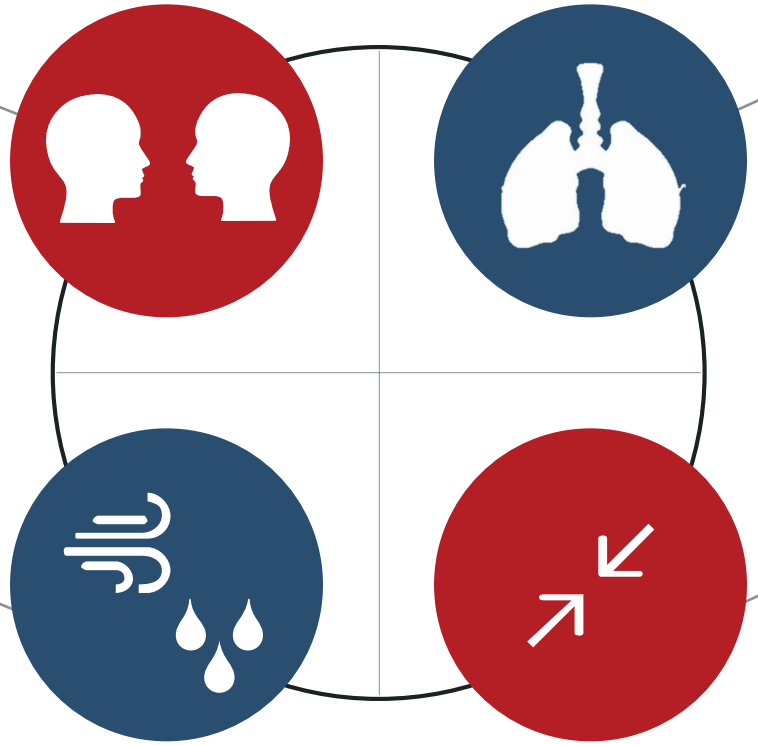
The Origins of Dry Hydrogen Peroxide (DHP)

Biomimetic Engineering

Replicating a natural process, New technologies derived from the principles of biological organisms

Our Immune System

Our lungs have enzymes that continuously convert oxygen and moisture in the lungs to Hydrogen Peroxide .



Oxygen + Humidity

$2H_2O(g) + O_2(g) + \rightarrow 2H_2O_2(g)$

Hydrogen Peroxide photocatalytically made from humidity and oxygen naturally present in the air

Microbial Attraction

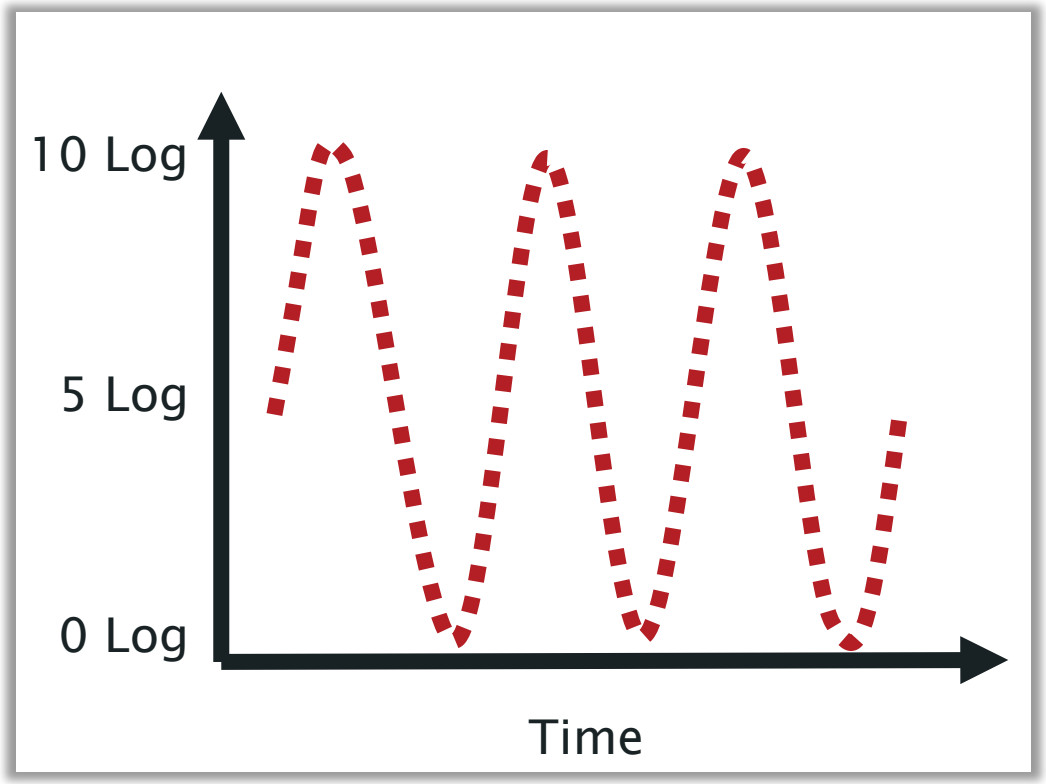
Microbes need water to survive. H_2O_2 has a very similar molecular structure to water and can also attach itself to microbes receptors.

The DHP Difference

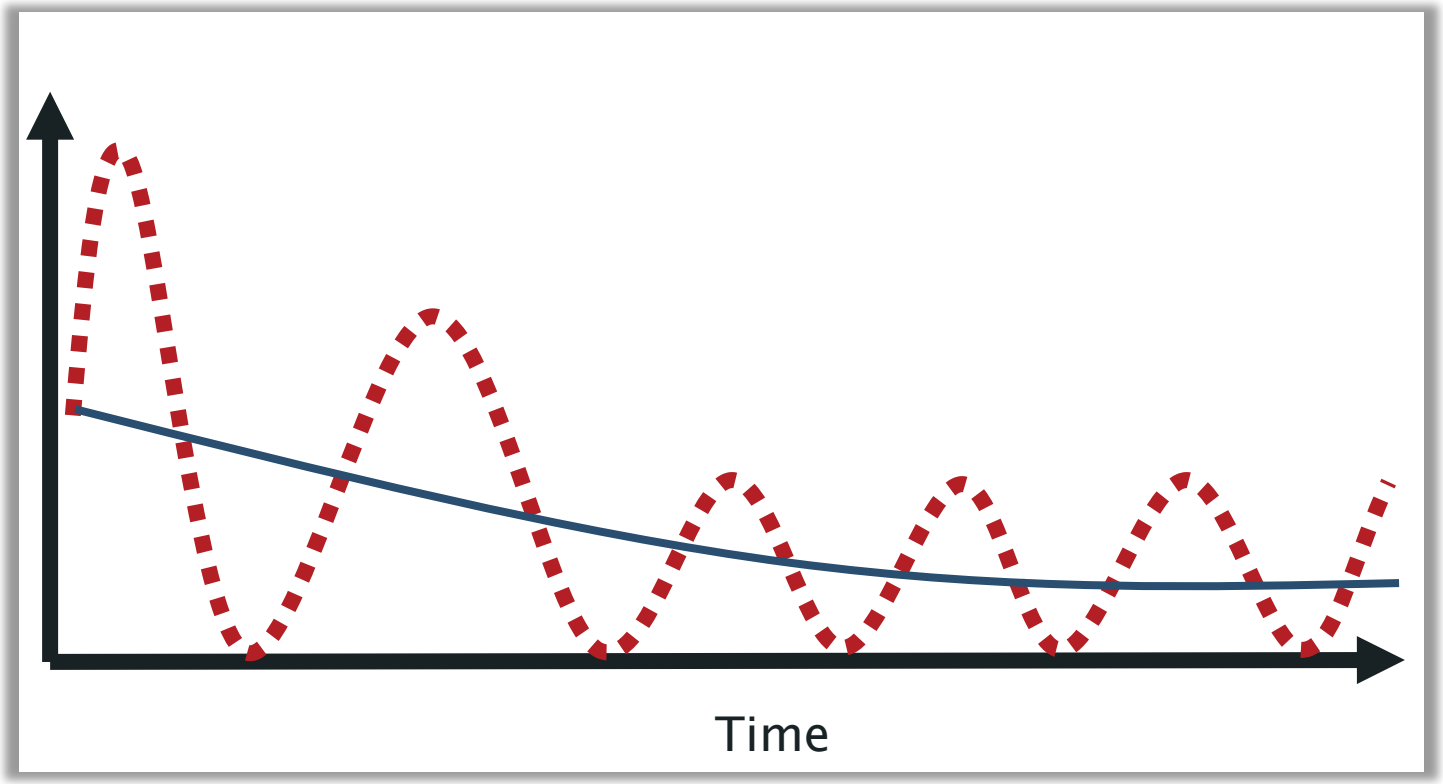
		Antimicrobial Surfaces	Cleaning Disinfectants	UV Light	Vaporized Agents	Dry Hydrogen Peroxide
Efficacy	Effective against viruses, bacteria, fungi	●	●	●	●	●
	Effective in out of reach areas				●	●
	Effective against airborne microbes			●	●	●
	Sustainable microbial reduction	●	●	●		●
	Wide area of effect					●
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	●				●

A New Steady State

Intermittent Disinfection Methods Only



Coupled with Dry Hydrogen Peroxide



Microbial Colonization in the Hospital Setting

FIGURE ONE	CFU Count (per 100mm)			Pre-Cleaning to 187 hour	Post-Cleaning to 187 hour
Microbe	Pre-Cleaning	Post-Cleaning	187 Hours	Reduction (%)	Reduction (%)
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%
Pseudomonos 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

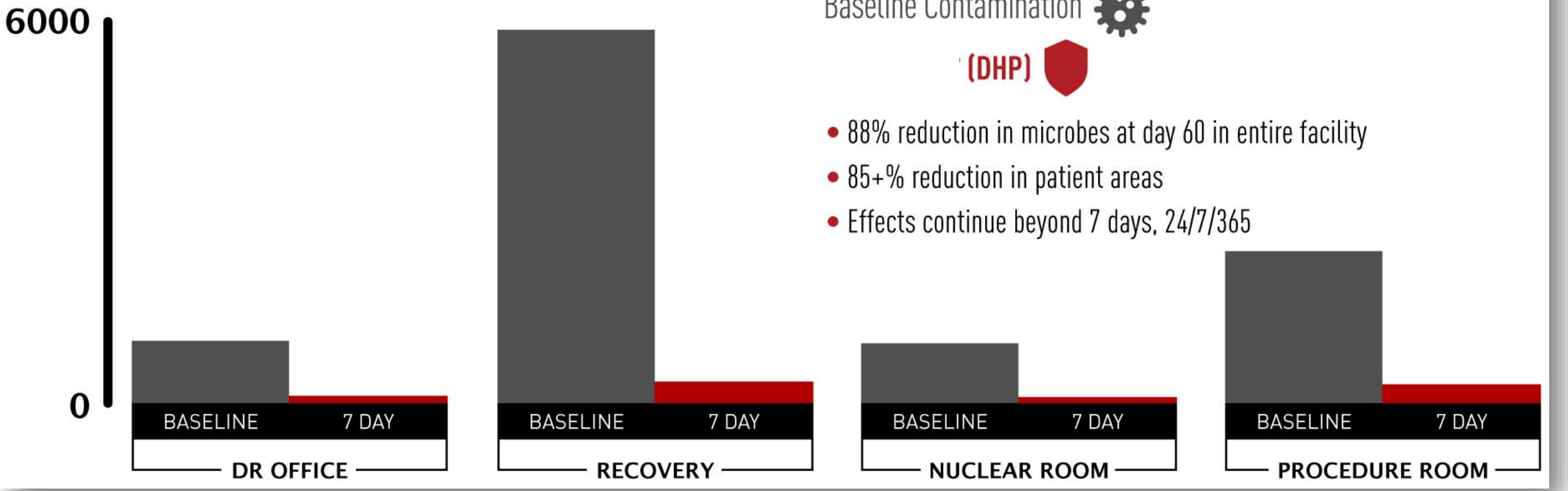
American Journal of Infection Control
Volume 43, Issue 6, Pages S25-S26 (June 2015)

