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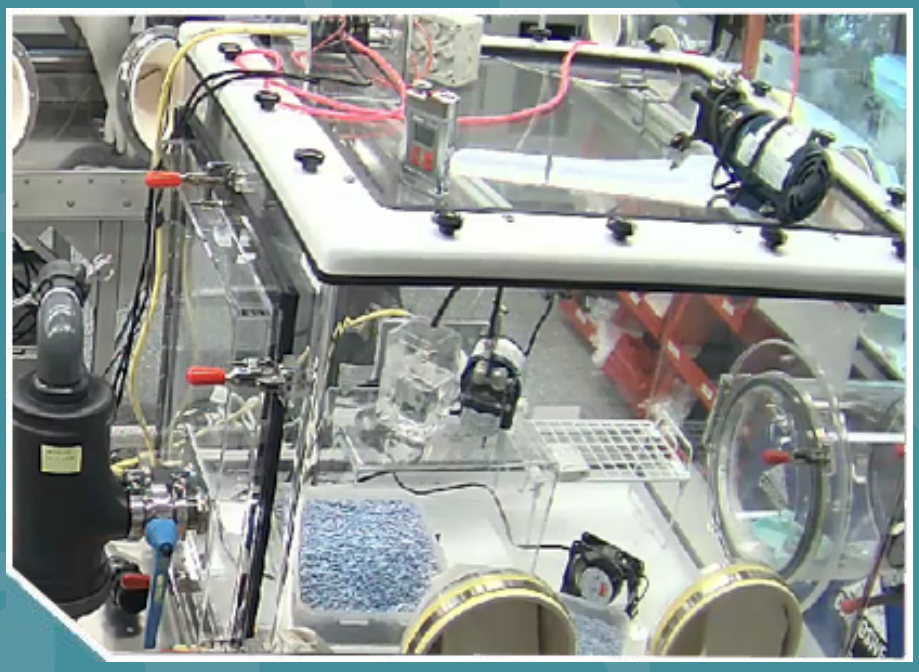
Decontamination of Materials Contaminated with Spores of *Bacillus anthracis* Ames and Vollum Strains Using Low Concentrations of Hydrogen Peroxide Vapor



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REPORT

Decontamination of Materials Contaminated with Spores of *Bacillus anthracis* Ames and Vollum Strains Using Low Concentrations of Hydrogen Peroxide Vapor

U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Disclaimer

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Executive Summary

The U.S. Environmental Protection Agency's (EPA's) Homeland Security Research Program (HSRP) is helping protect human health and the environment from adverse impacts resulting from the release of chemical, biological, or radiological agents. With an emphasis on decontamination and consequence management, water infrastructure protection, and threat and consequence assessment, the HSRP is working to develop technology and information that will help detect the intentional introduction of chemical, biological, or radiological contaminants in buildings or water systems; contain these contaminants; decontaminate buildings, water systems, other infrastructure and the outdoor environment; and facilitate the treatment and disposal of material resulting from restoration activities.

In the decontamination of buildings contaminated with *Bacillus anthracis* (*Ba*) spores using fumigation techniques, it may be challenging to reach the desired gas concentration without specialized equipment, modifications, or expertise. Thus, fumigating at relatively low levels may allow for contractors to provide decontamination services with less specialized equipment. This advantage may be critical to increasing the nation's decontamination capacity in the event of a wide area release of *Ba* spores.

In this study, the decontamination efficacy of low concentrations of hydrogen peroxide vapor (HPV) was evaluated on common building materials (glass, bare pine wood, carpet, painted wallboard paper, unpainted concrete, and ceiling tile) contaminated with *Ba* spores. All testing was conducted using both *Ba* Ames and Vollum strains concurrently to allow for direct comparison of the two strains. Decontamination efficacy was quantified based on the $\log_{10}$ reduction (LR) in viable spores, calculated from difference in spores recovered from positive controls and test materials.

Summary of Major Findings

Low concentrations (or levels) of HPV (e.g., 10-50 parts per million (ppm)) were effective in decontaminating all materials tested in the study except for unpainted concrete. Moreover, the glass, ceiling tile and painted wallboard paper materials were more amenable to decontamination by low concentrations of HPV compared to unpainted concrete, carpet, and wood. Even with using extended contact times (and hence higher dosages of HPV), the number of occurrences in which unpainted concrete, carpet, and wood were successfully decontaminated (complete inactivation of spore population or ≥6 log reduction) in the study was much less than the glass, ceiling tile, and painted wallboard materials. Although there were still several instances in which the carpet and wood materials were successfully decontaminated.

The results of the study may be summarized in terms of the minimum contact times needed to achieve effective decontamination of each material, for each experimental condition; refer to Tables ES-1 and ES-2. Contact times needed for effective decontamination generally decreased with increased HPV concentration. For example, at the higher concentration of 222 ppm (Test 1), only 15 minutes were required to decontaminate glass effectively; in contrast, at the 10-ppm level, 4-12 hours were required for effective decontamination of glass, depending on the strain and relative humidity (RH) level. With the Vollum strain of *Ba* on glass, ceiling tile, and painted wallboard paper, successful decontamination occurred in 2-16 hours for the 10-50 ppm HPV concentrations evaluated. In some experiments, however, effective decontamination may not have occurred for a material.

In terms of the HPV dosage requirements to achieve effective decontamination, again the results varied by material. For example, no more than 100-200 ppm*hours were required for effective decontamination in most of the tests for glass, painted wallboard, and ceiling tile. In some tests, the wood and carpet materials were successfully decontaminated with doses as low as 120-200 ppm*hours. However, there were a few tests in which successful decontamination was not achieved for wood and carpet when using the highest dose of 1200 ppm*hours.

While elevated RH has been shown to improve *Ba* spore inactivation with nearly all sporicidal fumigants, some debate still exists whether elevated RH is needed for HPV decontamination. From the statistical analysis of the study results, when assessed as a main effect, the RH level appeared to be a non-significant factor. However, when comparing the effect of RH by strain, significant differences were observed and varied by material type. As an example, for a given HPV concentration and strain, we found that the number of occurrences of successful decontamination always increased with increasing RH. In addition, the effect of increasing RH appears to have had more of an impact on the Ames strain.

Lastly, the data generated from this evaluation suggest that the resistance to inactivation by HPV is not significantly different for the two *Ba* strains that were used in the investigation.

Table ES-1. Minimum Time (Hours) Demonstrating Effective Decontamination for Ames Strain

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 9	Test 6	Test 7	Test 8
Average HPV ppm	222	9-10		25-26			44-50		
average % RH	38	58	76	33	62	92	26	60	77
	Time (hours)								
Glass	0.25	12	8	8	4	6	6	1	2
PW* Paper	0.5	>20	8	>12	>12	2	>12	1	2
Ceiling Tile	2	12	8	>12	4	6	2	4	4
Pine Wood	3	12	>20	>24	>24	>48	>24	16	24
Carpet	0.25	>20	>20	>24	16	20	>24	20	8
Concrete	>3	>20	>20	>24	>24	>48	>24	>24	>24

*Painted wallboard.

A ">" denotes that effective decontamination was not achieved at any time point, with the longest contact time listed

Table ES-2. Minimum Time (Hours) Demonstrating Effective Decontamination for Vollum Strain

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 9	Test 6	Test 7	Test 8
Average HPV ppm	222	9-10		25-26			44-50		
average % RH	38	58	76	33	62	92	26	60	77
	Time (hours)								
Glass	0.25	8	4	8	4	2	4	4	2
PW Paper	1	16	8	6	4	6	6	4	4
Ceiling Tile	1	8	8	8	6	6	2	4	4
Pine Wood	2	>20	>20	>24	>24	>48	24	16	24
Carpet	>3	>20	20	>24	24	20	24	20	12
Concrete	>3	>20	>20	>24	>24	>48	>24	>24	>24

A ">" denotes that effective decontamination was not achieved at any time point, with the longest contact time listed

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Abbreviations/Acronyms

ASTM	American Society of Testing and Materials
Ba	*Bacillus anthracis* Ames or Vollum
BBRC	Battelle Biomedical Research Center
BSC	biological safety cabinet
CFU	colony forming unit(s)
CI	confidence interval
cm	centimeter(s)
°C	degree(s) Celsius
DNA	Deoxyribonucleic Acid
DF	degrees of freedom
E-beam	electron beam
EPA	U.S. Environmental Protection Agency
H_2O_2	hydrogen peroxide
HPV	hydrogen peroxide vapor
h	Hour
HCl	Hydrochloric acid
HSRP	Homeland Security Research Program
HVAC	heating, ventilation, and air conditioning
kGy	kilogray(s)
LAL	Limulus Amebocyte Lysate
LR	Log_{10} reduction
PE	performance evaluation
PW	painted wallboard
µg	microgram(s)
µL	microliter(s)
mg	milligram(s)
mL	milliliter(s)
mil	thousandth of an inch
min	minute(s)
mm	millimeter(s)
µm	micrometer(s)
L	liter
NA	not applicable
NHSRC	National Homeland Security Research Center
ORD	Office of Research and Development
PBS	phosphate buffered saline
PBST	PBS + 0.1% Triton X-100
PCR	polymerase chain reaction
ppm	part(s) per million
QA	quality assurance

QAPP	Quality Assurance Project Plan
QC	quality control
QMP	Quality Management Plan
RH	relative humidity
rpm	revolution(s) per minute
s	second(s)
SD	standard deviation
SE	standard error
SFW	sterile filtered water (cell-culture grade)
TSA	technical systems audit

1.0 Introduction

The U.S. Environmental Protection Agency's (EPA's) Homeland Security Research Program (HSRP) is helping protect human health and the environment from adverse impacts resulting from the release of chemical, biological, or radiological agents. With an emphasis on decontamination and consequence management, water infrastructure protection, and threat and consequence assessment, the HSRP is working to develop technology and information that will help detect and contain these contaminants; decontaminate buildings, water systems, or other infrastructure and outdoor environments; and facilitate the disposal of material resulting from said restoration activities.

In the decontamination of buildings contaminated with *Bacillus anthracis* (*Ba*) spores using fumigation techniques, it may be challenging to reach the desired gas concentration, temperature, or relative humidity (RH) targets without special equipment, modifications, and/or expertise. Thus, fumigating at or near ambient temperatures and RH levels, and the use of lower fumigant concentrations (or levels), may allow for less experienced personnel to provide decontamination services and with less specialized equipment. This advantage may be critical in increasing decontamination capacity in the event of a large release of *Ba* spores.

In this investigation, the decontamination efficacy of hydrogen peroxide vapor (HPV) was evaluated using common building materials: glass, bare pine wood, carpet, painted wallboard paper, unpainted concrete, and ceiling tile. While the first experiment in the study was conducted at a more typical HPV concentration (250 parts per million [ppm]) to allow for some comparison to previous literature (Rogers et al. 2005; Rastogi et al. 2009; US EPA 2010; US EPA 2011), the remainder of the nine experiments utilized relatively low concentrations of HPV (10-50 ppm). The present study builds on previous research (Wood et al. 2016) that initially demonstrated low concentrations of HPV were effective for *Ba* spore inactivation, with the present study focusing on the additional experimental elements described below.

Testing was conducted with spores of *Ba*, using both Ames and Vollum strains. All testing was conducted with both strains concurrently (inoculated separately on coupon materials, however) to allow for direct comparison. While there is a large body of research and data for the decontamination of materials contaminated with the Ames strain, few efficacy data are available for the Vollum strain. One of the objectives of this study was to fill that data gap and assess the importance of strain variation.

In addition to HPV concentration, building material type, and *Ba* spore strain, other test variables that were examined as part of this study included contact time and RH. Each experiment consisted of exposing inoculated coupons to a constant HPV concentration, with coupons withdrawn from the test chamber at five pre-determined time points. Having five contact times in each experiment allowed for determining the minimum contact time needed for effective decontamination for a given HPV concentration and RH level. In addition, as testing proceeded, it became clear that the glass, painted wallboard, and ceiling tile materials were being effectively decontaminated at shorter contact times compared to the unpainted concrete, wood, and carpet materials. Because of this difference, beginning with the fourth experiment, we segregated these materials into two groups, with each group having its own set of five contact times.

Further, while elevated RH has been shown to improve *Ba* spore inactivation with nearly all sporicidal fumigants, some debate still exists whether elevated RH is needed for HPV

decontamination. Thus, another objective of this study was to evaluate the effect of different RH levels on HPV decontamination efficacy.

Decontamination efficacy was determined based on the $\log_{10}$ reduction (LR) in viable spores recovered from the inoculated samples, with and without exposure to HPV. A decontaminant or fumigant technology is effective via AOAC 966.04 if a 6 LR or greater is achieved on the materials tested for a given set of fumigation conditions (fumigant concentration, temperature, contact time, and RH (US EPA, 2010).

2.0 Procedures

This section provides an overview of the procedures used for the bench-scale evaluation of low concentration HPV to inactivate *Ba* Ames and Vollum on six material types.

2.1 Test Matrix

The test matrix for the decontamination tests is shown in Table 2-1. Each test was performed using six material types inoculated with *Ba* Ames and another set of the same six material types inoculated with *Ba* Vollum. Testing was conducted at ambient temperature and low (26-38%) medium (59-62%), or high (76-92%) average RH levels. Note in each the first three tests, all materials shared the same contact times. After that, the materials that were harder to decontaminate (wood, carpet, unpainted concrete) were exposed to longer contact times. (Specifically, one of the aims was to see if we could achieve effective decontamination for unpainted concrete by extending the contact time.) Lastly, various equipment was used to generate the HPV; this is further discussed in Section 2.5.

The first test was meant to be conducted at a vendor's EPA antimicrobial label requirements for use as a sterilant for both porous and nonporous materials (US EPA, 2012), to tie back to previous testing. Following Test 1, all tests thereafter used a target HPV concentration of either 10, 25, or 50 ppm, paired with different RH levels.

Table 2-1 Decontamination Test Matrix

Test Number	Equipment	Target HPV Level (ppm)	Temp (°C)	RH	Easy[1] Material Contact Times (h)	Difficult[2] Material Contact Times (h)	Materials
1	Generator	250	23	Low	0.25,0.50,1,2,3		Glass, Painted Wallboard Paper, Ceiling Tile, Pine Wood, Carpet, Unpainted Concrete
2	Bubbler	10	23	Medium	4, 8, 12, 16, 20		
3	Bubbler	10	23	High	4, 8, 12, 16, 20		
4	Generator	25	23	Low	2,4,6,8,12	8,12,16,20,24	
5	Generator	25	23	Medium	2,4,6,8,12	8,12,16,20,24	
6	Generator	50	23	Low	2,4,6,8,12	8,12,16,20,24	
7	Generator	50	23	Medium	1,2,4,5,6	8,12,16,20,24	
8	Generator	50	23	High	1,2,4,5,6	8,12,16,20,24	
9	Bubbler	25	23	High	1,2,6,8,12	8,12,20,24, 48	

[1] Glass, Painted Wallboard Paper and Ceiling Tile

[2] Pine Wood, Carpet, Unpainted Concrete

2.2 Biological Agents

The virulent *Ba* Ames (Ames-Lot B21) and Vollum (Vollum-Lot BAV-1) spores used for this testing were prepared from qualified stocks at the Battelle Biomedical Research Center (BBRC, , West Jefferson, OH) using a BioFlo 3000 fermenter (New Brunswick Scientific Co., Inc., Edison, NJ). The spore lot was subjected to a stringent characterization and qualification process required by the Battelle standard operating procedure for spore production. Specifically, the spore lots were characterized prior to use by observation of colony morphology, direct microscopic observation of spore morphology, and size and determination of percent refractivity and percent encapsulation. In addition, the number of viable spores was determined by colony count and expressed as colony forming units per milliliter (CFU/mL). Theoretically, once plated onto bacterial growth media, each viable spore germinates and can yield one CFU. Variations in the expected colony phenotypes were recorded. Endotoxin concentration of each spore preparation was determined by the Limulus Amebocyte Lysate (LAL) assay to assess whether contamination from gram-negative bacteria occurred during the propagation and purification process of the spores. Genomic deoxyribonucleic acid (DNA) was extracted from the spores and DNA fingerprinting by polymerase chain reaction (PCR) was done to confirm the genotype. This work was confirmed by an independent third party. The virulence of the original spore lot was measured by challenging guinea pigs intradermally with a dilution series of spore suspensions, and virulence was expressed as the intradermal median lethal dose. In addition, testing of the original spore lot was conducted for robustness of the Ames strain spores via hydrochloric acid (HCl) resistance.

The *Ba* Ames and Vollum stock spore suspensions were prepared in sterile filtered water (SFW) at an approximate concentration of 1×10^9 CFU/mL and stored at 2 to 8 degrees Celsius (°C). This suspension medium was chosen to be consistent with previous work conducted with the U.S. EPA.

2.3 Test Materials

Decontamination testing was conducted using common building materials (glass, bare pine wood, carpet, painted wallboard paper, unpainted concrete, and ceiling tile). Information on these materials is presented in Table 2-2, and a picture of each is presented in Figure 2-1. Material coupons were cut to uniform length and width (Table 2-2) from larger pieces of stock material. Materials were prepared for testing by either sterilization via electron beam (E-beam) irradiation at ~200 kilograys (kGy; E-beam Services Inc., Lebanon, OH) or autoclaved at 121 °C for 15 minutes (min). E-beam-irradiated material coupons were sealed in 6 mil (0.006 inch) Uline Poly Tubing (Cat. No. S-2940, Uline, Chicago, IL), and autoclaved coupons were sealed in sterilization pouches (Cat. No. 01-812-50, Fisher, Pittsburgh, PA) to preserve sterility until the coupons were ready for use. Sterilization was intended to eliminate contamination by endogenous microorganisms.

Figure 2-1. Coupon Types from Left to Right: Glass, Painted Wallboard Paper, Ceiling Tile, Bare Pine Wood, Unpainted Concrete, and Carpet

Table 2-2. Test Materials

Material	Lot, Batch, or ASTM No., or Observation	Manufacturer/ Supplier Name Location	Approximate Coupon Size, Width x Length x Thickness	Sterilization Technique
Glass	C1036	Brooks Brothers, Columbus, OH	1.9 centimeters (cm) x 7.6 cm x 0.2 cm	Autoclave
Bare Pine Wood	Generic Molding	Commercial lumber retailer	1.9 cm x 3.8 cm x 0.2 cm	E-Beam
Carpet	Shaw Swizzle EcoWorx, Style: 10401 Color: Jacks	Shaw Industries, Dalton, GA	1.9 cm x 3.8 cm x 0.2 cm	E-Beam
Painted Wallboard Paper	Roller painted on one side using Martin Senour Paints. One primer (#71-1185) and two finish (flat, #70-1001) coats	United States Gypsum Company, Chicago, IL	1.9 cm x 3.8 cm x 0.2 cm	E-Beam
Unpainted Concrete	ASTM C90 cinder block	Wellnitz Columbus, OH	1.9 cm x 7.6 cm x 0.2 cm	E-Beam
Ceiling Tile	Armstrong® B513, classic fine textured	Armstrong, Columbus, OH	1.9 cm x 3.8 cm x 0.2 cm	E-Beam

2.4 Inoculation of Coupons

Test (exposed to HPV) and positive control (not exposed to HPV) coupons were placed on a flat surface within a Class II biological safety cabinet (BSC) and inoculated with approximately 1×10^8 CFU of viable *Ba* Ames or Vollum spores per coupon. A 100 microliter (µL) aliquot of a stock suspension of approximately 1×10^9 CFU/mL was dispensed using a micropipette applied as 10 µL droplets across the coupon surface (see Figure 2-2). This approach provided a more uniform distribution of spores across the coupon surface than would be obtained through a single drop of the suspension.

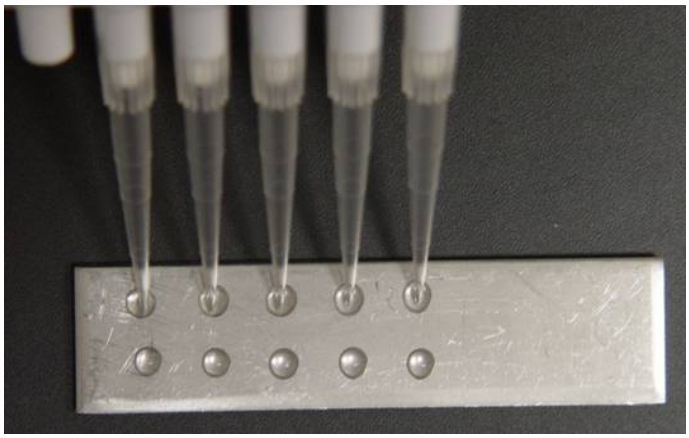

Figure 2-2. Liquid Inoculation of Coupon Using a Micropipette

Although application of the inoculum onto each material was uniform, the behavior of the inoculum droplets was not. Droplets beaded on the surface of the glass (nonporous material) while they soaked into the other porous materials after producing a liquid bead for a short period of time. The difference in the behavior of the inoculum droplets on each material could lead to a variance in microorganism distribution across coupons; however, this effect was not studied in this evaluation. After inoculation, the coupons were transferred to a Class III BSC and left undisturbed overnight to dry under ambient conditions, approximately 22 °C and 40% RH.

The number and type of replicate test coupons and positive controls used for each experiment, for each material and *Ba* strain is as follows:

- Three test coupons per material, timepoint, and strain
- Five positive controls for each material and strain (inoculated with *Ba* but not exposed to HPV)
- One laboratory blank (not inoculated and not exposed to HPV) for each material
- One procedural blank (not inoculated and exposed to HPV) for each material.

On the day following inoculation, coupons intended for decontamination (including blanks) were transferred into the test chamber and exposed to the HPV using the apparatus and application conditions specified in Section 2.5. Control coupons remained in the BSC III chamber where they were dried and collected for processing after the last contact time.

2.5 Test Chamber and Procedures

Decontamination testing was conducted inside a 498 liter (L) custom acrylic compact glove box (Plaslabs, Lansing, MI). The test chamber was outfitted with three low-speed mixing fans and two patch panels on the walls to allow for the required plumbing and electrical connections. All testing was conducted at ambient laboratory temperatures and was not controlled. Fixed humidity point salts or Drierite® were utilized to adjust RH prior to the initiation of an experiment. Temperature and RH inside the test chamber were measured using an MX1101 temperature and humidity data logger (Onset, Bourne, MA) and data were recorded every minute for the duration of the experiment. HPV concentration was measured using an ATI B12 2-wire gas transmitter (Analytical Technology, Inc., Collegeville, PA) and was connected to a CNI-822 process controller (Omega Engineering, Norwalk, CT) which allowed for automatic control of concentration within the test chamber, and data were recorded every minute during the experiment using the associated iLOG software. The test chamber was hard-ducted to the facility exhaust system, but during each test, valves on both the exhaust and supply were closed to create a sealed enclosure. Once the final contact time had concluded, the exhaust and supply valves were opened to allow for any residual fumigant to be removed.

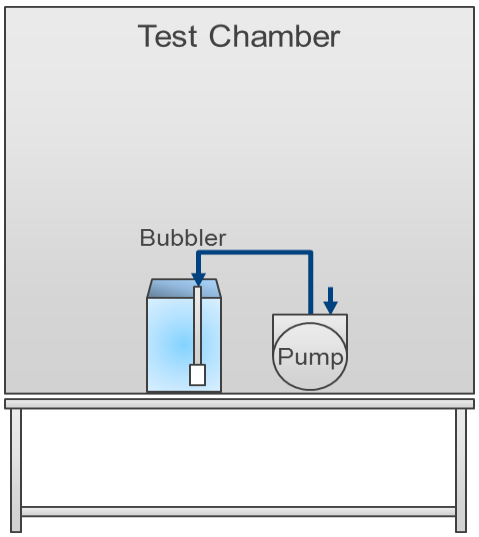

Figure 2-3. Bubbler Method

Generation of the HPV fumigant was achieved using either a bubbler method or with the use of a commercial generator, depending on the target concentration. A stock solution of 35% aqueous hydrogen peroxide (H_2O_2) Cat # HPV-AQ was used as the starting material for both methods (Bioquell, Horsham, PA). Figure 2-3 illustrates the bubbler method, which used a fritted impinger connected to a small air circulating pump. Test chamber air was circulated through the pump and supplied to the impinger which created bubbles when immersed into a 1 L bottle containing the H_2O_2 stock solution. This pump was controlled by the Omega CNI-822 using the ATI B12 ppm data. This method was used for fumigant concentrations up to 25 ppm. Higher concentrations were attempted using this method but resulted in excessive humidity and condensation on chamber walls, skewing the concentration data.

The commercial generator method utilized a STERIS 1000ED HPV generator (STERIS Corp., Mentor, OH). These types of commercial generators typically target much higher concentrations (e.g., 200-400 ppm) and use higher flow rates, resulting in the need for three separate configurations of the generator, test chamber, and a third class III BSC chamber, which were used to achieve lower targeted concentrations. These are discussed as follows. Figure 2-4 shows the generator configured in a daisy chain approach that allowed for increased chamber volume to be able to target concentrations at or above 200 ppm.