ELSEVIER

William Rutala Award 2015

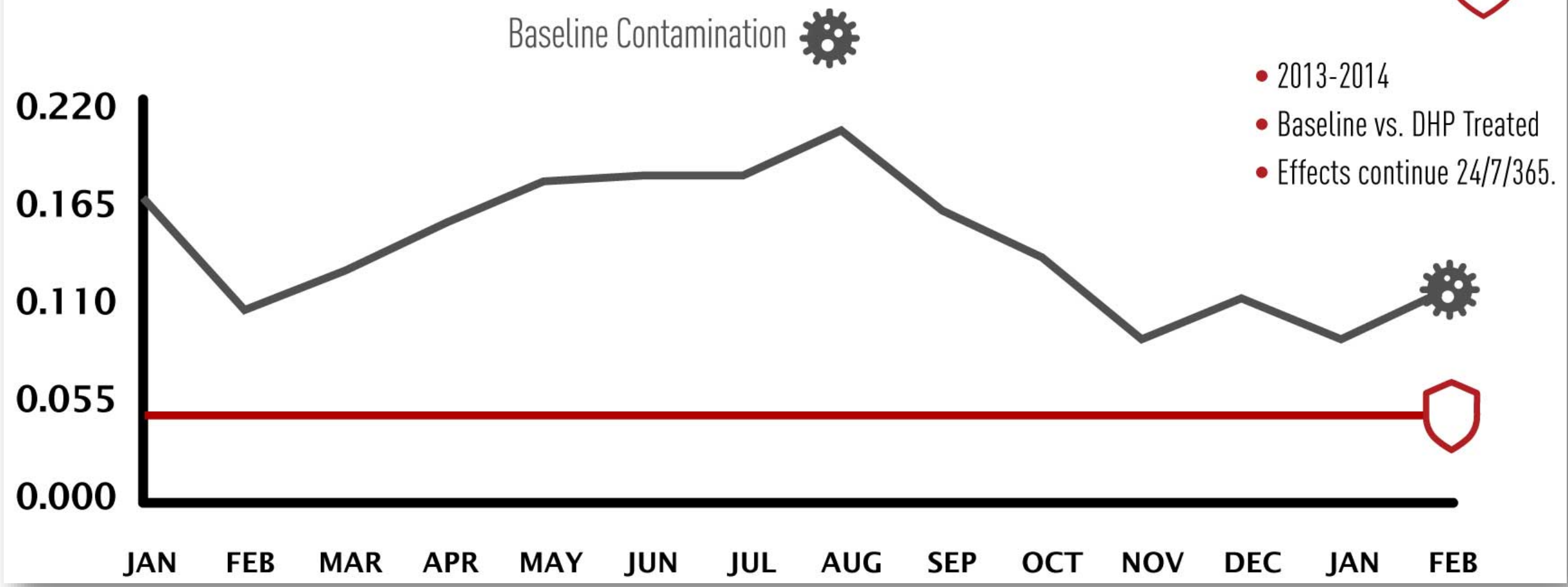
Cardiology Lab

DRY HYDROGEN PEROXIDE **(DHP)**



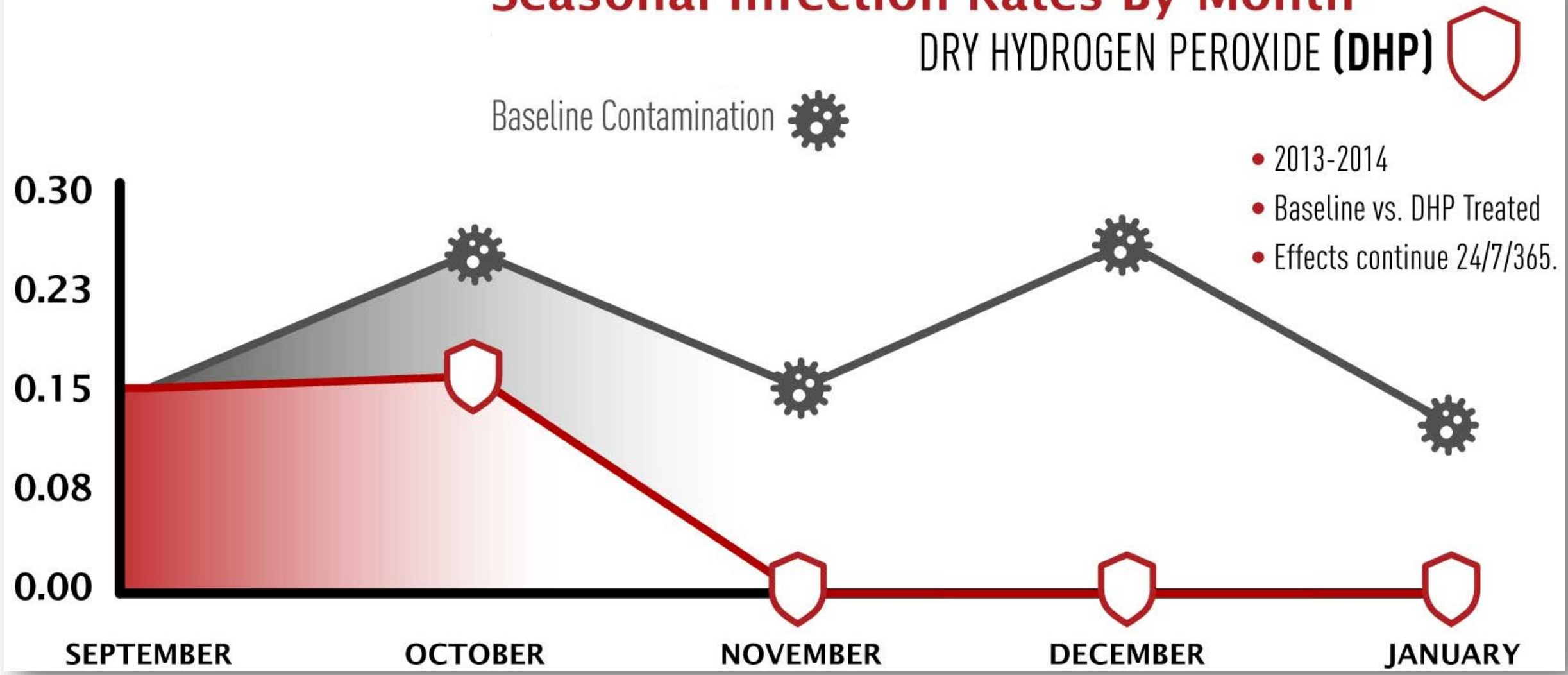
Moving Average Infection Rates

DRY HYDROGEN PEROXIDE **(DHP)**



Seasonal Infection Rates By Month

DRY HYDROGEN PEROXIDE **(DHP)**

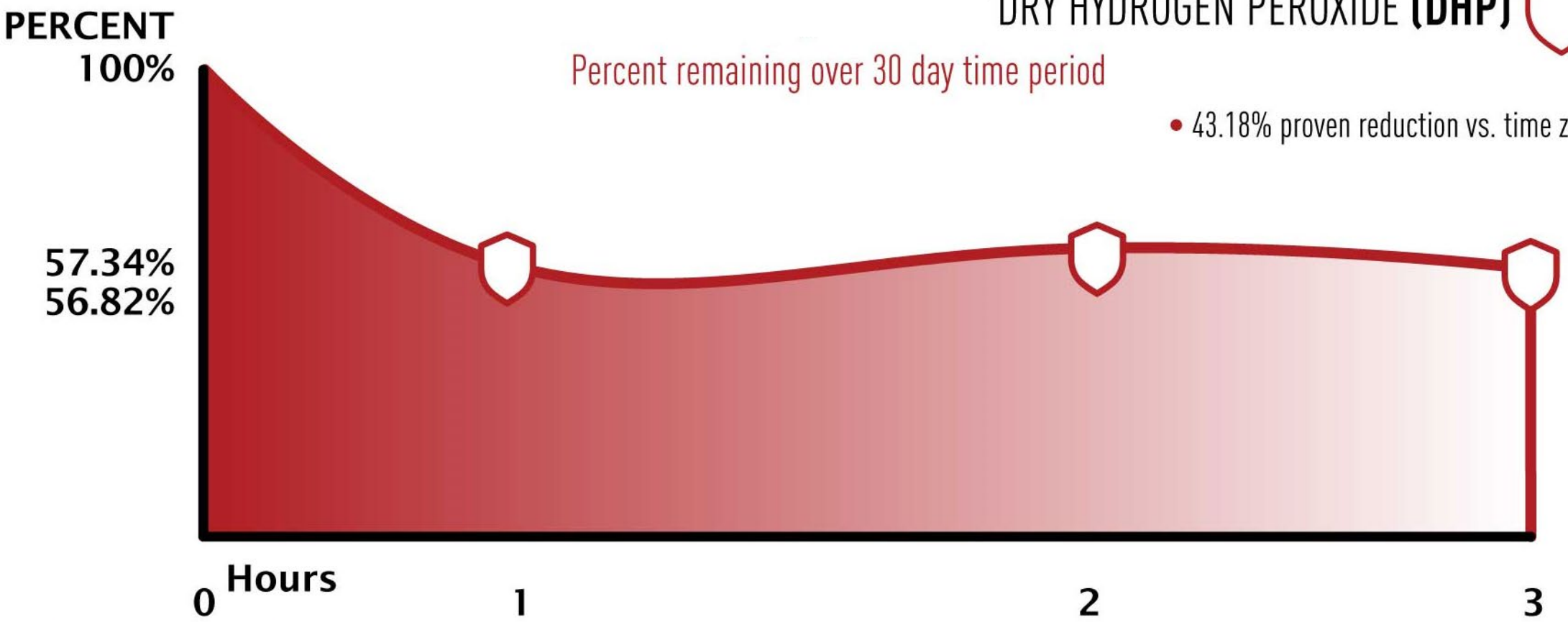


Wound Care Center Arkansas: Air

DRY HYDROGEN PEROXIDE **(DHP)**

Percent remaining over 30 day time period

- 43.18% proven reduction vs. time zero



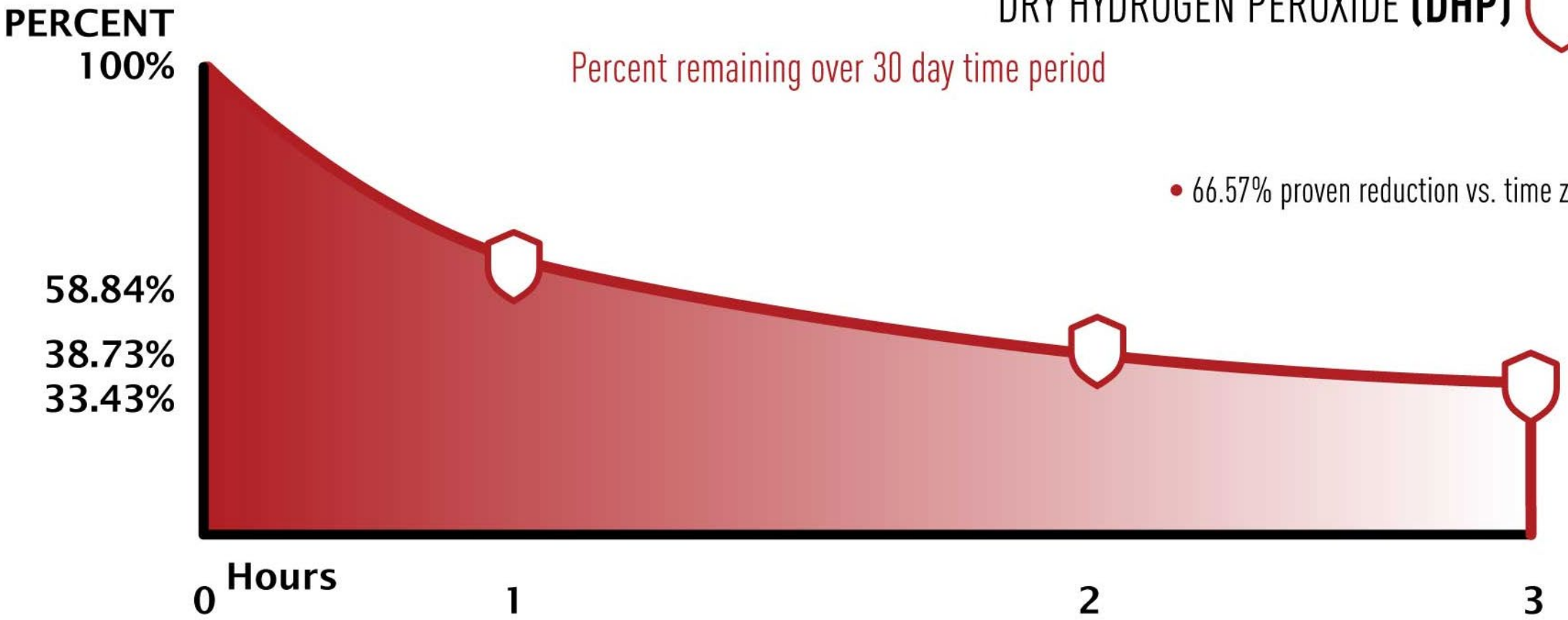
Test conducted in a controlled environment **Third Party Test Data**

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

Wound Care Center Arkansas: Surface

DRY HYDROGEN PEROXIDE **(DHP)**

Percent remaining over 30 day time period



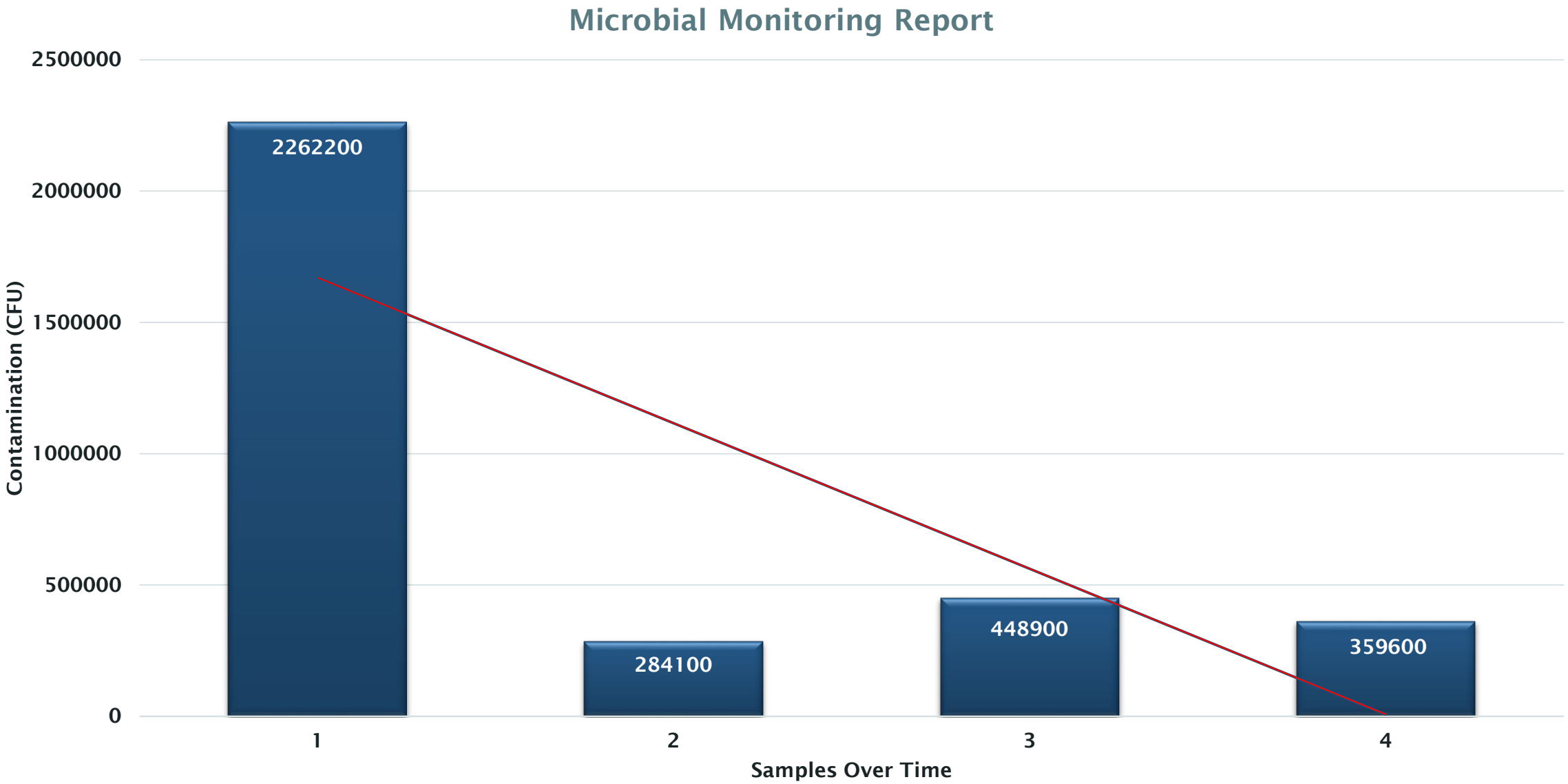
- 66.57% proven reduction vs. time zero

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.

The Elliott Community

Long Term Care Facility

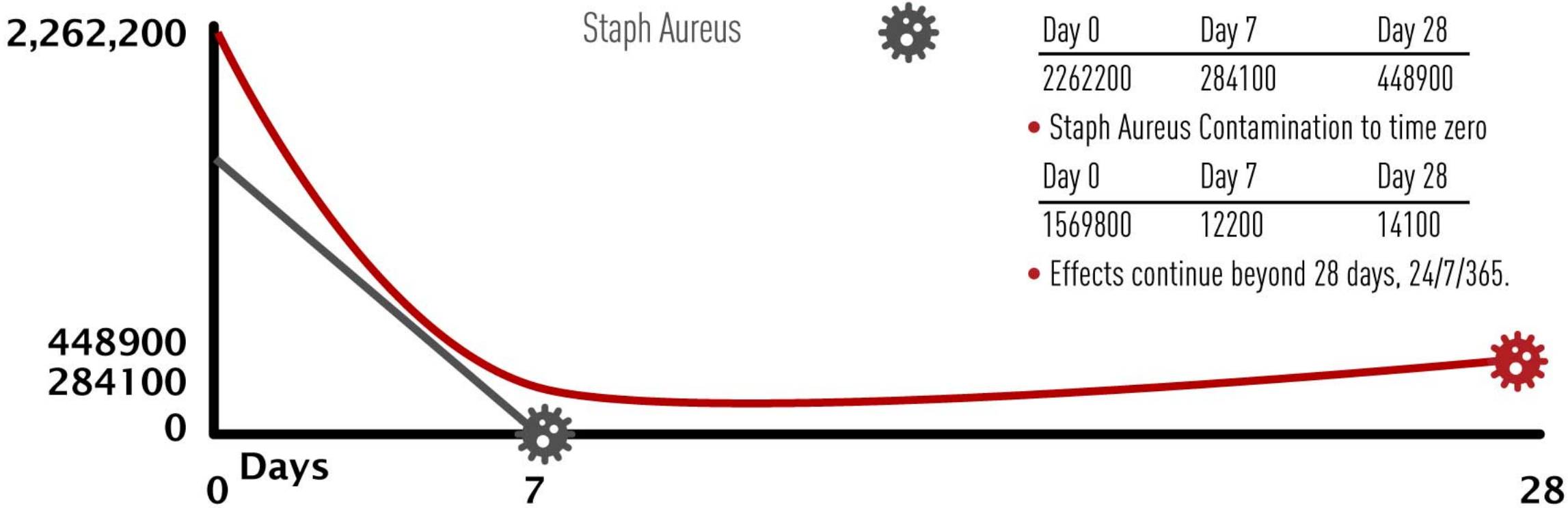


Long Term Care Facility Results

DRY HYDROGEN PEROXIDE **(DHP)**

Baseline Contamination

Staph Aureus



- Total Microbes Contamination to time zero

Day 0	Day 7	Day 28
2262200	284100	448900

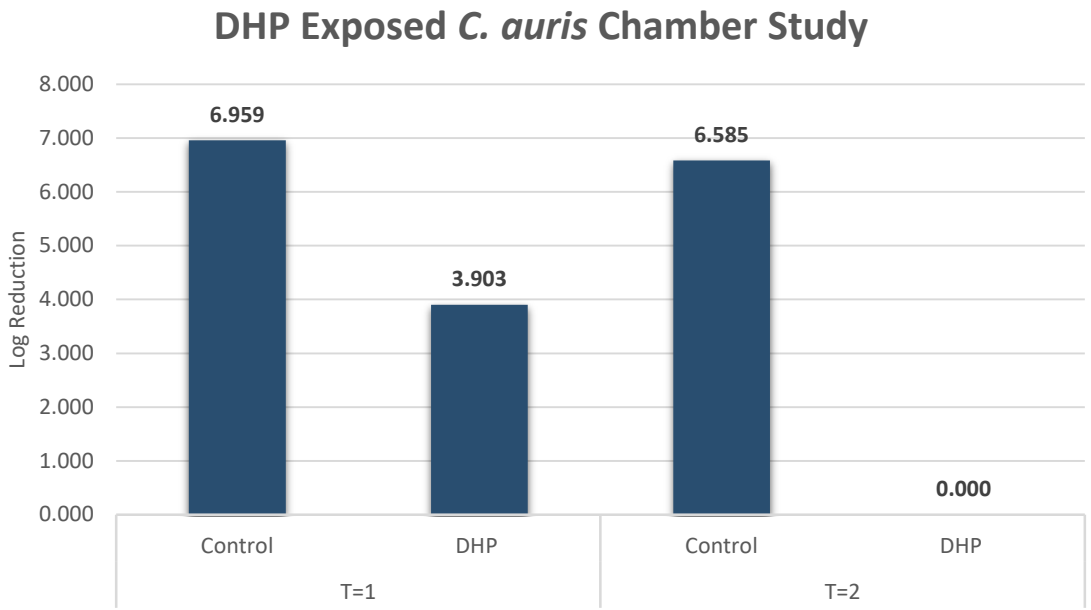
- Staph Aureus Contamination to time zero