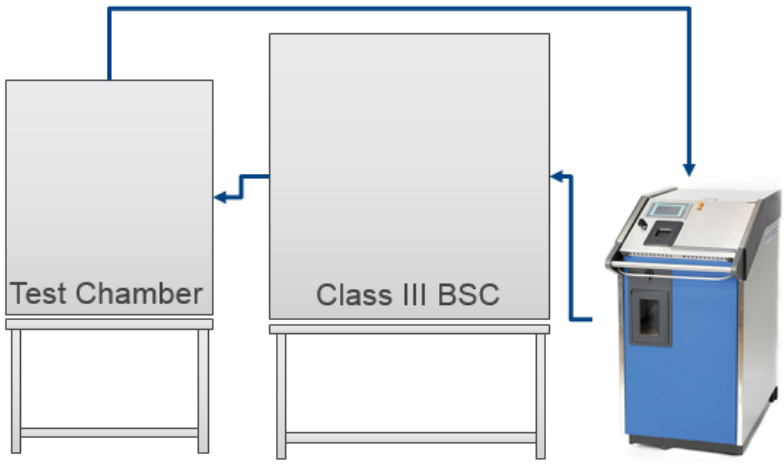

Figure 2-4. Generator Method, Configuration 1

Figure 2-5 shows the commercial generator, configuration 2, in which the generator was connected primarily to the class III BSC. A higher-than-target ppm was generated in this chamber. The test chamber used the Omega controller to turn the pump placed inside this BSC III on and off to draw HPV vapor from the primary BSC III chamber to the test chamber. This method allowed for concentrations ranging from 1 to 200 ppm and was used during testing for 25 and 50 ppm concentrations.

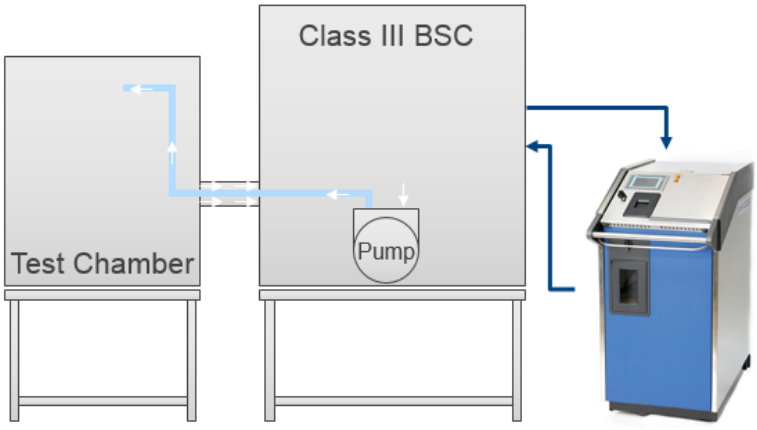

Figure 2-5. Generator Method, Configuration 2

A representative graph of the test chamber conditions (Test 7) data collection can be seen in Figure 2-6. The generator we used continually dries and catalytically breaks down the HPV atmosphere returning to the generator. This can be seen in the figure by the drying effect from approximately 79% RH down to the mid 50% range. Later in the run, as the desiccant within the

generator began to be saturated, the RH began to rise again. Test runs lasting longer than 24 hours were therefore run in a third configuration shown in Figure 2-7. In this approach, the HPV was supplied to the class III BSC but then it was exhausted through the facility heating, ventilation and air conditioning (HVAC) system. This approach allowed for laboratory air to be supplied to the STERIS generator so that the desiccant was not challenged by the high RH conditions.

The method for achieving the target RH varied by HPV generation method. As stated previously, the commercial generator continuously dried the returning atmosphere from the test chamber to avoid high humidity levels (which would potentially result in condensation on chamber walls). Test runs that utilized the commercial generator resulting in high RH levels required the use of saturated salts during the run to re-humidify the test chamber. The bubbler method increased RH whenever the pump was active. Tests using this method with low RH target levels utilized Drierite to pre-dehumidify the test chamber prior to initiation of testing. This pre-dehumidification step is also a standard procedure used by commercial generators. Tests were limited with this method in general to approximately 24 hours (h) before condensation would begin to form on the chamber walls. Once the condensation began to form, HPV concentrations decreased and caused the pump to run continuously.

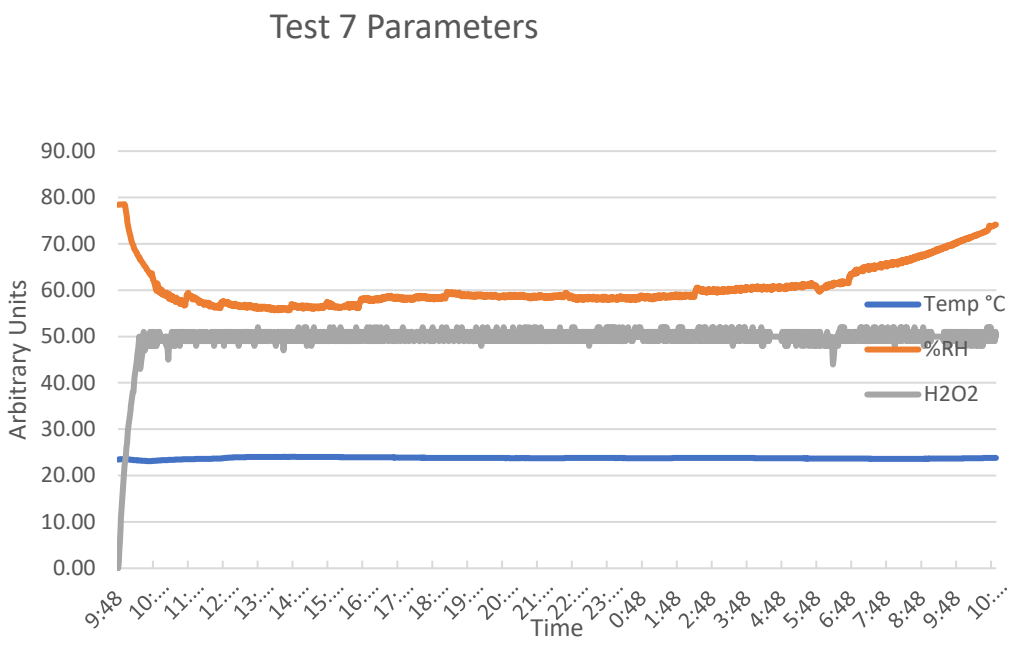

Figure 2-6. Representative Graph of Temperature, RH, and Fumigant Stability (Test 7)

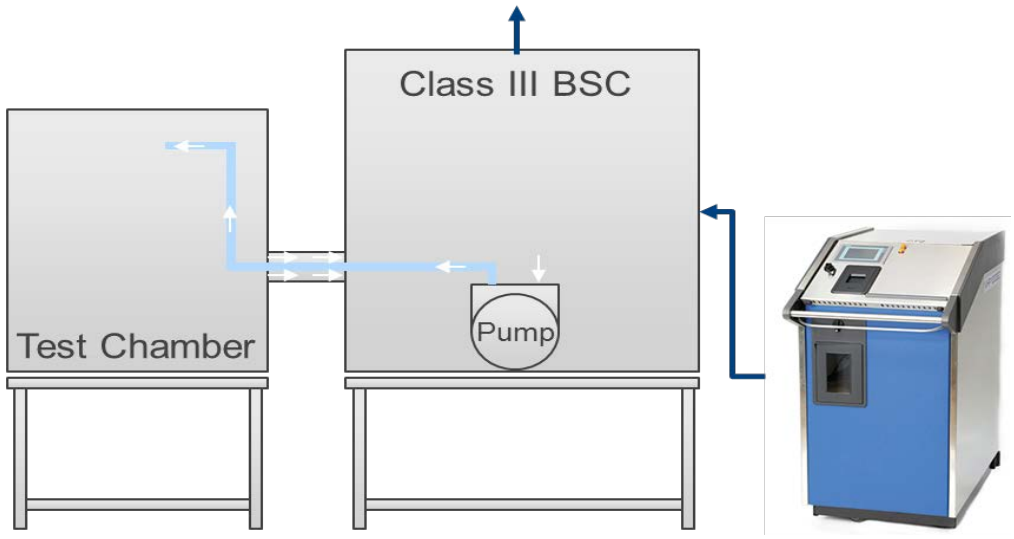

Figure 2-7. Generator Method, Configuration 3

2.6 Coupon Extraction and Biological Agent Quantification

Spore extraction from coupons was achieved by placing test, positive control, and blank coupons in 50 mL polypropylene conical tubes containing 10 mL of sterile phosphate buffered saline plus 0.1% Triton X-100 (PBST). The vials were capped, placed on their side and agitated on an orbital shaker for 15 min at approximately 200 revolutions per minute (rpm) at room temperature.

The number of residual viable spores was determined using a dilution plating approach. Following extraction, the extract was removed, and a series of tenfold dilutions was prepared in SFW. An aliquot (0.1 mL) of either the undiluted extract and/or each serial dilution was plated onto tryptic soy agar (TSA) in triplicate and incubated for 18 to 24 hours at 37 ± 2 ºC. Colonies were counted manually, and CFU/mL was determined by multiplying the average number of colonies per plate by the reciprocal of the dilution, for plates ranging between 25-250 CFU for diluted samples and 0-250 CFU for undiluted samples. Dilution data representing the greatest number of individually definable colonies were expressed as arithmetic mean ± standard deviation (SD) of the numbers of CFU observed. Laboratory blanks controlled for sterility and procedural blanks controlled for viable spores inadvertently introduced to test coupons. The target acceptance criterion for extracts of laboratory or procedural blanks was zero CFU.

After each decontamination test, the test and control chambers were thoroughly cleaned (using separate steps involving bleach, ethanol, water, then drying).

2.7 Decontamination Efficacy

The mean percent spore recovery from each coupon was calculated using results from positive control coupons (inoculated, not decontaminated), by means of the following equation:

$$\text{Mean \% Recovery} = [\text{Mean } CFU_{pc}/CFU_{spike}] \times 100 \quad (1)$$

where Mean CFU_{pc} is the mean number of CFU recovered from five replicate positive control coupons of a single material, and CFU_{spike} is the number of CFU spiked onto each of those coupons. The value of CFU_{spike} was known from enumeration of the stock spore suspension. One aliquot of the stock suspension was plated and enumerated on each day of testing to confirm CFU_{spike} concentration. Spore recovery was calculated for *Ba* Ames or Vollum on each coupon, and the results are included in Section 4 and Appendix A.

The performance or efficacy of the fumigant was assessed by determining the number of CFU remaining on each test coupon after decontamination. Those numbers were compared to the number of CFU extracted from the positive control coupons.

The number of viable spores of *Ba* Ames or Vollum in extracts of test and positive control coupons was determined to calculate efficacy of the decontaminant. Efficacy (in terms of LR) is defined as the extent to which viable spores extracted from test coupons after decontamination were less numerous than the viable spores extracted from positive control coupons. The logarithm of the CFU abundance from each coupon extract was determined, and the mean of those logarithm values was then determined for each set of control and associated test coupons, respectively. Efficacy of a decontaminant for a test organism/test condition on the i^{th} coupon material was calculated as the difference between those mean log values, i.e.:

$$Efficacy\,(LR) = \overline{(\log_{10} CFUc_{ij})} - \overline{(\log_{10} CFUt_{ij})} \quad (2)$$

where $\log_{10} CFUc_{ij}$ refers to the j individual logarithm values obtained from the positive control coupons and $\log_{10} CFUt_{ij}$ refers to the j individual logarithm values obtained from the individual corresponding test coupons, and the overbar designates a mean value. In tests conducted under this plan, there were five positive controls (i.e., $j = 5$) and three corresponding test coupons for each coupon material. A decontaminant or fumigant technology is considered effective via AOAC 966.04 if a 6 LR or greater is achieved (US EPA 2016).

In the case where no viable spores were found in the extracts of any of the three test coupon replicates after decontamination, a CFU abundance of 1 was assigned, resulting in a $\log_{10}$ CFU of 0 for that material. This situation occurred when the decontaminant was highly effective, and no viable spores were found on the decontaminated test coupons. In such cases, the final efficacy on that material was reported as greater than or equal to (≥) the value calculated by Equation 2.

The variances (i.e., the square of the SD) of the $\log_{10} CFUc_{ij}$ and $\log_{10} CFUt_{ij}$ values were also calculated for both the control and test coupons (i.e., S^2c_{ij} and S^2t_{ij}), and were used to calculate the pooled standard error (SE) for the efficacy value calculated in Equation 2, as follows:

$$SE = \sqrt{\frac{S^2c_{ij}}{5} + \frac{S^2t_{ij}}{3}} \quad (3)$$

where the number 5 again represents the number j of coupons in the control and 3 in the test data sets. Each efficacy result is reported as an LR value with an associated 95% confidence interval (CI), calculated as follows:

$$95\ \%\ \text{CI} = \textit{Efficacy (LR)} \pm (1.96 \times \text{SE}) \quad (4)$$

In some cases, the significance of differences in efficacy across different test conditions and *Ba* strain was assessed based on the 95% CI of each efficacy result. Differences in efficacy were judged to be significant if the 95% CIs of the two efficacy results did not overlap. This comparison is not applicable when the two efficacy results being compared are both reported with LRs as ≥ some value (complete inactivation).