Day 0	Day 7	Day 28
1569800	12200	14100

- Effects continue beyond 28 days, 24/7/365.


Lab Data

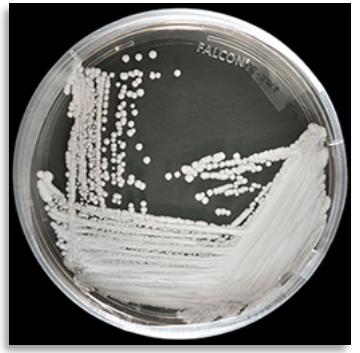
Candida auris Exposure to Dry Hydrogen Peroxide



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	

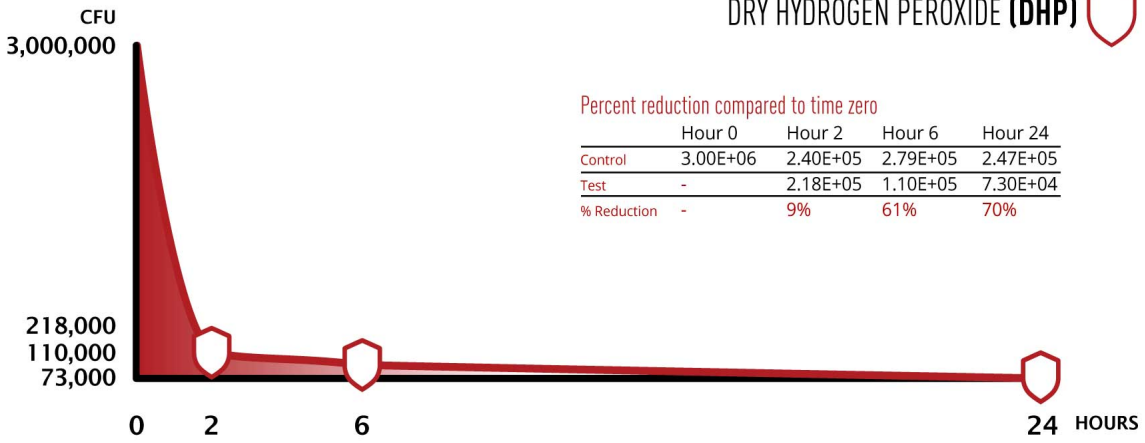


A strain of *Candida auris* cultured in a petri dish at CDC.

C. diff

Clostridium difficile (C. diff)

DRY HYDROGEN PEROXIDE **(DHP)**



Percent reduction compared to time zero

	Hour 0	Hour 2	Hour 6	Hour 24
Control	3.00E+06	2.40E+05	2.79E+05	2.47E+05
Test	-	2.18E+05	1.10E+05	7.30E+04
% Reduction	-	9%	61%	70%

Test conducted in a controlled environment ATS Labs

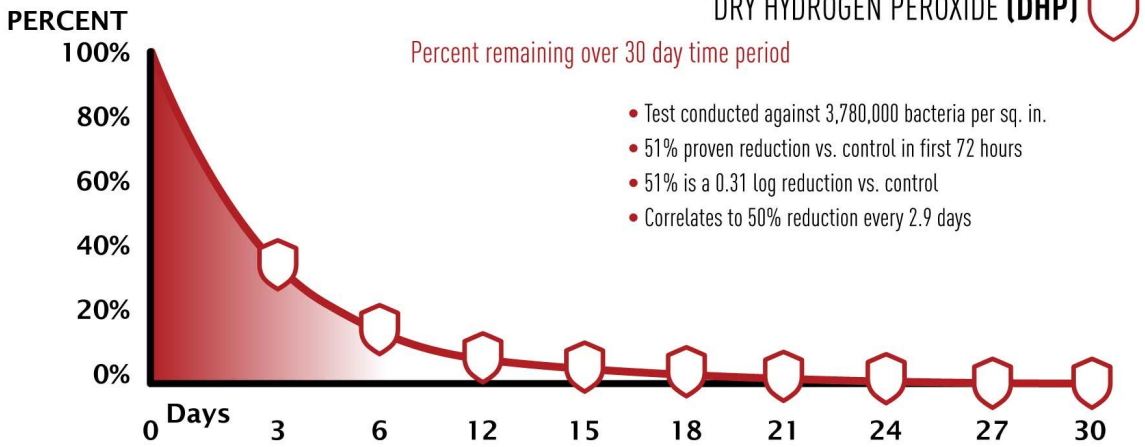
- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

171214

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

DRY HYDROGEN PEROXIDE **(DHP)**

Percent remaining over 30 day time period



- Test conducted against 3,780,000 bacteria per sq. in.
- 51% proven reduction vs. control in first 72 hours
- 51% is a 0.31 log reduction vs. control
- Correlates to 50% reduction every 2.9 days

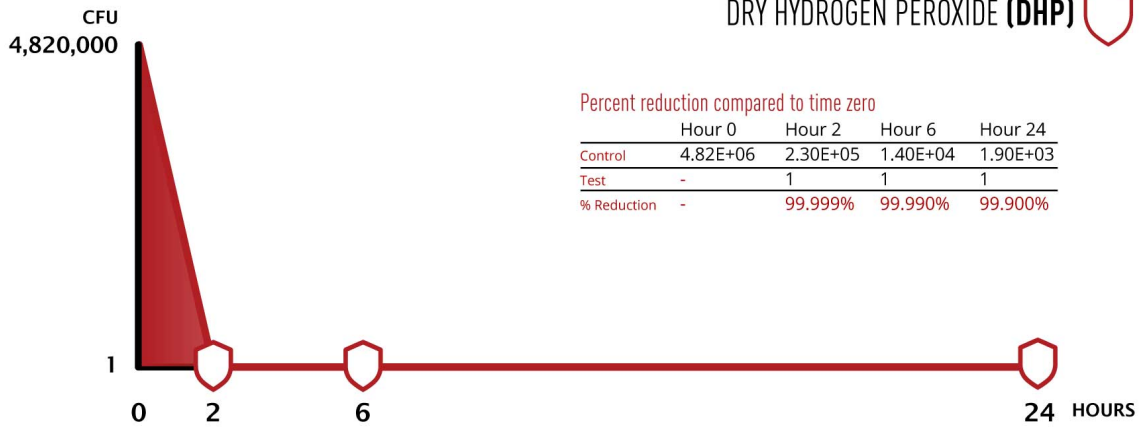
Test conducted in a controlled environment **ATL Labs (accredited)**

- 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)**



Percent reduction compared to time zero

	Hour 0	Hour 2	Hour 6	Hour 24
Control	4.82E+06	2.30E+05	1.40E+04	1.90E+03
Test	-	1	1	1
% Reduction	-	99.999%	99.990%	99.900%

Test conducted in a controlled environment ATS Labs

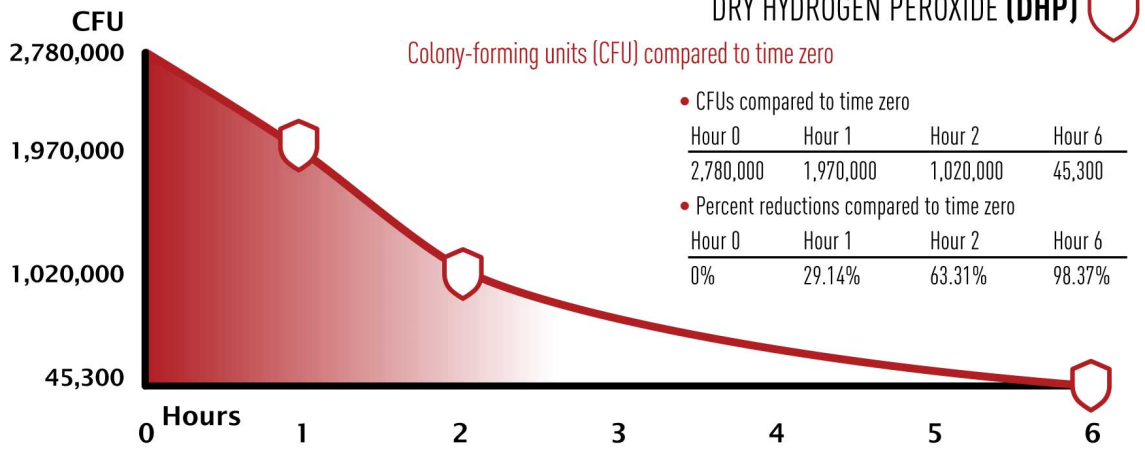
- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

171214

Enterococcus faecalis

DRY HYDROGEN PEROXIDE **(DHP)**

Colony-forming units (CFU) compared to time zero



- CFUs compared to time zero

Hour 0	Hour 1	Hour 2	Hour 6
2,780,000	1,970,000	1,020,000	45,300

- Percent reductions compared to time zero

Hour 0	Hour 1	Hour 2	Hour 6
0%	29.14%	63.31%	98.37%

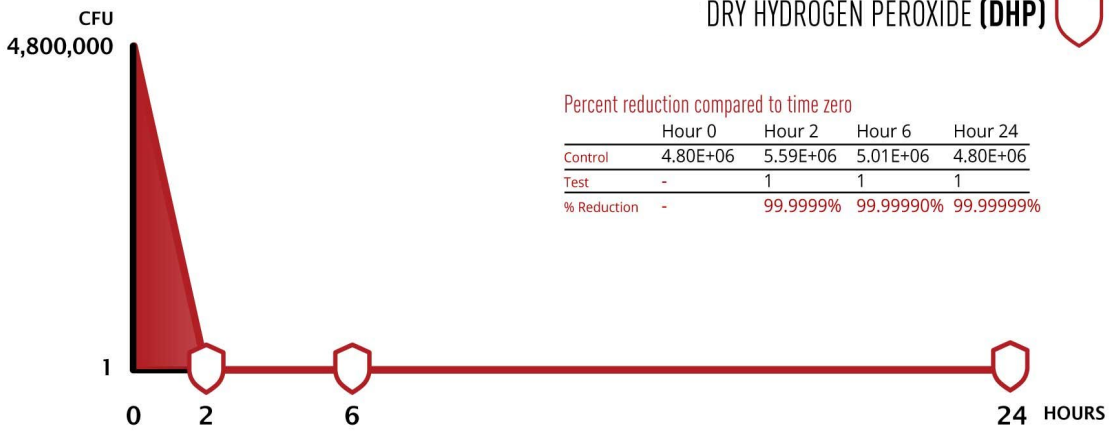
Test conducted in a controlled environment **Microchem (accredited)**

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

MRSA

Methicillin-resistant *Staphylococcus aureus* (MRSA)

DRY HYDROGEN PEROXIDE **(DHP)**



Percent reduction compared to time zero

	Hour 0	Hour 2	Hour 6	Hour 24
Control	4.80E+06	5.59E+06	5.01E+06	4.80E+06
Test	-	1	1	1
% Reduction	-	99.9999%	99.99990%	99.99999%

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.

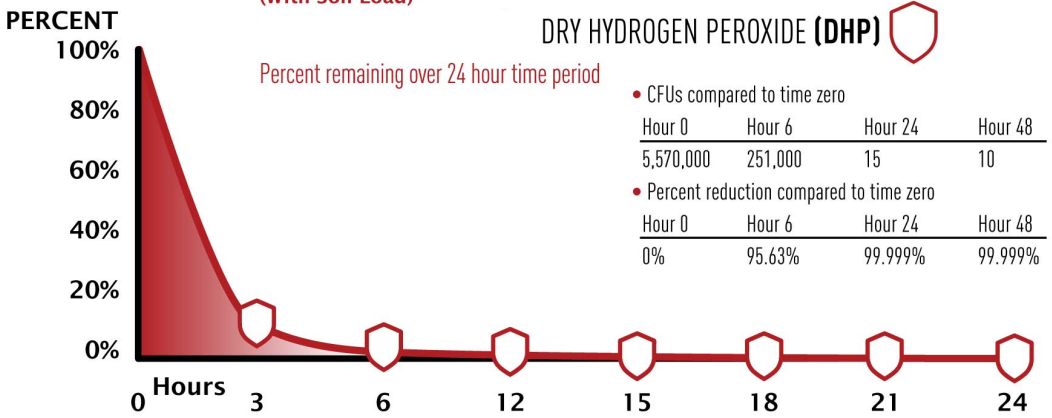
171214

Methicillin-resistant *Staphylococcus aureus* (MRSA)

(With Soil Load)

DRY HYDROGEN PEROXIDE **(DHP)**

Percent remaining over 24 hour time period



- CFUs compared to time zero

Hour 0	Hour 6	Hour 24	Hour 48
5,570,000	251,000	15	10

- Percent reduction compared to time zero

Hour 0	Hour 6	Hour 24	Hour 48
0%	95.63%	99.999%	99.999%

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

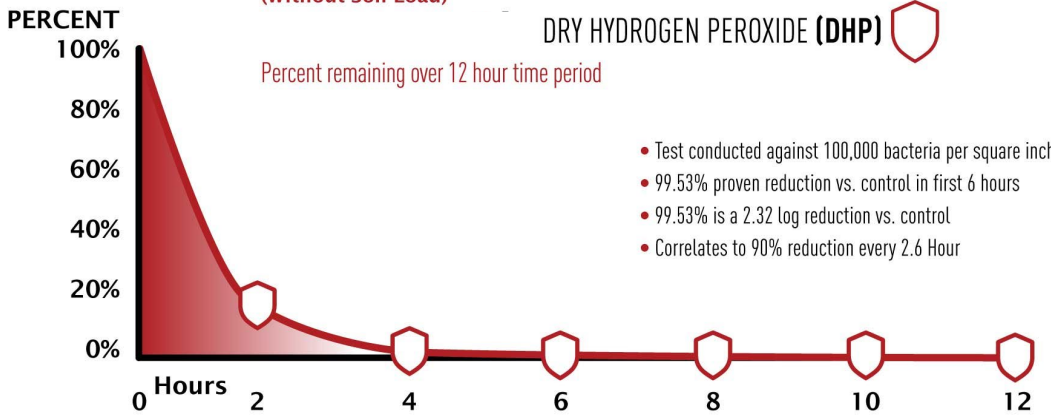
- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

Methicillin-resistant *Staphylococcus aureus* (MRSA)

(Without Soil Load)

DRY HYDROGEN PEROXIDE **(DHP)**

Percent remaining over 12 hour time period



- Test conducted against 100,000 bacteria per square inch
- 99.53% proven reduction vs. control in first 6 hours
- 99.53% is a 2.32 log reduction vs. control
- Correlates to 90% reduction every 2.6 Hour

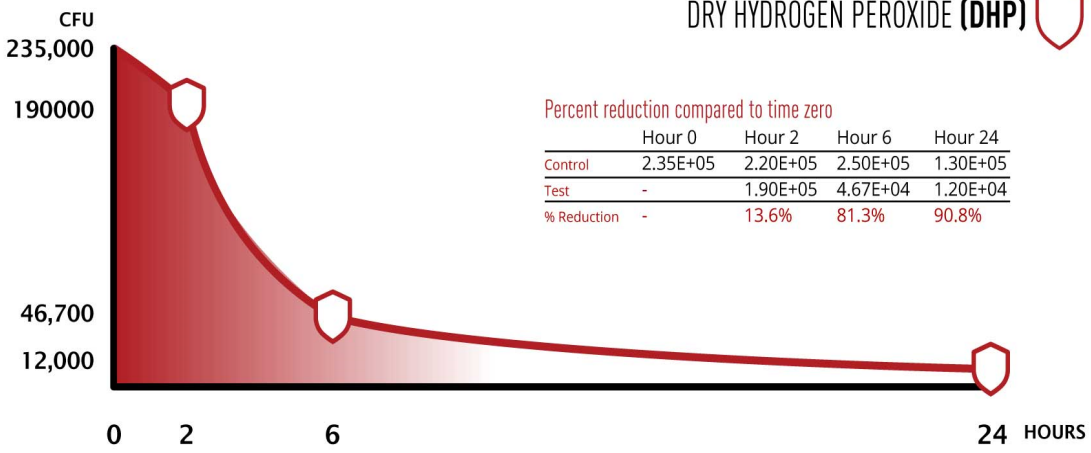
Test conducted in a controlled environment **ATL Labs (accredited)**

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

Aspergillus niger (A. niger)

Vegetative *Aspergillus niger* (*A. niger*)

DRY HYDROGEN PEROXIDE **(DHP)**



Percent reduction compared to time zero

	Hour 0	Hour 2	Hour 6	Hour 24
Control	2.35E+05	2.20E+05	2.50E+05	1.30E+05
Test	-	1.90E+05	4.67E+04	1.20E+04
% Reduction	-	13.6%	81.3%	90.8%

Test conducted in a controlled environment ATS Labs

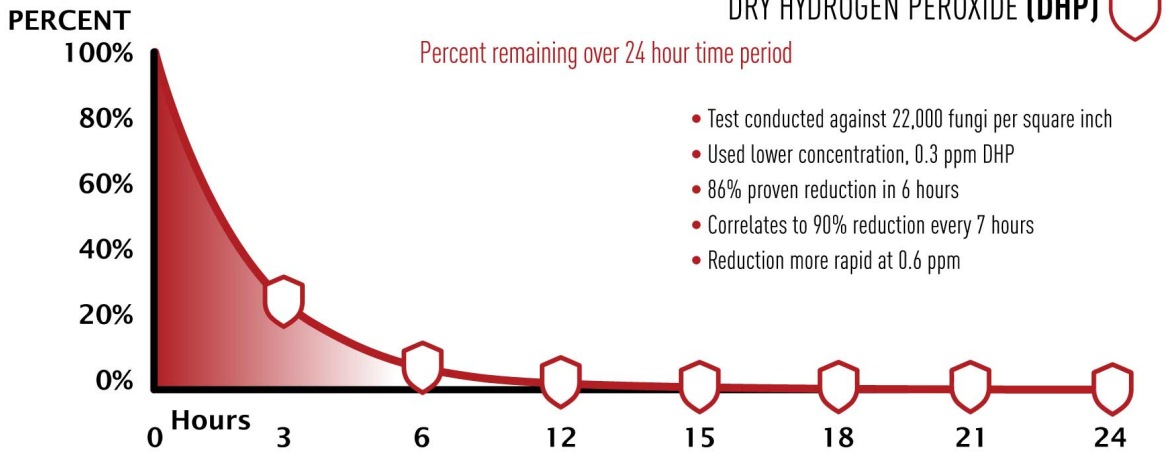
- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce contamination reservoirs missed by other methods.

171214

Vegetative *Aspergillus niger* (*A. niger*)