2.8 Statistical Analysis

A binary response based on LR in spores was the primary endpoint. For this endpoint, a trial was recorded as a success if either: 1) the LR was greater than or equal to 6, or 2) the $\log_{10}$ recovery was equal to or less than the average control recovery (complete inactivation). The proportion of tests that were successful and the 95 percent Clopper-Pearson confidence intervals (Clopper and Pearson, 1934) were computed by strain (Ames or Vollum), material, contact time, RH, and HPV concentration.

A logistic regression model was fitted to the full data set to test whether the proportions of successes were significantly associated with any effects included in the model. The logistic regression model included main effects for strain (Ames or Vollum), material, dose (defined as contact time times HPV concentration, i.e., ppm*hours), and RH; the model also included all two-factor interactions and the three-factor interaction for dose, strain, and material. An implicit assumption in the analysis was that the effect of dose is the same for any concentration and time used to achieve it.

For comparisons, results may be presented in terms of an odds ratio. The “odds ratio” is defined as the ratio of probability of successful decontamination (≥ 6 LR or complete kill) to the probability of unsuccessful decontamination. When the odds ratio is greater than one, a higher odds ratio implies greater odds of successful decontamination for the level 1 of the factor compared to level 2. For odds ratios less than one, there are greater odds of successful decontamination for level 2 of the factor compared to level 1. An odds ratio equal to one indicates the odds of successful decontamination are approximately the same for both levels of the factor. All statistical analyses were performed using SAS (version 9.4; Cary, NC). All results are reported at the 0.05 level of significance. Further details on the statistical analysis methods and results are found in Appendix D.

2.9 Surface Damage

The physical effect of the HPV on the materials was qualitatively monitored during the evaluation. This approach provided a visual assessment of whether the test condition changed the appearance of the test materials compared to positive controls. The procedural blank was visually compared to a laboratory blank coupon when testing was completed.

3.0 Quality Assurance/Quality Control

Quality assurance (QA)/quality control (QC) procedures were performed in accordance with the Testing and Evaluation (T&E II) Program Quality Management Plan (QMP), Version 1 and the TO14 quality assurance project plan. The QA/QC procedures and results are summarized below.

3.1 Equipment Calibration

All equipment (e.g., pipettes, incubators, biological safety cabinets) and monitoring devices (e.g., Vaisala thermometer/hygrometer and ATI HPV sensor) used at the time of the evaluation were verified as being certified, calibrated, or validated.

3.2 QC Results

QC efforts conducted during decontaminant testing included positive control samples, procedural blanks, laboratory blanks, and inoculation control samples.

All positive control results were within the target recovery range of 5 to 120% of the inoculated CFU amount for the *Ba* Ames strain. The *Ba* Vollum strain exhibited relatively lower recovery for most materials, for most of the tests (75% of Vollum positive control recoveries were < 5% of the inoculated level), with recoveries ranging from 3.4 to 13% on glass, 4.3 to 47.4% on painted wallboard paper, 0.1 to 1.5% on ceiling tile, 0.5 to 5.3% on pine wood, 0.7 to 13.4% on industrial carpet, and 0.8 to 10.5% on unpainted concrete. The positive control recovery results are summarized in Table 3-1.

While occasional low recoveries of bacterial spores from porous surfaces is not uncommon, the generally high percentage of low recoveries for Vollum was a new trend not seen before with the Ames strain. (Further research may be warranted to help explain this phenomenon.) Testing proceeded in these cases, with the implication that depending on the recovery, complete decontamination of a material may have occurred without achieving ≥ 6 LR. Finally, all procedural and laboratory blanks met the criterion of no observed CFU for both strains.

Table 3-1. Summary of Average Recovery (Percent) of Spores from Positive Controls

Average ± SD Ames % Recovery									
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**	**Test 6**	**Test 7**	**Test 8**	**Test 9**
Glass	38±13	37±1	59±7	57±9	47±8	36±7	55±5	15±7	42±7
PW Paper	84±4	83±7	79±9	72±25	63±12	63±8	66±13	41±16	64±9
Ceiling Tile	43±11	30±12	31±4	38±7	37±6	26±6	40±5	25±12	14±2
Wood	28±10	27±9	18±12	22±11	23±11	10±2	24±12	15±4	21±21
Carpet	79±30	89±8	92±8	73±9	87±3	75±5	69±7	50±7	92±9
Concrete	15±9	100±27	39±25	19±24	14±4	12±8	25±14	11±4	27±15
Average ± SD Vollum % Recovery									
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**	**Test 6**	**Test 7**	**Test 8**	**Test 9**
Glass	13±5	6±3	8±2	4±1	4±2	3±0.1	9±1	9±3	6±3
PW Paper	47±61	17±26	5±0.3	6±1	4±0.5	5±1	6±1	6±2	7±1
Ceiling Tile	2±2	0.3±0.1	0.1±0.0	0.7±0.4	0.4±0.2	0.4±0.3	0.3±0	0.4±0.1	0.9±1
Wood	5±2	2±1	0.5±0.1	4±2	4±3	4±0.4	1±1	5±1	3±2
Carpet	13±1	6±0	8±1	4±1	0.9±1.0	4±1	5±2	10±2	5±1
Concrete	2±3	0.8±1	10±5	2±1	0.01±0	1±0.8	2±2	3±3	6±4

Inoculation control samples were taken from the spore suspension on the day of testing and serially diluted, plated, and counted to establish the spore density used to inoculate the samples. The spore density levels met the QA target criterion of 1×10^9 CFU/mL (±1 log) for all tests.

3.3 Operational Parameters

The temperature, RH, and HPV concentration during each test were monitored as described in Section 2.0. For some tests, the RH was passively controlled by using Drierite or saturated salt solutions as described in Section 2.5. This method allowed for consistent targeted starting conditions for RH but ultimately the RH varied somewhat during a test due to the dynamic nature of constantly adding moisture to the system through use of 35% HPV or the continuous drying effect of the generator. Readings were taken once every minute for the duration of the contact time. The actual fumigation parameters for each test are shown in Table 3-2 and reported as the average value ± SD. Due to commercial equipment issues in Tests 1 and 8, the HPV concentrations temporarily dropped below the target range. Test 1 had a target concentration of 250 ppm but average actual measurement was 222 ppm due to a low flow alarm which caused the equipment to cease operation mid-testing. Upon finding this error, the system was reset and the run continued. Test 8 again used the commercial generator, but targeted high RH conditions. The target concentration was 50 ppm but an actual concentration of 44 ppm HPV resulted. As the desiccant in the commercial generator was approaching saturation level, the vaporization of HPV became less efficient causing the HPV concentrations to decrease. To remedy this issue, the generator return line was disconnected, which allowed for room air (lower RH) to be introduced into the system. Instead of returning to the generator, the excess HPV concentration was vented through the facility exhaust system to stabilize the HPV concentration in the Class III BSC and test chamber.

Table 3-2. Actual Fumigant Conditions for Tests

Test Number	Target HPV ppm	Avg. HPV ppm*	Temperature (°C)	RH (%)		Contact Time (hours)†	
				Target	Actual*	Easy[1] Materials	Hard[2] Materials
1	250	221.6 ± 30.9	23.0 ± 0.0	Low	38.1 ± 4.3	0.25,0.50,1,2,3	
2	10	10.4 ± 0.6	23.6 ± 0.3	Medium	58.5 ± 9.1	4, 8, 12, 16, 20	
3	10	9.3 ± 1.0	27.4 ± 0.8	High	76.1 ± 5.4	4, 8, 12, 16, 20	
4	25	25.7 ± 1.4	22.9 ± 0.1	Low	32.6 ± 22.4	2,4,6,8,12	8,12,16,20,24
5	25	25.5 ± 1.0	23.9 ± 0.1	Medium	62.4 ± 23.9	2,4,6,8,12	8,12,16,20,24
6	50	50.3 ± 1.51	23.5 ± 0.3	Low	25.9 ± 1.9	2,4,6,8,12	8,12,16,20,24
7	50	50.0 ± 1.1	23.8 ± 3.9	Medium	60.1 ± 3.9	1,2,4,5,6	8,12,16,20,24
8	50	43.5 ± 12.6	23.0 ± 0.4	High	76.9 ± 5.5	1,2,4,5,6	8,12,16,20,24
9	25	25.2 ± 1.6	23.8 ± 0.4	High	91.6 ± 6.3	1,2,6,8,12	8,12,20,24, 48

[1] Glass, Painted Wallboard Paper and Ceiling Tile
[2] Pine Wood, Carpet, Concrete
* Data reported as average ± SD.
† Contact time did not deviate from target during any test.

3.4 Audits

3.4.1 Performance Evaluation Audit

Performance evaluation (PE) audits were conducted to assess the quality of the results obtained during these experiments. Table 3-3 summarizes the PE audits that were performed.

No PE audits were performed for confirmation of the concentration and purity of *Ba* Ames or Vollum spores because quantitative standards do not exist for these organisms. The titer enumerations and the control and blank test coupons support the spore measurements.

Table 3-3. Performance Evaluation Audits

Measurement	Audit Procedure	Allowable Tolerance	Actual Tolerance
Volume of liquid from micropipettes	Gravimetric evaluation	± 10%	± 0.04% to 2.33%
Time	Compared to independent clock	± 2 s/h	0 s/h
Temperature	Compared to independent calibrated thermometer	± 2 °C	± 0.42 to 0.52 °C
Relative Humidity	Compare to independent calibrated hygrometer	± 10%	± 0.42 to 0.99%

3.4.2 Technical Systems Audit

Observations and findings from the TSA were documented and submitted to the laboratory technical lead for response. TSAs were conducted on July 11, 2017, to ensure that tests were being conducted in accordance with the appropriate QAPP and QMP. As part of the audit, test procedures were compared to those specified in the QAPP, and data acquisition and handling procedures were reviewed. None of the findings of the TSA required corrective action.

3.4.3 Data Quality Audit

At least 10 % of the data acquired during the evaluation were audited. Data were reviewed in 5 separate batches from May 2017 through Feb 2018. A QA auditor traced the data from the initial acquisition, through reduction and statistical analysis, to final reporting to ensure the integrity of the reported results. All calculations performed on the data undergoing the audit were verified. Only minor issues were noted with the data, mostly data transcription errors that were corrected.

3.5 QA/QC Reporting

Each assessment and audit was documented in accordance with the QAPP and QMP. For these tests, findings were noted (none significant) in the data quality audit, and no follow-up corrective action was necessary. The findings were mostly minor data transcription errors requiring some recalculation of efficacy results, but none were gross errors in recording. QA/QC procedures were performed in accordance with the QAPP.

3.6 Data Review

Records and data generated in the evaluation received a QC/technical review before they were utilized in calculating or evaluating results and prior to incorporation in this report.

4.0 Results and Discussion

The decontamination efficacy of HPV was assessed against virulent spores of *Ba* Ames and Vollum strains. A total of nine tests were conducted with contact times ranging from 0.25 to 48 hours. Each test was performed using six material types inoculated with *Ba* Ames and an additional set of coupons of the same materials were inoculated with *Ba* Vollum. Testing was conducted at ambient temperature (~ 23 °C) and low (26-38%), medium (59-62%), and high (76-92%) RH levels. The first test was conducted at an HPV-generation equipment vendor's label requirement (target of 250 ppm for 90 minutes) to tie back to previous testing using more typical levels of HPV. Following Test 1, all tests proceeded with using target HPV concentrations of either 10, 25, or 50 ppm, paired with different RH levels. All nine tests utilized five contact times.

Overall results of the study are summarized in Tables 4-1 and 4-2, which show the minimum contact times needed to achieve effective decontamination of each material for each experimental condition. Contact times for effective decontamination generally decreased with increased HPV concentration. For example, at the higher concentration of 222 ppm (Test 1), only 15 minutes were required to effectively decontaminate glass; in contrast, at the 10-ppm level, 4-12 hours were required for effective decontamination of glass, depending on the strain and RH level. With the Vollum strain on glass, ceiling tile, and painted wallboard paper, successful decontamination occurred in 2-16 hours for the 10-50 ppm HPV concentrations evaluated. In some experiments, effective decontamination may not have occurred for a specific material(s) at the longest contact time evaluated; these results are displayed in Tables 4-1 and 4-2 as greater than the longest contact time tested.

The results for each individual test are summarized via Tables 4-3 to 4-11. Additional detailed decontamination efficacy results, showing the average CFU recovery from each material for both positive controls and test coupons, for all tests, are found in Appendix A. Further, Appendix B provides graphical representations of the decontamination efficacy results (LR) for each test. This chapter also discusses decontamination efficacy as a function of some of the variables that were tested in the study. Statistical results are also presented when applicable to indicate whether test variables significantly affected efficacy.