DRY HYDROGEN PEROXIDE **(DHP)**

Percent remaining over 24 hour time period



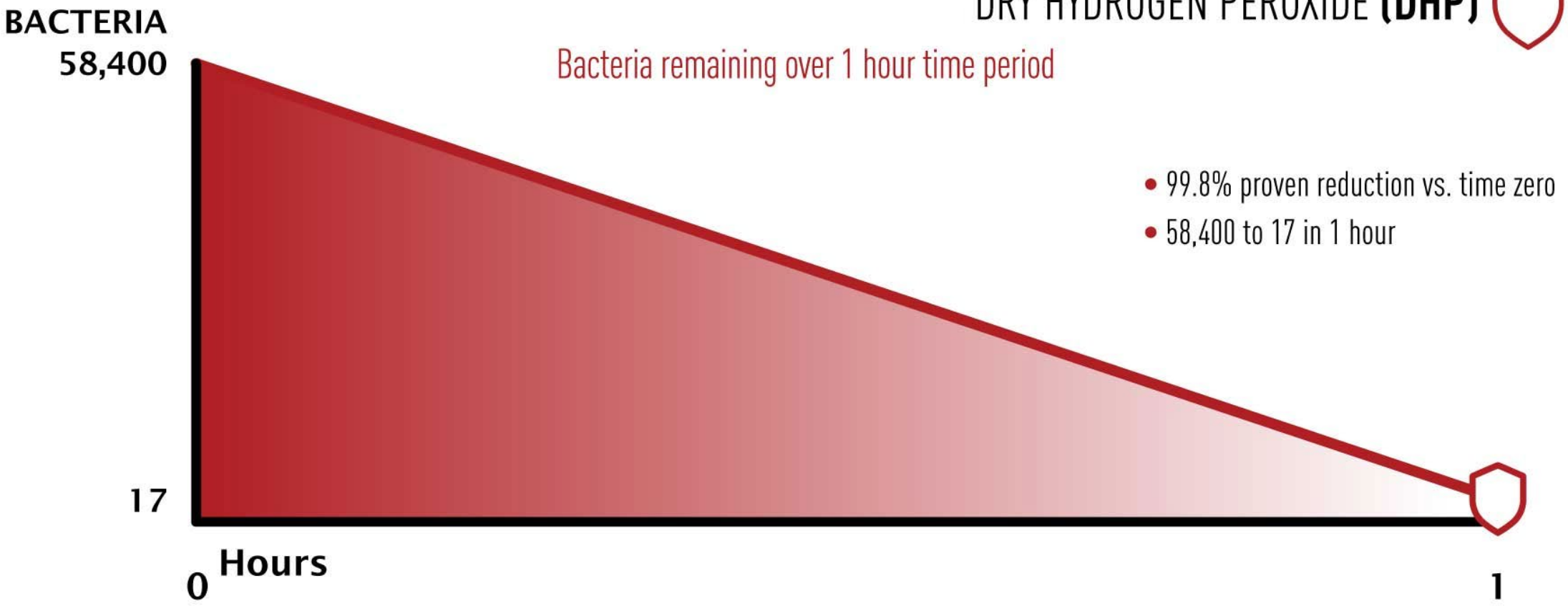
- Test conducted against 22,000 fungi per square inch
- Used lower concentration, 0.3 ppm DHP
- 86% proven reduction in 6 hours
- Correlates to 90% reduction every 7 hours
- Reduction more rapid at 0.6 ppm

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)**



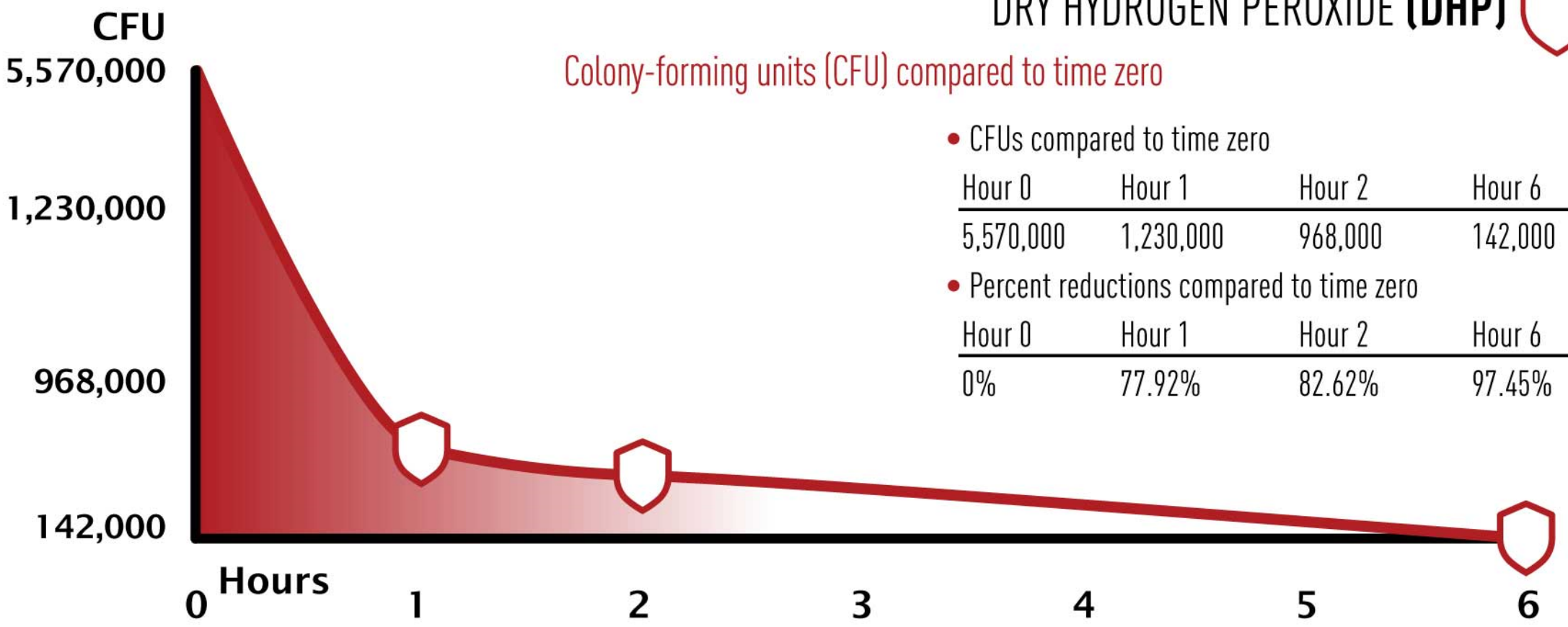
Test conducted in a controlled environment **Microchem (accredited)**

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

Escherichia coli bacteriophage MS2

DRY HYDROGEN PEROXIDE **(DHP)**

Colony-forming units (CFU) compared to time zero



- CFUs compared to time zero

Hour 0	Hour 1	Hour 2	Hour 6
5,570,000	1,230,000	968,000	142,000

- Percent reductions compared to time zero

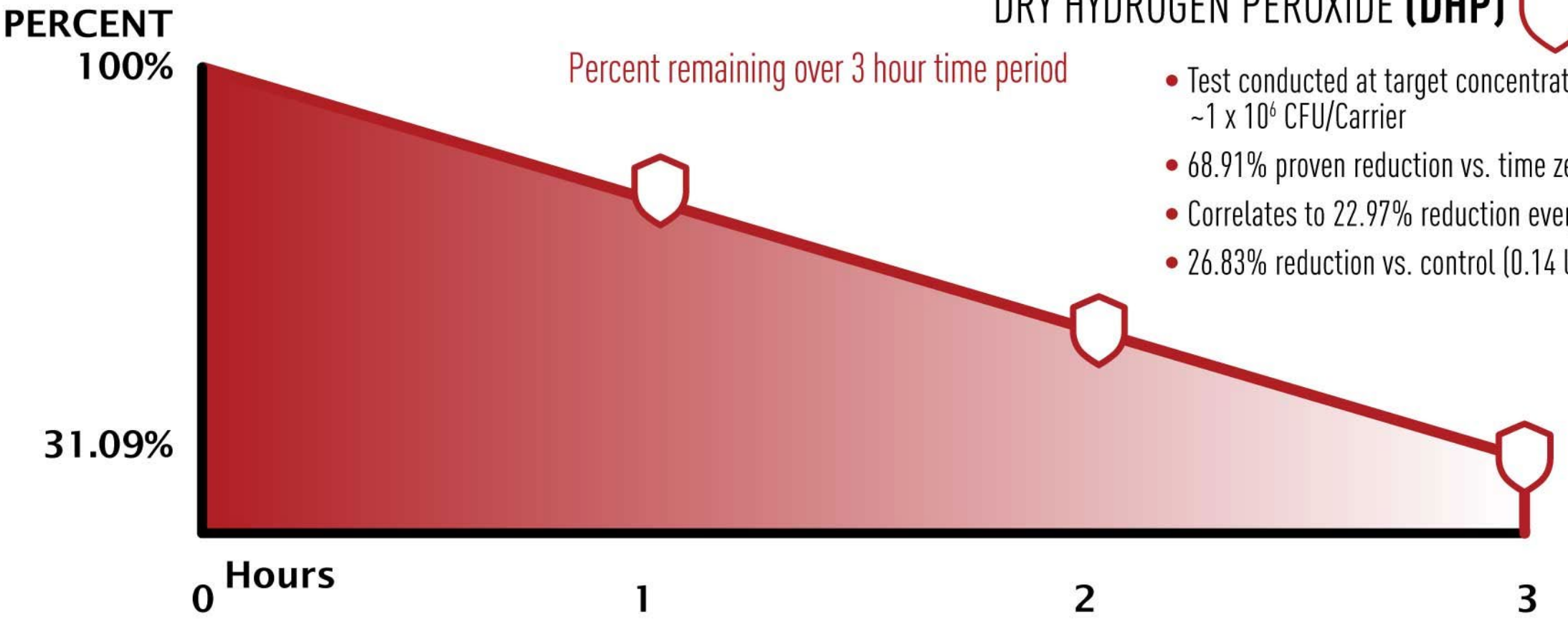
Hour 0	Hour 1	Hour 2	Hour 6
0%	77.92%	82.62%	97.45%

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.

Escherichia coli (Migula)

DRY HYDROGEN PEROXIDE **(DHP)**



- Test conducted at target concentration of ~1 x 10^6 CFU/Carrier
- 68.91% proven reduction vs. time zero
- Correlates to 22.97% reduction every hour
- 26.83% reduction vs. control (0.14 log)

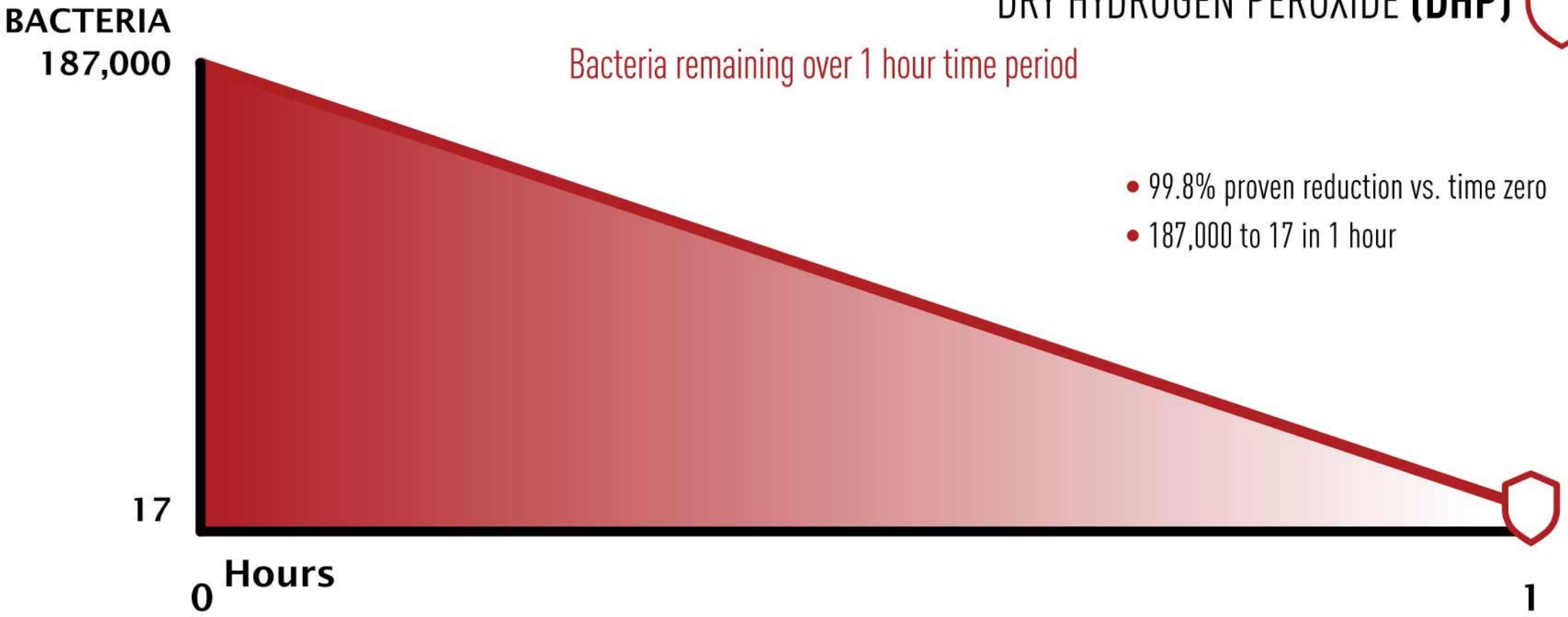
Test conducted in a controlled environment **Microchem (accredited)**

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

Airborne *Escherichia coli*

DRY HYDROGEN PEROXIDE **(DHP)**

Bacteria remaining over 1 hour time period



- 99.8% proven reduction vs. time zero
- 187,000 to 17 in 1 hour

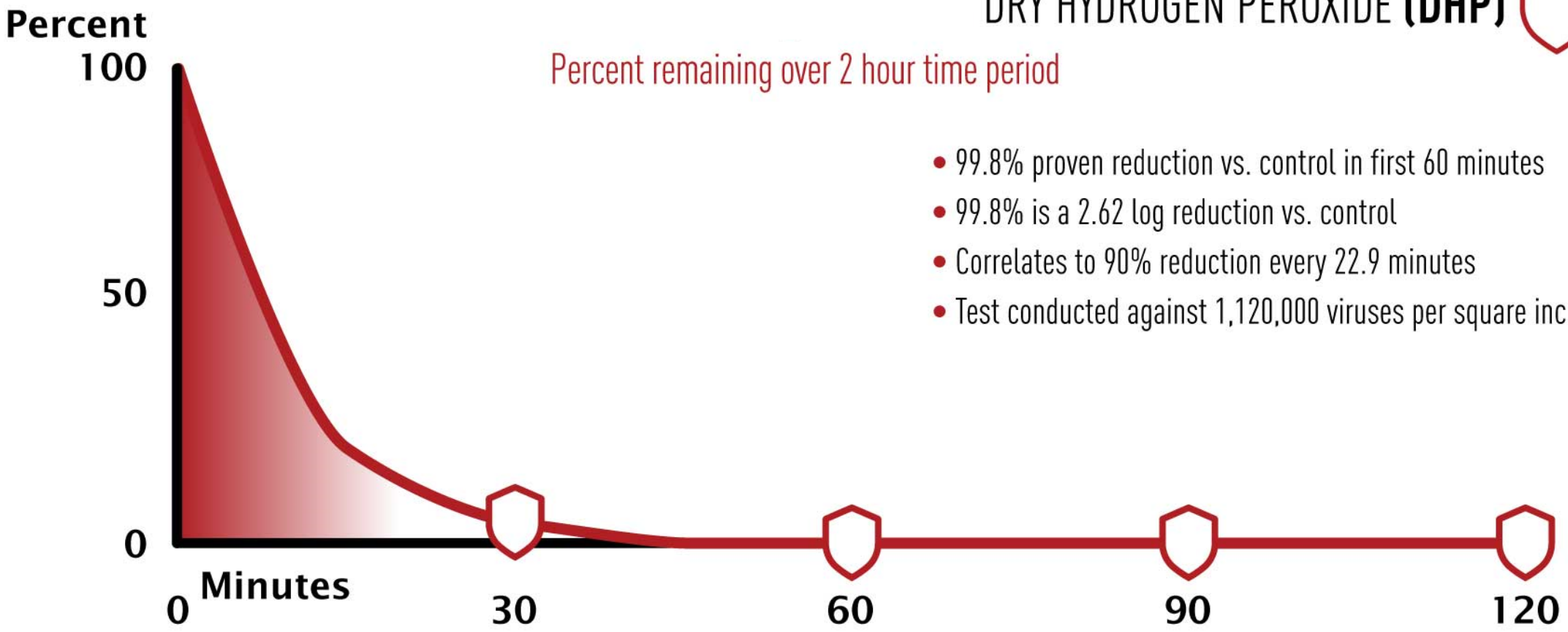
Test conducted in a controlled environment **Microchem (accredited)**

- 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)**

Percent remaining over 2 hour time period



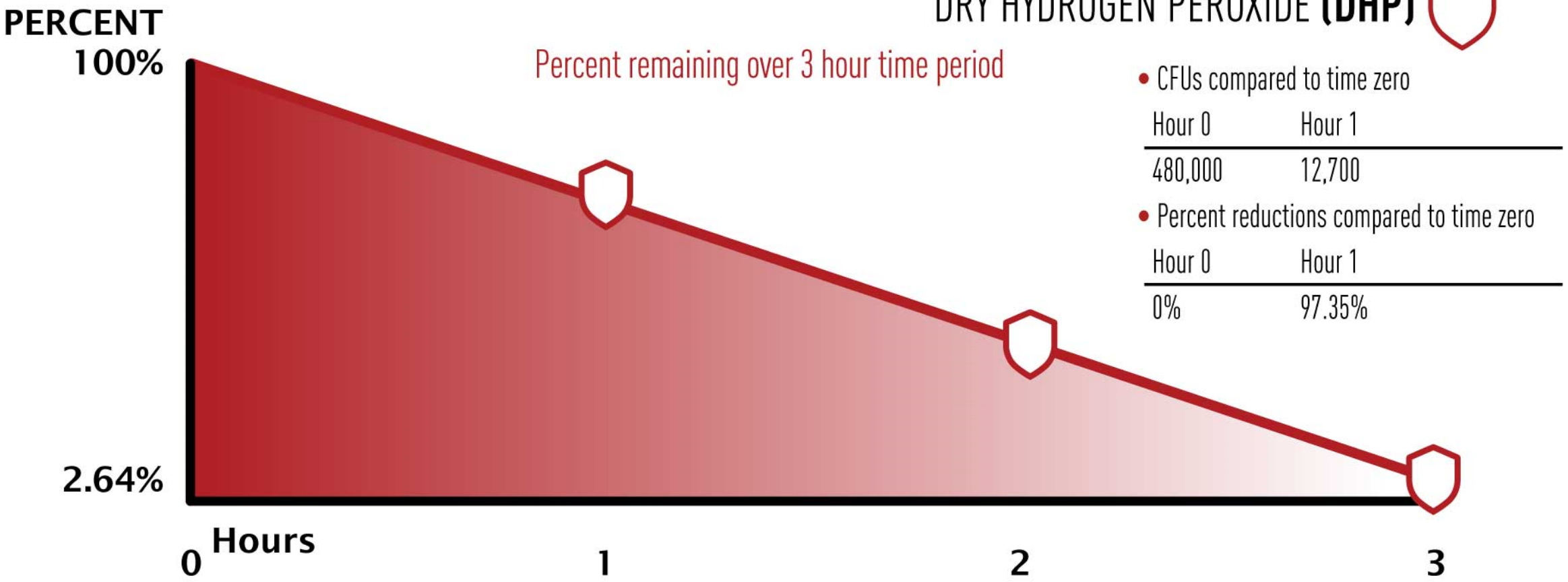
- 99.8% proven reduction vs. control in first 60 minutes
- 99.8% is a 2.62 log reduction vs. control
- Correlates to 90% reduction every 22.9 minutes
- Test conducted against 1,120,000 viruses per square inch

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.

Listeria monocytogenes

DRY HYDROGEN PEROXIDE **(DHP)**



- CFUs compared to time zero

Hour 0	Hour 1
480,000	12,700

- Percent reductions compared to time zero

Hour 0	Hour 1
0%	97.35%

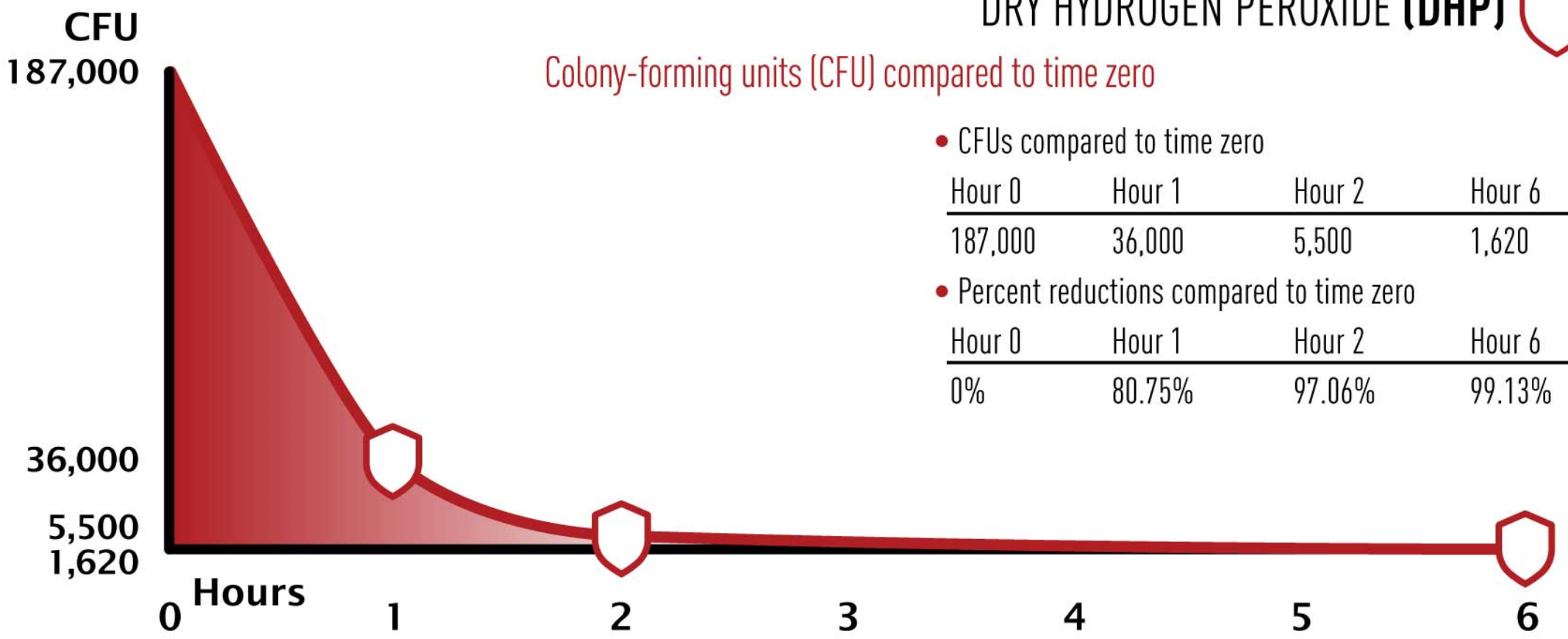
Test conducted in a controlled environment **Microchem (accredited)**