Table 4-1. Minimum Time (Hours) Demonstrating Effective Decontamination for Ames Strain

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 9	Test 6	Test 7	Test 8
Average HPV ppm	222	9-10		25-26			44-50		
Average % RH	38	58	76	33	62	92	26	60	77
	Time (hours)								
Glass	0.25	12	8	8	4	6	6	1	2
PW Paper	0.5	>20	8	>12	>12	2	>12	1	2
Ceiling Tile	2	12	8	>12	4	6	2	4	4
Pine Wood	3	12	>20	>24	>24	>48	>24	16	24
Carpet	0.25	>20	>20	>24	16	20	>24	20	8
Concrete	>3	>20	>20	>24	>24	>48	>24	>24	>24

A ">" denotes that effective decontamination was not achieved at any time point, with the longest contact time listed

Table 4-2. Minimum Time (Hours) Demonstrating Effective Decontamination for Vollum Strain

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 9	Test 6	Test 7	Test 8
Average HPV ppm	222	9-10		25-26			44-50		
Average % RH	38	58	76	33	62	92	26	60	77
	Time (hours)								
Glass	0.25	8	4	8	4	2	4	4	2
PW Paper	1	16	8	6	4	6	6	4	4
Ceiling Tile	1	8	8	8	6	6	2	4	4
Pine Wood	2	>20	>20	>24	>24	>48	24	16	24
Carpet	>3	>20	20	>24	24	20	24	20	12
Concrete	>3	>20	>20	>24	>24	>48	>24	>24	>24

A ">" denotes that effective decontamination was not achieved at any time point, with the longest contact time listed

The efficacy results for Test 1 are shown in Table 4-3, in terms of the LR ± the 95% confidence interval (CI). Note that the actual average HPV concentration of 222 ppm was below the vendor's registered fumigation condition of 250 ppm, due to equipment malfunction. Nevertheless, for the glass, ceiling tile, and wallboard materials, effective decontamination occurred with contact times ~ 1-2 hours, in a range mostly consistent with the vendor's registration requirement of a 90-minute contact time. However, for the wood, carpet, and unpainted concrete, effective decontamination occurred in only three instances (out of 30) under

the Test 1 conditions. These results are generally consistent with a previous EPA study (US EPA, 2010).

Table 4-3. Summary of Efficacy Results (LR) for Test 1 (222 ppm HPV) and Low RH Against *B. anthracis* Ames and Vollum.

Test 1					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95% CI***	***Ba Vollum Efficacy***	***95%CI***
Glass	0.25	7.02	1.20	6.52	1.02
	0.5	4.37	3.51	4.34	2.73
	1	6.74	1.75	7.03	0.21
	2	7.63	0.16	7.03	0.21
	3	7.63	0.16	5.36	1.68
Wallboard Paper	0.25	5.55	2.74	2.90	2.96
	0.5	8.00	0.02	2.55	0.71
	1	4.68	3.27	7.42	0.38
	2	8.00	0.02	7.42	0.38
	3	8.00	0.02	7.42	0.38
Ceiling Tile	0.25	1.84	0.39	5.44	1.07
	0.5	3.26	0.61	4.83	1.18
	1	6.99	1.39	5.95	0.40
	2	7.70	0.10	5.95	0.40
	3	7.70	0.10	5.95	0.40
Pine Wood	0.25	3.47	3.96	2.47	0.75
	0.5	2.05	0.29	3.05	0.99
	1	3.70	1.16	5.43	2.29
	2	4.40	1.69	6.08	1.02
	3	6.61	1.75	5.01	1.83
Industrial Carpet	0.25	7.23	1.40	1.02	0.18
	0.5	5.16	4.04	0.30	0.46
	1	4.03	3.85	2.32	0.07
	2	4.67	3.22	4.94	2.10
	3	4.74	3.14	4.55	0.27
Unpainted Concrete	0.25	0.32	0.59	1.06	1.07
	0.5	0.36	0.23	1.58	1.42
	1	0.35	0.43	2.92	0.65
	2	0.59	0.22	4.52	2.74
	3	0.58	0.26	2.59	0.68

Results highlighted in yellow represent effective decontamination but not complete inactivation. Results highlighted in green represent complete inactivation.

Table 4-4. Summary of Efficacy Results (LR) at 10 ppm and Medium RH against *B. anthracis* Ames and Vollum.

Test 2					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95% CI***	***Ba Vollum Efficacy***	***95% CI***
Glass	4	2.68	0.43	3.47	3.85
	8	3.91	1.63	6.79	2.16
	12	7.62	0.01	6.79	0.19
	16	6.11	1.69	6.79	0.19
	20	7.62	0.01	6.79	0.19
Wallboard Paper	4	0.55	0.92	2.41	1.86
	8	2.89	1.46	5.83	1.25
	12	3.75	4.22	5.83	2.34
	16	5.91	4.02	7.00	0.42
	20	3.81	1.29	7.00	0.80
Ceiling Tile	4	0.86	0.23	2.38	0.47
	8	3.31	0.56	5.49	0.14
	12	6.89	1.56	5.49	0.14
	16	7.48	0.20	5.49	0.14
	20	7.48	0.20	5.49	0.14
Pine Wood	4	2.39	0.65	2.44	0.89
	8	4.32	3.07	3.69	2.58
	12	7.44	0.15	4.61	1.66
	16	7.44	0.15	5.56	1.22
	20	7.44	0.15	5.56	1.22
Industrial Carpet	4	0.04	0.05	0.23	0.07
	8	0.68	0.06	1.04	0.08
	12	1.65	0.24	4.06	0.64
	16	1.66	0.21	3.83	0.08
	20	2.09	0.16	5.51	1.39
Unpainted Concrete	4	1.18	0.25	0.95	0.80
	8	0.99	0.24	0.44	0.75
	12	1.26	0.49	1.36	0.63
	16	1.53	0.26	2.24	0.74
	20	1.49	0.13	1.29	0.73

Results highlighted in yellow represent effective decontamination but not complete inactivation.
Results highlighted in green represent complete inactivation.

Table 4-5. Summary of Efficacy Results (LR) at 10 ppm and High RH against *B. anthracis* Ames and Vollum.

Test 3					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95%CI***	***Ba Vollum Efficacy***	***95%CI***
Glass	4	7.17	1.19	6.83	0.11
	8	7.78	0.05	6.83	0.11
	12	7.78	0.05	6.83	0.11
	16	7.78	0.05	6.83	0.11
	20	7.78	0.05	6.83	0.11
Wallboard Paper	4	3.43	2.67	5.33	2.62
	8	6.90	1.97	6.67	0.02
	12	7.90	0.05	6.67	0.02
	16	7.90	0.05	6.67	0.02
	20	7.90	0.05	6.67	0.02
Ceiling Tile	4	3.84	0.22	2.58	0.37
	8	6.99	1.00	4.89	0.11
	12	7.50	0.05	4.89	0.11
	16	7.50	0.05	4.89	0.11
	20	7.50	0.05	4.89	0.11
Pine Wood	4	2.24	0.53	2.36	1.54
	8	3.23	1.06	2.83	0.20
	12	3.12	1.76	5.61	0.10
	16	3.55	0.77	5.10	1.00
	20	3.42	0.78	4.34	1.26
Industrial Carpet	4	0.24	0.03	0.90	0.15
	8	1.45	0.32	2.18	0.05
	12	1.00	0.16	3.59	0.08
	16	2.32	0.22	5.15	1.65
	20	2.67	0.69	6.83	0.03
Unpainted Concrete	4	-0.02	0.47	1.30	0.29
	8	1.36	1.38	4.26	2.68
	12	1.06	0.55	2.68	0.51
	16	1.35	0.71	2.78	0.86
	20	1.36	0.66	5.26	1.70

Results highlighted in yellow represent effective decontamination but not complete inactivation.
Results highlighted in green represent complete inactivation.

Table 4-6. Summary of Efficacy Results (LR) at 25 ppm and Low RH against *B. anthracis* Ames and Vollum.

Test 4					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95% CI***	***Ba Vollum Efficacy***	***95% CI***
Glass	2	1.82	0.63	5.85	1.39
	4	3.56	1.43	5.39	1.19
	6	4.64	1.09	5.82	1.46
	8	7.73	0.06	6.56	0.11
	12	5.58	2.31	6.56	0.11
Wallboard Paper	2	0.36	0.50	1.51	0.94
	4	0.86	0.27	4.90	1.74
	6	1.06	0.29	6.67	0.08
	8	2.20	0.57	6.67	0.08
	12	2.99	0.77	6.67	0.08
Ceiling Tile	2	1.94	0.15	2.32	0.33
	4	2.77	0.22	4.51	1.22
	6	2.63	0.10	5.17	1.04
	8	3.98	0.37	5.68	0.30
	12	3.94	0.09	5.68	0.30
Pine Wood	8	2.88	0.65	3.63	1.67
	12	3.03	0.45	4.26	0.82
	16	2.22	0.31	3.93	0.88
	20	2.98	0.71	5.38	1.19
	24	4.20	1.57	3.50	1.17
Industrial Carpet	8	1.21	0.12	2.02	0.61
	12	0.80	0.08	2.05	0.36
	16	2.11	0.26	2.60	0.18
	20	2.28	1.07	5.49	1.95
	24	2.34	1.07	4.94	1.62
Unpainted Concrete	8	0.47	0.57	2.01	0.56
	12	0.73	0.61	3.60	2.40
	16	1.10	1.58	2.22	0.80
	20	0.64	0.61	2.58	0.40
	24	0.57	0.45	2.30	0.28

Results highlighted in yellow represent effective decontamination but not complete inactivation.
Results highlighted in green represent complete inactivation.

Table 4-7. Summary of Efficacy Results (LR) at 25 ppm and Medium RH against *B. anthracis* Ames and Vollum.

Test 5					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95%CI***	***Ba Vollum Efficacy***	***95%CI***
Glass	2	4.34	3.20	5.56	1.81
	4	7.60	0.07	6.48	0.19
	6	7.60	0.07	6.48	0.19
	8	7.09	1.00	6.48	0.19
	12	7.60	0.07	6.48	0.19
Wallboard Paper	2	2.87	1.79	2.35	0.55
	4	4.05	2.11	6.58	0.04
	6	3.85	1.15	6.58	0.04
	8	3.80	1.35	6.58	0.04
	12	5.18	0.26	6.58	0.04
Ceiling Tile	2	4.16	2.05	2.22	0.69
	4	6.88	1.19	4.95	1.02
	6	6.14	1.34	5.46	0.25
	8	6.78	1.39	5.46	0.25
	12	7.49	0.06	5.46	0.25
Pine Wood	8	2.92	1.30	4.94	1.65
	12	4.94	2.34	5.54	1.71
	16	3.95	0.28	4.86	1.63
	20	4.66	2.59	5.18	2.40
	24	3.07	1.33	5.29	2.20
Industrial Carpet	8	5.70	4.25	0.89	0.43
	12	2.34	0.57	2.53	0.36
	16	6.22	3.23	3.26	0.76
	20	7.87	0.01	4.42	1.40
	24	7.87	0.01	5.71	0.35
Unpainted Concrete	8	0.50	0.16	1.91	0.68
	12	0.65	0.25	3.06	2.58
	16	0.55	0.37	2.19	0.41
	20	0.64	0.17	2.03	0.46
	24	0.55	0.17	1.74	0.36

Results highlighted in yellow represent effective decontamination but not complete inactivation.
Results highlighted in green represent complete inactivation.

Table 4-8. Summary of Efficacy Results (LR) at 50 ppm and Low RH against *B. anthracis* Ames and Vollum.

Test 6					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95%CI***	***Ba Vollum Efficacy***	***95%CI***
Glass	2	5.57	2.17	5.96	0.99
	4	5.94	1.63	6.47	0.01
	6	7.61	0.07	6.47	0.01
	8	7.61	0.07	5.47	1.96
	12	7.61	0.07	6.47	0.01
Wallboard Paper	2	1.51	0.41	3.20	0.11
	4	1.86	1.13	4.65	0.61
	6	1.90	0.92	6.62	0.10
	8	2.44	0.54	6.62	0.10
	12	4.01	0.92	6.62	0.10
Ceiling Tile	2	6.94	1.00	5.49	0.22
	4	5.71	1.76	5.49	0.22
	6	6.17	1.33	5.49	0.22
	8	7.45	0.11	5.49	0.22
	12	7.45	0.11	5.49	0.22
Pine Wood	8	2.89	0.82	4.34	2.11
	12	3.15	1.10	5.70	1.55
	16	1.83	0.37	5.89	1.19
	20	3.57	1.28	5.89	1.19
	24	2.95	2.20	6.49	0.04
Industrial Carpet	8	0.48	0.05	1.06	0.09
	12	1.53	0.30	3.30	0.24
	16	1.91	0.39	5.17	1.46
	20	2.01	0.13	5.22	1.30
	24	2.99	0.24	6.53	0.07
Unpainted Concrete	8	0.18	0.21	1.90	0.35
	12	0.47	0.29	3.51	2.43
	16	0.79	0.43	2.06	0.36
	20	0.74	0.56	2.74	0.53
	24	0.87	0.44	2.86	0.37

Results highlighted in yellow represent effective decontamination but not complete inactivation.
Results highlighted in green represent complete inactivation.

Table 4-9. Summary of Efficacy Results (LR) at 50 ppm and Medium RH against *B. anthracis* Ames and Vollum.

Test 7					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95%CI***	***Ba Vollum Efficacy***	***95%CI***
Glass	1	7.71	0.04	2.12	0.13
	2	7.71	0.04	5.39	0.31
	4	7.71	0.04	7.08	0.04
	5	7.71	0.04	7.08	0.04
	6	7.71	0.04	7.08	0.04
Wallboard Paper	1	7.79	0.08	1.80	0.13
	2	7.79	0.08	5.71	2.25
	4	5.05	3.21	6.35	1.00
	5	5.71	0.69	6.86	0.05
	6	4.32	1.15	6.86	0.05
Ceiling Tile	1	3.63	0.94	2.38	0.16
	2	5.42	0.66	3.79	0.05
	4	7.58	0.05	5.61	0.05
	5	7.58	0.05	5.61	0.05
	6	7.58	0.05	5.61	0.05
Pine Wood	8	2.17	0.53	2.43	0.52
	12	4.10	3.26	3.66	1.22
	16	6.22	2.17	6.14	0.21
	20	4.24	3.04	6.14	0.21
	24	7.32	0.18	5.63	1.02
Industrial Carpet	8	1.49	0.17	3.54	0.71
	12	2.51	0.27	3.95	0.68
	16	4.96	2.83	5.50	0.67
	20	6.08	1.84	6.04	0.79
	24	5.67	2.18	6.78	0.74
Unpainted Concrete	8	0.83	0.35	1.78	0.38
	12	0.83	0.42	2.07	0.64
	16	0.62	0.22	1.96	1.26
	20	1.04	0.27	2.57	1.46
	24	0.78	0.34	2.23	0.12

Results highlighted in yellow represent effective decontamination but not complete inactivation.
Results highlighted in green represent complete inactivation.

Table 4-10. Summary of Efficacy Results (LR) at 50 ppm and High RH against *B. anthracis* Ames and Vollum.

Test 8					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95% CI***	***Ba Vollum Efficacy***	***95% CI***
Glass	1	5.81	2.33	5.65	1.11
	2	7.00	0.16	6.77	0.13
	4	7.00	0.16	6.77	0.13
	5	7.00	0.16	6.77	0.13
	6	7.00	0.16	6.77	0.13
Wallboard Paper	1	2.65	1.90	1.14	0.35
	2	7.42	0.21	2.13	0.94
	4	6.55	1.73	6.59	0.10
	5	7.42	0.21	6.59	0.10
	6	7.42	0.21	6.59	0.10
Ceiling Tile	1	1.70	0.30	0.92	0.12
	2	4.98	2.22	1.83	0.12
	4	7.21	0.18	5.49	0.07
	5	7.21	0.18	5.49	0.07
	6	7.21	0.18	5.49	0.07
Pine Wood	8	2.81	0.44	5.96	1.19
	12	3.99	3.00	5.96	1.19
	16	3.64	1.81	4.31	0.72
	20	3.67	0.64	5.25	1.30
	24	7.00	0.11	6.57	0.08
Industrial Carpet	8	6.03	2.98	4.97	0.50
	12	7.55	0.05	6.83	0.66
	16	7.55	0.05	6.83	0.45
	20	7.55	0.05	6.83	0.49
	24	7.55	0.05	6.83	0.51
Unpainted Concrete	8	0.78	0.40	2.60	0.41
	12	0.77	0.20	2.58	0.08
	16	1.38	0.53	3.28	0.08
	20	0.85	0.25	2.90	0.08
	24	0.80	0.41	2.54	0.08

Results highlighted in yellow represent effective decontamination but not complete inactivation.
Results highlighted in green represent complete inactivation.

Table 4-11. Summary of Efficacy Results (LR) at 25 ppm and High RH against *B. anthracis* Ames and Vollum.

Test 9					
Material	**Contact Time (h)**	***Ba Ames Efficacy***	***95%CI***	***Ba Vollum Efficacy***	***95%CI***
Glass	1	0.97	0.10	1.67	0.39
	2	1.88	0.49	6.19	1.21
	6	7.56	0.07	6.79	0.21
	8	7.56	0.07	6.79	0.21
	12	7.56	0.07	6.79	0.21
Wallboard Paper	1	1.72	0.19	1.10	0.14
	2	6.08	3.28	1.76	0.33
	6	7.75	0.05	6.91	0.04
	8	7.75	0.05	6.91	0.04
	12	7.75	0.05	6.91	0.04
Ceiling Tile	1	0.34	0.25	1.02	0.39
	2	1.07	0.24	1.88	0.40
	6	7.09	0.06	5.82	0.38
	8	5.92	2.31	5.82	0.38
	12	7.09	0.06	5.82	0.38
Pine Wood	8	2.35	0.95	4.20	0.42
	12	2.27	0.49	2.91	1.81
	20	2.22	0.33	3.53	0.91
	24	2.76	1.24	4.09	1.14
	48	4.86	2.30	4.08	2.37
Industrial Carpet	8	2.04	0.28	4.07	0.24
	12	2.00	0.46	4.59	0.23
	20	7.91	0.52	6.78	0.42
	24	7.91	0.34	6.78	1.00
	48	7.91	0.90	6.78	0.30
Unpainted Concrete	8	1.45	0.16	2.23	0.32
	12	0.87	0.12	2.77	0.48
	20	1.26	0.04	4.36	0.10
	24	1.71	0.04	3.42	0.10
	48	1.83	0.04	4.53	0.10

Results highlighted in yellow represent effective decontamination but not complete inactivation.
Results highlighted in green represent complete inactivation.

4.1 Comparing the effect of material and strain on decontamination efficacy

Overall study results can also be summarized in terms of the number of instances (out of the five contact times) in which successful decontamination (complete inactivation or ≥6 LR) occurred for each experiment, material, and strain. These results are displayed in Tables 4-12 and 4-13. Decontamination results vary by material and strain, and so it is important to know which materials and strains are problematic to decontaminate or inactivate, respectively.

As these tables show, the number of successful decontaminations was highest for the glass, ceiling tile, and painted wallboard paper materials for both Ames and Vollum strains. These materials were effectively decontaminated in 63, 55, and 46 out of a potential 90 instances (2 strains X 5 contact times X 9 experiments), respectively. (Note that for ceiling tile, while there was routinely complete inactivation, the efficacy never exceeded 6.0 due to the lower recovery from positive controls.) After the first three tests, it was evident that the wood, carpet, and unpainted concrete materials were being decontaminated much less effectively. Therefore, these materials were exposed to the same HPV concentrations, but at longer contact times (compared with the other materials, in the same experiment) beginning with Test 4. Even with exposure to HPV at these longer contact times, the carpet, wood, and unpainted concrete were effectively decontaminated in only 28, 12, and 0 instances, respectively. The highest efficacy achieved for unpainted concrete during the study was 5.3 LR (Test 3 for Vollum). The results showing that unpainted concrete was difficult to decontaminate effectively is consistent with previous findings when testing peracetic acid and aqueous hydrogen peroxide fogging (Richter et al., 2018).

Comparing the two strains, out of a total of 270 efficacy results for each strain (9 tests X 6 materials X 5 contact times), there were 97 instances of successful decontamination for *Ba* Ames and 107 instances for the Vollum strain.

Table 4-12. Number of Successful Decontamination Instances for *Ba* Ames by Test and Material

	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**	**Test 9**	**Test 6**	**Test 7**	**Test 8**	**Total**
Average HPV ppm	222	10	9	26	26	25	50	50	44	
average % RH	38	58	76	33	62	92	26	60	77	
	Number of Successful Decontamination Instances									
Glass	4	3	5	1	4	3	3	5	4	31
PW Paper	3	0	4	0	0	4	0	2	4	17
Ceiling Tile	3	3	4	0	4	2	3	3	3	26
Pine Wood	1	3	0	0	0	0	3	2	1	7
Carpet	1	0	0	0	3	3	0	1	5	16
Concrete	0	0	0	0	0	0	0	0	0	0
Total	**12/30**	**9/30**	**13/30**	**1/30**	**11/30**	**12/30**	**9/30**	**13/30**	**17/30**	**97**

* Results shown are the number of effective decontamination instances (out of five time-points) for each test

Table 4-13. Number of Successful Decontamination Instances for *Ba* Vollum by Test and Material

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 9	Test 6	Test 7	Test 8	Total
Average HPV ppm	222	10	9	26	26	25	50	50	44	
average % RH	38	58	76	33	62	92	26	60	77	
	Number of Successful Decontamination Instances									
Glass	3	3	5	2	4	4	3	3	4	32
PW Paper	3	2	4	3	4	3	3	3	3	29
Ceiling Tile	3	4	4	2	3	3	5	3	3	29
Pine Wood	1	0	1	0	0	0	1	2	1	5
Carpet	0	0	1	0	1	3	1	2	4	12
Concrete	0	0	0	0	0	0	0	0	0	0
Total	**10/30**	**9/30**	**15/30**	**7/30**	**12/30**	**13/30**	**13/30**	**13/30**	**15/30**	**107**

As discussed in Section 2.8, statistical analysis was performed by converting all LR data into a binary response with the endpoint being a success if LR $\geq$ 6.0 or if complete inactivation occurred. Table 4-14 shows results from the logistic regression model which was fitted to the full data set to test whether the proportion of success was significantly associated with the *Ba* strain, material, dose (concentration x time), and RH. The Wald test statistic, the degrees of freedom (DF), and the p-value are shown in the table; the Wald statistic is the appropriate statistic when using a logistic model. The presence of a statistically significant three-factor interaction complicated interpretation of the results, as all results for one of the three factors must be interpreted with respect to the levels of the other two factors. While the main effects for strain, average RH, and dose were not statistically significant, the two factor interactions involving these factors are statistically significant: these factors do impact the probability of a successful decontamination, but the successful decontamination is dependent on the strain, the material, and the dose.

Based on the parameters of the logistic model, the effect of material type was significant, but the significance varied compared against the other materials. With respect to the effect of strain, using the full logistical regression model, the results showed that *Ba* Ames and Vollum were not significantly different (p-value = 0.99) from each other relative to successful decontamination. When assessing the two-factor interactions of material and RH level, the odds ratio for Ames compared to Vollum showed significance and decreased with dose for all materials except glass (which increased) and concrete (slight increase). Refer to Appendix C for the full results of the statistical analyses.

Table 4-14. Significant Effects Based on Logistic Regression Model Fitted to Full Dataset

Effect	DF	Wald Test Statistic	p-value
Strain	1	0.0001	0.9943
Material	5	33.0119	<.0001*
Avg. RH	2	0.4301	0.8065
Strain*Material	5	22.6643	0.0004*
Strain*Avg. RH	2	12.0131	0.0025*
Material*Avg. RH	10	44.0611	<.0001*
Dose*Material	5	88.5148	<.0001*
Dose*Avg. RH	2	18.1219	0.0001*

* Effect is statistically significant at or below the 0.05 level; DF = degrees of freedom

4.2 Effect of HPV Dose on Efficacy

The overall results of the study may also be summarized and interpreted in terms of the minimum dose of HPV (in ppm*hours) demonstrating effective decontamination. These results are summarized by material and *Ba* strain in Table 4-15. More detailed individual dosage requirements for each test (per given HPV and RH level), material, and strain combination are found in Appendix C. The HPV dose was shown to have a significant effect on the odds of successful decontamination when material or RH was factored (refer to Table 4-14).

For the glass, painted wallboard, and ceiling tile materials, dosages as low as 100-200 ppm*hours were all that were needed for effective decontamination in most of the tests. In some tests, the wood and carpet materials were successfully decontaminated with doses as low as 120-200 ppm*hours, although there were a few tests that required > 1200 ppm*hours for successful decontamination. In general, successful decontamination using lower dosages of HPV were associated with higher RH levels, as well as with the Vollum strain, although there were exceptions. In an actual decontamination scenario using HPV, these results may be helpful to officials in determining target dosage levels based on the presence of materials.

Table 4-15. Minimum HPV Dose Required for Effective Decontamination

	Range in Minimum Dose Demonstrating Effective Decontamination for Ames Strain (ppm*Hours)	**Range in Minimum Dose Demonstrating Effective Decontamination for Vollum Strain (ppm*Hours)**
Glass	50-200	40-200
PW Paper	50 - >1200	80-300
Ceiling Tile	80 - >600	80-222
Pine Wood	120 - >1200	444- >1200
Carpet	>200 - >1200	200 - 1200
Unpainted Concrete	>200 - >1200	>200 - >1200

4.3 Effects of Relative Humidity on Efficacy

When assessed as a main effect by the statistical analyses, the RH level appeared to be a non-significant factor. However, when comparing average RH by strain, significant differences were observed, and the differences varied by material type. These effects are illustrated in Table 4-16. As Table 4-16 shows, the number of successful decontaminations always increased with increasing RH (for a given HPV concentration and strain). This effect was most pronounced when comparing Tests 4 and 5 (25 ppm HPV, RH increased from 33% to 62%). The effect of increasing RH appears to have more of an impact on the Ames strain.