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

Salmonella Enteritidis

DRY HYDROGEN PEROXIDE **(DHP)**

Colony-forming units (CFU) compared to time zero



- CFUs compared to time zero

Hour 0	Hour 1	Hour 2	Hour 6
187,000	36,000	5,500	1,620

- Percent reductions compared to time zero

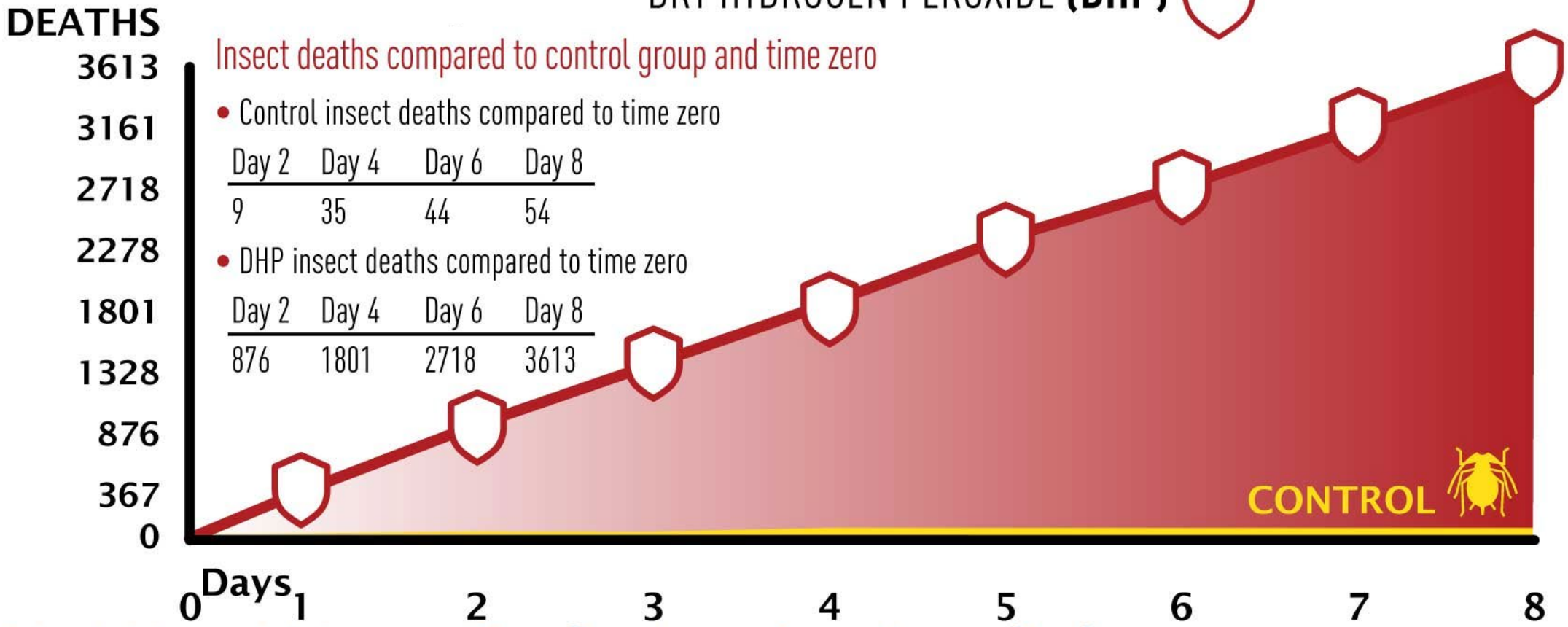
Hour 0	Hour 1	Hour 2	Hour 6
0%	80.75%	97.06%	99.13%

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.

Green Peach Aphids *(Myzus persicae)*

DRY HYDROGEN PEROXIDE **(DHP)**



Insect deaths compared to control group and time zero

- Control insect deaths compared to time zero

Day 2	Day 4	Day 6	Day 8
9	35	44	54

- DHP insect deaths compared to time zero

Day 2	Day 4	Day 6	Day 8
876	1801	2718	3613

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

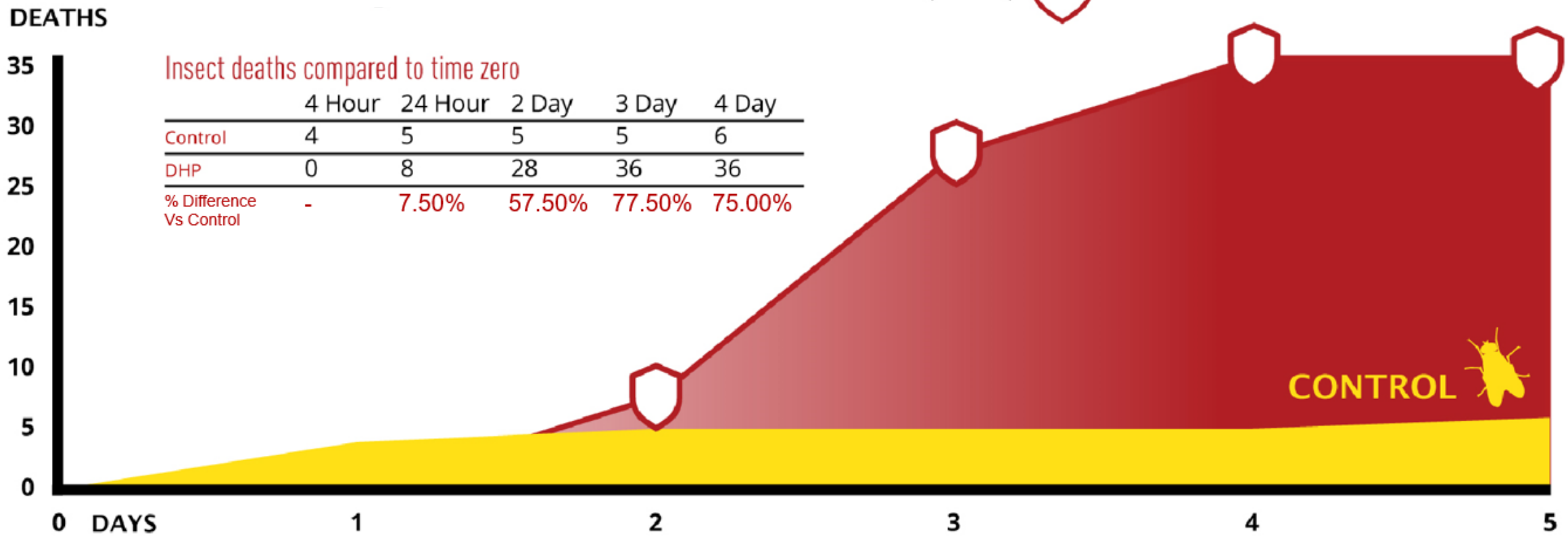
- Effects continue beyond study duration, 24/7/365
- Continuous operation provides the ability to reduce insect population missed by other methods.

House Fly Mortality

DRY HYDROGEN PEROXIDE **(DHP)**

Insect deaths compared to time zero

	4 Hour	24 Hour	2 Day	3 Day	4 Day
Control	4	5	5	5	6
DHP	0	8	28	36	36
% Difference Vs Control	-	7.50%	57.50%	77.50%	75.00%



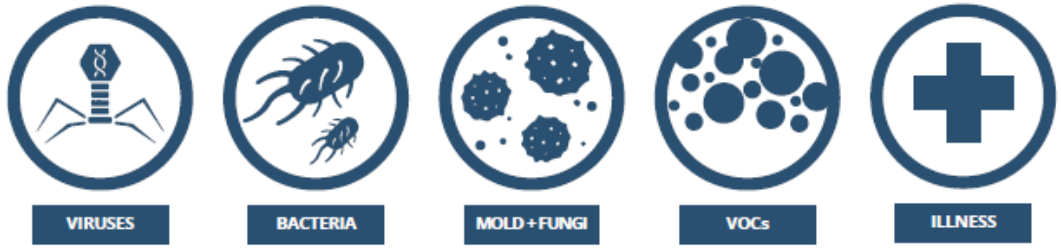
Test conducted in a controlled environment:

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

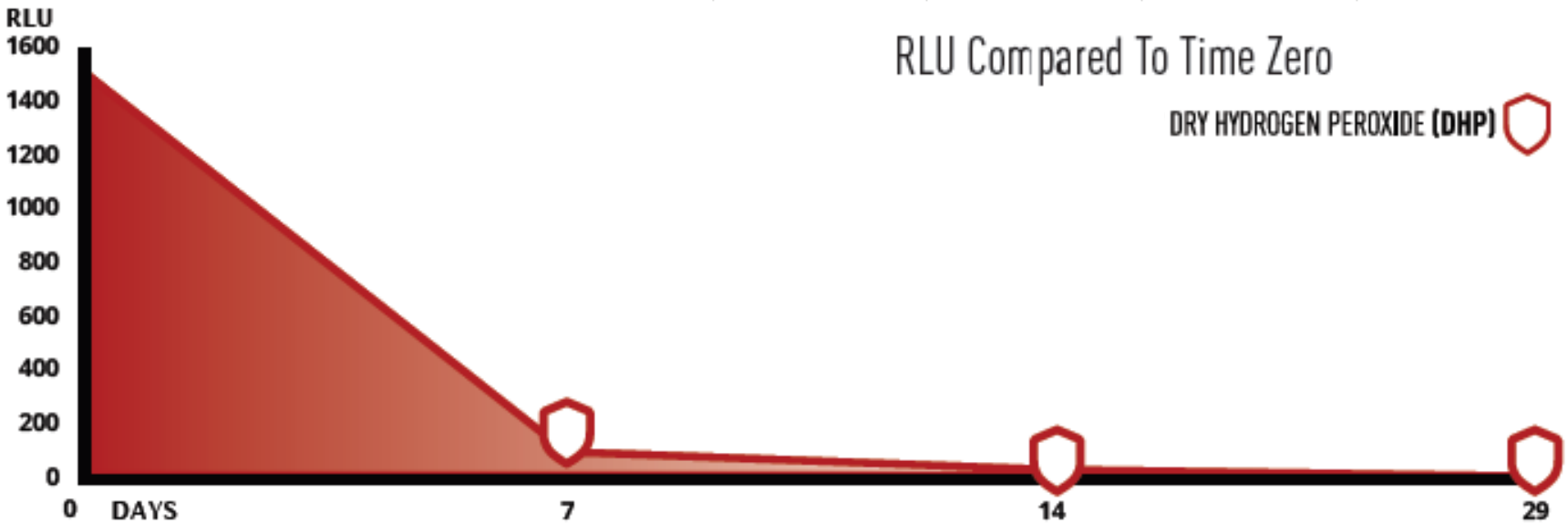
Client Examples

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%



Thank You