Table 4-16. Number of Successful Decontaminations by RH

	Test 2	Test 3	Test 4	Test 5	Test 9	Test 6	Test 7	Test 8
average HPV (ppm)	10		25			50		
average RH %	58.5	76.1	32.6	62.4	91.6	25.9	60.1	76.9
	Number of Successful Decontaminations							
Ames Total	9	12	1	11	12	10	13	17
Vollum Total	9	14	7	12	13	13	14	15

* Results shown are the number of successful decontamination results per test.

4.4 Surface Damage to Materials

At the end of each decontamination test, the procedural blanks were visually compared to the laboratory blanks, and test coupons were visually compared to positive controls to qualitatively assess any aesthetic impact the low-concentration HPV may have had on each material type. Based on the visual appearance of the decontaminated coupons, there were no apparent changes in the color, reflectivity, or roughness of the six material surfaces after being exposed to the low concentrations of the sporicidal fumigant.

4.5 Summary

This investigation focused on finding efficacious conditions (e.g., minimum contact times) for inactivating *Ba* Ames and Vollum strains on a variety of building materials when using relatively low concentrations of HPV. In addition to *Ba* strain and material, other test variables included were HPV concentration, contact time, and RH level. These independent variables were adjusted to assess their effect on decontamination efficacy.

In general, fumigating at or near ambient temperatures and RH levels, with the use of lower fumigant concentrations, would allow for personnel and contractors to provide decontamination services with less specialized equipment. This advantage may be critical in increasing the decontamination capacity of the nation in the event of a large release of *Ba* spores, in which numerous buildings and other infrastructures may become contaminated.

The data generated from this evaluation suggest that the resistance to inactivation by HPV is not significantly different for the two *Ba* strains that were used in the investigation. The side-by-side

data with both strains provide evidence indicating that the Ames data may be representative of the Vollum strain when using HPV for decontamination.

Low concentrations of HPV (e.g., 10-50 ppm) were effective in decontaminating all materials tested in the study except for unpainted concrete. Moreover, the glass, ceiling tile and painted wallboard paper materials were more amenable to decontamination by low concentrations of HPV compared to unpainted concrete, carpet, and wood. Even using extended contact times (and hence higher dosages of HPV), the number of occurrences in which unpainted concrete, carpet, and wood were successfully decontaminated in the study was much less than the glass, ceiling tile, and painted wallboard materials. That said, there were in fact several instances when the carpet and wood materials were successfully decontaminated.

Contact times required for effective decontamination generally decreased with increased HPV concentration. For example, at the highest HPV concentration tested (222 ppm), only 15 minutes were required to effectively decontaminate glass; in contrast, at 10 ppm, 4-12 hours were required for effective decontamination of glass, depending on the strain and RH level. In terms of HPV dosage requirements, only 100-200 ppm*hours were required for effective decontamination in most of the tests for the glass, painted wallboard, and ceiling tile. In some tests, the wood and carpet materials were successfully decontaminated with doses as low as 120-200 ppm*hours, although there were a few tests that required > 1200 ppm*hours for successful decontamination of wood and carpet.

While elevated RH has been shown to improve *Ba* spore inactivation with nearly all sporicidal fumigants, some debate still exists whether elevated RH is needed for HPV decontamination. From the statistical analysis of the study results, when assessed as a main effect, the RH level appeared to be a non-significant factor. However, when comparing the effect of RH by strain, significant differences were observed and varied by material type. For example, the effect of increasing RH appears to generally have had more of an impact on the Ames strain. In addition, for a given HPV concentration and strain, it was found that the number of occurrences of successful decontamination always increased with increasing RH.

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Appendix A
Detailed Test Results

Efficacy results for low level HPV against *Ba* Ames and Vollum on six material types are shown in Tables A-1 through A-18. Zero CFU were observed on all laboratory and procedural blanks.

Table A-1. Inactivation of *B. anthracis* Ames Spores using low level HPV[a]

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
1	250	STERIS 1000ED	23.0 ± 0.04	38.1 ± 4.3	1.19E+08	0.25	Glass	4.55 ± 1.61 x 10^7	2.29 ± 3.79 x 10^1	7.02 ± 1.20
						0.50			4.98 ± 8.59 x 10^5	4.37 ± 3.51
						1.00			1.56 ± 2.69 x 10^2	6.74 ± 1.75
						2.00			0.00 ± 0.00	≥7.63 ± 0.16
						3.00			0.00 ± 0.00	≥7.63 ± 0.16
						0.25	Pine Wood	3.34 ± 1.14 x 10^7	7.53 ± 6.54 x10^5	3.47 ± 3.96
						0.50			3.04 ± 1.38 x 10^5	2.05 ± 0.29
						1.00			3.32 ± 5.46 x 10^4	3.70 ± 1.16
						2.00			1.09 ± 1.72 x 10^4	4.40 ± 1.69
						3.00			1.56 ± 2.69 x 10^2	6.61 ± 1.75
						0.25	Carpet	9.38 ± 3.57 x 10^7	4.50 ± 7.62 x 10^1	7.23 ± 1.40
						0.50			2.06 ± 3.56 x 10^6	5.17 ± 4.04
						1.00			5.87 ± 6.99 x 10^5	4.03 ± 3.85
						2.00			5.76 ± 5.80 x 10^4	4.67 ± 3.22
						3.00			4.29 ± 4.04 x 10^4	4.74 ± 3.14
						0.25	Painted Wallboard Paper	1.00 ± 0.05 x 10^8	2.29 ± 3.93 x 10^4	5.55 ± 2.74
						0.50			0.00 ± 0.00	≥8.00 ± 0.02
						1.00			7.19 ± 7.87 x 10^4	4.68 ± 3.30
						2.00			0.00 ± 0.00	≥8.00 ± 0.02
						3.00			0.00 ± 0.00	≥8.00 ± 0.02
						0.25	Unpainted Concrete	1.79 ± 1.09 x 10^7	1.15 ± 1.28 x 10^7	0.32 ± 0.59
						0.50			6.92 ± 1.26 x 10^6	0.36 ± 0.23
						1.00			8.65 ± 7.15 x 10^6	0.35 ± 0.43
						2.00			4.11 ± 0.49 x 10^6	0.59 ± 0.22
						3.00			4.26 ± 1.18 x 10^6	0.58 ± 0.26
						0.25	Ceiling Tile	5.15 ± 1.30 x 10^7	8.75 ± 6.57 x 10^5	1.84 ± 0.39
						0.50			3.93 ± 2.90 x 10^4	3.26 ± 0.61
						1.00			4.50 ± 7.62 x 10^1	6.99 ± 1.39
						2.00			0.00 ± 0.00	≥7.70 ± 0.10
						3.00			0.00 ± 0.00	≥7.70 ± 0.10

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-2. Inactivation of *B. anthracis* Ames Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
2	10.42 ± 0.60	Bubbler	23.6 ± 0.26	58.5 ± 9.12	1.10E+08	0.25	Glass	$4.14 \pm 0.13 \times 10^7$	$1.06 \pm 0.65 \times 10^5$	2.68 ± 0.43
						0.50			$4.47 \pm 7.22 \times 10^4$	3.91 ± 1.63
						1.00			0.00 ± 0.00	≥7.62 ± 0.01
						2.00			$3.34 \pm 5.49 \times 10^2$	6.11 ± 1.69
						3.00			0.00 ± 0.00	≥7.62 ± 0.01
						0.25	Pine Wood	$2.93 \pm 0.94 \times 10^7$	$1.74 \pm 1.53 \times 10^5$	2.39 ± 0.65
						0.50			$3.60 \pm 3.93 \times 10^4$	4.32 ± 3.07
						1.00			0.00 ± 0.00	≥7.44 ± 0.15
						2.00			0.00 ± 0.00	≥7.44 ± 0.15
						3.00			0.00 ± 0.00	≥7.44 ± 0.15
						0.25	Carpet	$9.77 \pm 0.87 \times 10^7$	$8.89 \pm 0.72 \times 10^7$	0.04 ± 0.05
						0.50			$2.04 \pm 0.20 \times 10^7$	0.68 ± 0.06
						1.00			$2.34 \pm 0.95 \times 10^6$	1.65 ± 0.24
						2.00			$2.28 \pm 0.99 \times 10^6$	1.66 ± 0.21
						3.00			$8.18 \pm 2.62 \times 10^5$	2.09 ± 0.16
						0.25	Painted Wallboard Paper	$9.13 \pm 0.82 \times 10^7$	$5.20 \pm 4.58 \times 10^7$	0.55 ± 0.92
						0.50			$1.02 \pm 1.71 \times 10^6$	2.89 ± 1.46
						1.00			$4.15 \pm 6.89 \times 10^6$	3.75 ± 4.22
						2.00			$4.67 \pm 8.08 \times 10^5$	5.91 ± 4.01
						3.00			$4.79 \pm 5.55 \times 10^4$	3.81 ± 1.29
						0.25	Unpainted Concrete	$1.10 \pm 0.29 \times 10^8$	$7.74 \pm 4.03 \times 10^6$	1.18 ± 0.25
						0.50			$1.18 \pm 0.46 \times 10^7$	0.99 ± 0.24
						1.00			$7.65 \pm 4.97 \times 10^6$	1.26 ± 0.49
						2.00			$3.51 \pm 1.92 \times 10^6$	1.53 ± 0.27
						3.00			$3.52 \pm 0.62 \times 10^6$	1.49 ± 0.13
						0.25	Ceiling Tile	$3.33 \pm 1.31 \times 10^7$	$4.26 \pm 0.88 \times 10^6$	0.86 ± 0.23
						0.50			$2.11 \pm 2.01 \times 10^4$	3.31 ± 0.56
						1.00			$7.83 \pm 13.4 \times 10^1$	6.69 ± 1.56
						2.00			0.00 ± 0.00	≥7.48 ± 0.20
						3.00			0.00 ± 0.00	≥7.48 ± 0.20

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE).). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-3. Inactivation of *B. anthracis* Ames Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
3	9.29 ± 1.02	Bubbler	27.4 ± 0.84	76.1 ± 5.43	1.02E+08	4.00	Glass	6.06 ± 0.74 x 10^7	2.29 ± 3.79 x 10^1	7.17 ± 1.19
						8.00			0.00 ± 0.00	≥7.78 ± 0.05
						12.00			0.00 ± 0.00	≥7.78 ± 0.05
						16.00			0.00 ± 0.00	≥7.78 ± 0.05
						20.00			0.00 ± 0.00	≥7.78 ± 0.05
						4.00	Pine Wood	1.86 ± 1.20 x 10^7	7.33 ± 2.51 x 10^4	2.24 ± 0.53
						8.00			1.66 ± 1.90 x 10^4	3.23 ± 1.06
						12.00			5.84 ± 7.87 x 10^4	3.12 ± 1.76
						16.00			5.03 ± 4.90 x 10^3	3.55 ± 0.77
						20.00			7.35 ± 7.81 x 10^3	3.42 ± 0.78
						4.00	Carpet	9.35 ± 0.85 x 10^7	5.31 ± 0.03 x 10^7	0.24 ± 0.03
						8.00			3.85 ± 2.62 x 10^6	1.45 ± 0.32
						12.00			9.57 ± 2.78 x 10^6	1.00 ± 0.16
						16.00			4.70 ± 2.02 x 10^5	2.32 ± 0.22
						20.00			3.39 ± 3.41 x 10^5	2.67 ± 0.69
						4.00	Painted Wallboard Paper	8.04 ± 0.97 x 10^7	4.60 ± 7.97 x 10^6	3.43 ± 2.67
						8.00			3.44 ± 5.94 x 10^2	6.90 ± 1.97
						12.00			0.00 ± 0.00	≥7.90 ± 0.05
						16.00			0.00 ± 0.00	≥7.90 ± 0.05
						20.00			0.00 ± 0.00	≥7.90 ± 0.05
						4.00	Unpainted Concrete	3.94 ± 2.56 x 10^7	4.13 ± 2.54 x 10^7	-0.02 ± 0.47
						8.00			4.74 ± 4.09 x 10^6	1.36 ± 1.38
						12.00			3.78 ± 2.57 x 10^6	1.06 ± 0.56
						16.00			2.77 ± 3.60 x 10^6	1.35 ± 0.71
						20.00			2.51 ± 3.13 x 10^6	1.36 ± 0.67
						4.00	Ceiling Tile	3.19 ± 0.38 x 10^7	4.88 ± 2.28 x 10^3	3.84 ± 0.22
						8.00			1.18 ± 1.86 x 10^1	6.99 ± 1.00
						12.00			0.00 ± 0.00	≥7.50 ± 0.05
						16.00			0.00 ± 0.00	≥7.50 ± 0.05
						20.00			0.00 ± 0.00	≥7.50 ± 0.05

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).
[b] Positive Controls = samples inoculated, not decontaminated.
[c] Test Coupons = samples inoculated, decontaminated.
[d] CI = confidence interval (± 1.96 × SE).). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-4. Inactivation of *B. anthracis* Ames Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
4	25.7 ± 1.41	STERIS 1000ED	22.9 ± 0.05	32.6 ± 22.4	9.50E+07	2.00	Glass	5.41 ± 0.81 x 10^6	1.42 ± 1.72 x 10^6	1.82 ± 0.63
						4.00			1.41 ± 2.39 x 10^5	3.56 ± 1.43
						6.00			3.23 ± 3.49 x 10^3	4.64 ± 1.09
						8.00			0.00 ± 0.00	≥7.73 ± 0.06
						12.00			3.98 ± 6.69 x 10^3	5.58 ± 2.31
						8.00	Pine Wood	2.05 ± 1.05 x 10^7	3.56 ± 2.60 x 10^4	2.88 ± 0.65
						12.00			2.10 ± 1.25 x 10^4	3.03 ± 0.45
						16.00			1.21 ± 0.63 x 10^4	2.22 ± 0.31
						20.00			3.01 ± 2.35 x 10^4	2.98 ± 0.71
						24.00			1.50 ± 2.57 x 10^4	4.20 ± 1.57
						8.00	Carpet	6.97 ± 0.83 x 10^7	4.38 ± 1.00 x 10^6	1.21 ± 0.12
						12.00			1.12 ± 0.15 x 10^7	0.80 ± 0.08
						16.00			5.81 ± 2.51 x 10^5	2.11 ± 0.26
						20.00			8.79 ± 8.40 x 10^5	2.28 ± 1.07
						24.00			8.03 ± 8.37 x 10^5	2.34 ± 1.07
						2.00	Painted Wallboard Paper	6.81 ± 2.34 x 10^7	3.73 ± 3.61 x 10^7	0.36 ± 0.50
						4.00			9.81 ± 3.33 x 10^6	0.86 ± 0.27
						6.00			5.92 ± 2.74 x 10^6	1.06 ± 0.29
						8.00			5.53 ± 4.33 x 10^5	2.20 ± 0.57
						12.00			1.24 ± 1.49 x 10^5	2.99 ± 0.77
						8.00	Unpainted Concrete	7.86 ± 5.14 x 10^7	4.26 ± 3.26 x 10^6	0.27 ± 0.44
						12.00			2.51 ± 2.20 x 10^6	0.53 ± 0.49
						16.00			3.29 ± 2.83 x 10^6	0.90 ± 1.54
						20.00			2.91 ± 1.85 x 10^6	0.44 ± 0.48
						24.00			2.84 ± 0.34 x 10^6	0.37 ± 0.26
						2.00	Ceiling Tile	3.58 ± 0.65 x 10^7	4.17 ± 1.14 x 10^5	1.94 ± 0.15
						4.00			6.35 ± 2.66 x 10^4	2.77 ± 0.22
						6.00			8.33 ± 1.17 x 10^4	2.63 ± 0.10
						8.00			4.48 ± 3.28 x 10^3	3.98 ± 0.37
						12.00			4.10 ± 0.46 x 10^2	3.94 ± 0.09

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE).). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-5. Inactivation of *B. anthracis* Ames Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
5	25.5 ± 0.98	STERIS 1000ED	23.9 ± 0.05	62.4 ± 23.9	8.50E+07	2.00	Glass	4.01 ± 0.65 x 10^7	5.38 ± 5.12 x 10^4	4.34 ± 3.20
						4.00			0.00 ± 0.00	≥7.60 ± 0.07
						6.00			0.00 ± 0.00	≥7.60 ± 0.07
						8.00			1.18 ± 1.86 x 101	7.09 ± 1.00
						12.00			0.00 ± 0.00	≥7.60 ± 0.07
						8.00	Pine Wood	1.99 ± 0.95 x 10^7	1.48 ± 2.47 x 10^5	2.92 ± 1.30
						12.00			3.20 ± 4.65 x 10^3	4.94 ± 2.34
						16.00			2.20 ± 0.85 x 10^3	3.95 ± 0.28
						20.00			7.16 ± 9.40 x 10^3	4.66 ± 2.59
						24.00			1.04 ± 1.72 x 10^5	3.07 ± 1.33
						8.00	Carpet	7.36 ± 2.14 x 10^7	1.07 ± 1.85 x 10^6	5.70 ± 4.25
						12.00			5.11 ± 5.36 x 10^5	2.34 ± 0.57
						16.00			2.94 ± 5.10 x 10^4	6.22 ± 3.23
						20.00			0.00 ± 0.00	≥7.87 ± 0.01
						24.00			0.00 ± 0.00	≥7.87 ± 0.01
						2.00	Painted Wallboard Paper	5.33 ± 1.05 x 10^7	4.23 ± 4.50 x 10^5	2.87 ± 1.79
						4.00			3.70 ± 3.22 x 10^4	4.05 ± 2.11
						6.00			3.73 ± 6.12 x 10^4	3.85 ± 1.15
						8.00			5.31 ± 8.66 x 10^4	3.80 ± 1.35
						12.00			3.78 ± 1.68 x 10^2	5.18 ± 0.26
						8.00	Unpainted Concrete	1.17 ± 0.38 x 10^7	3.56 ± 6.49 x 10^6	0.50 ± 0.16
						12.00			2.62 ± 0.99 x 10^6	0.65 ± 0.25
						16.00			3.57 ± 1.91 x 10^6	0.55 ± 0.37
						20.00			2.60 ± 0.53 x 10^6	0.64 ± 0.17
						24.00			3.20 ± 0.69 x 10^6	0.55 ± 0.17
						2.00	Ceiling Tile	3.11 ± 0.49 x 10^7	4.77 ± 8.08 x 10^4	4.16 ± 2.05
						4.00			2.29 ± 3.79 x 10^1	6.88 ± 1.19
						6.00			7.82 ± 8.36 x 10^1	6.14 ± 1.34
						8.00			4.50 ± 7.62 x 10^1	6.78 ± 1.39
						12.00			0.00 ± 0.00	≥7.49 ± 0.06

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE).). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-6. Inactivation of *B. anthracis* Ames Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
6	50.3 ± 1.51	STERIS 1000ED	23.5 ± 0.28	25.9 ± 1.93	1.13E+08	2.00	Glass	4.09 ± 0.75 x 10^7	2.21 ± 3.66 x 10^3	5.57 ± 2.17
						4.00			2.12 ± 1.89 x 10^2	5.94 ± 1.63
						6.00			0.00 ± 0.00	≥7.61 ± 0.07
						8.00			0.00 ± 0.00	≥7.61 ± 0.07
						12.00			0.00 ± 0.00	≥7.61 ± 0.07
						8.00	Pine Wood	1.10 ± 0.22 x 10^7	3.30 ± 4.68 x 10^4	2.89 ± 0.82
						12.00			3.25 ± 5.21 x 10^4	3.15 ± 1.10
						16.00			1.95 ± 1.55 x 10^5	1.83 ± 0.37
						20.00			1.49 ± 2.35 x 10^4	3.57 ± 1.28
						24.00			3.41 ± 5.79 x 10^5	2.95 ± 2.20
						8.00	Carpet	8.46 ± 0.58 x 10^7	2.81 ± 0.27 x 10^7	0.48 ± 0.05
						12.00			2.84 ± 1.89 x 10^6	1.53 ± 0.30
						16.00			1.24 ± 0.74 x 10^6	1.91 ± 0.39
						20.00			8.52 ± 2.33 x 10^5	2.01 ± 0.13
						24.00			9.31 ± 4.06 x 10^4	2.99 ± 0.24
						2.00	Painted Wallboard Paper	7.11 ± 0.94 x 10^7	2.61 ± 1.56 x 10^6	1.51 ± 0.41
						4.00			3.98 ± 6.18 x 10^6	1.86 ± 1.13
						6.00			2.20 ± 2.86 x 10^6	1.90 ± 0.92
						8.00			3.88 ± 4.22 x 10^5	2.44 ± 0.54
						12.00			1.57 ± 1.84 x 10^4	4.01 ± 0.92
						8.00	Unpainted Concrete	1.40 ± 0.91 x 10^7	8.27 ± 1.13 x 10^6	0.18 ± 0.21
						12.00			4.48 ± 2.08 x 10^6	0.47 ± 0.29
						16.00			2.51 ± 2.10 x 10^6	0.79 ± 0.43
						20.00			3.29 ± 3.51 x 10^6	0.74 ± 0.56
						24.00			2.06 ± 1.54 x 10^6	0.87 ± 0.44
						2.00	Ceiling Tile	2.89 ± 0.71 x 10^7	1.18 ± 1.86 x 10^1	6.94 ± 1.00
						4.00			3.78 ± 5.17 x 10^2	5.71 ± 1.76
						6.00			7.81 ± 10.70 x 10^2	6.17 ± 1.33
						8.00			0.00 ± 0.00	≥7.45 ± 0.11
						12.00			0.00 ± 0.00	≥7.45 ± 0.11

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE).). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-7. Inactivation of *B. anthracis* Ames Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
7	50.0 ± 1.10	STERIS 1000ED	23.77 ± 3.86	60.07 ± 3.86	9.53E+07	1.00	Glass	$5.20 \pm 0.47 \times 10^7$	0.00 ± 0.00	≥7.71 ± 0.04
						2.00			0.00 ± 0.00	≥7.71 ± 0.04
						4.00			0.00 ± 0.00	≥7.71 ± 0.04
						5.00			0.00 ± 0.00	≥7.71 ± 0.04
						6.00			0.00 ± 0.00	≥7.71 ± 0.04
						8.00	Pine Wood	$2.31 \pm 1.14 \times 10^7$	$2.09 \pm 2.24 \times 10^5$	2.17 ± 0.53
						12.00			$1.16 \pm 1.88 \times 10^5$	4.10 ± 3.26
						16.00			$0.67 \pm 1.17 \times 10^3$	6.22 ± 2.17
						20.00			$3.19 \pm 3.56 \times 10^4$	4.24 ± 3.04
						24.00			0.00 ± 0.00	≥7.32 ± 0.18
						8.00	Carpet	$6.59 \pm 0.70 \times 10^7$	$2.19 \pm 0.79 \times 10^5$	1.49 ± 0.17
						12.00			$2.27 \pm 1.31 \times 10^5$	2.51 ± 0.27
						16.00			$1.66 \pm 2.13 \times 10^4$	4.96 ± 2.83
						20.00			$5.77 \pm 9.13 \times 10^2$	6.08 ± 1.84
						24.00			$1.95 \pm 2.94 \times 10^3$	5.67 ± 2.18
						1.00	Painted Wallboard Paper	$6.31 \pm 1.24 \times 10^7$	0.00 ± 0.00	≥7.79 ± 0.08
						2.00			0.00 ± 0.00	≥7.79 ± 0.08
						4.00			$1.53 \pm 2.65 \times 10^5$	5.05 ± 3.21
						5.00			$2.22 \pm 2.71 \times 10^2$	5.71 ± 0.69
						6.00			$1.43 \pm 2.33 \times 10^4$	4.32 ± 1.15
						8.00	Unpainted Concrete	$2.35 \pm 1.32 \times 10^7$	$3.38 \pm 1.75 \times 10^6$	0.83 ± 0.35
						12.00			$3.53 \pm 1.47 \times 10^6$	0.83 ± 0.42
						16.00			$4.96 \pm 0.19 \times 10^6$	0.62 ± 0.22
						20.00			$1.96 \pm 0.67 \times 10^6$	1.04 ± 0.27
						24.00			$3.78 \pm 1.98 \times 10^6$	0.78 ± 0.34
						1.00	Ceiling Tile	$3.83 \pm 0.51 \times 10^7$	$2.56 \pm 3.74 \times 10^4$	3.63 ± 0.94
						2.00			$2.33 \pm 2.19 \times 10^2$	5.42 ± 0.67
						4.00			0.00 ± 0.00	≥7.58 ± 0.05
						5.00			0.00 ± 0.00	≥7.58 ± 0.05
						6.00			0.00 ± 0.00	≥7.58 ± 0.05

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE).). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-8. Inactivation of *B. anthracis* Ames Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
8	43.50 ± 12.61	STERIS 1000ED	22.98 ± 0.43	76.91 ± 5.45	7.17E+07	1.00	Glass	1.27 ± 0.47 x 10^7	1.21 ± 2.10 x 10^3	5.81 ± 2.33
						2.00			0.00 ± 0.00	≥7.00 ± 0.16
						4.00			0.00 ± 0.00	≥7.00 ± 0.16
						5.00			0.00 ± 0.00	≥7.00 ± 0.16
						6.00			0.00 ± 0.00	≥7.00 ± 0.16
						8.00	Pine Wood	1.04 ± 0.30 x 10^7	2.04 ± 1.88 x 10^4	2.81 ± 0.44
						12.00			3.66 ± 5.41 x 10^4	3.99 ± 3.00
						16.00			1.35 ± 1.33 x 10^4	3.64 ± 1.81
						20.00			3.68 ± 4.32 x 10^3	3.67 ± 0.64
						24.00			0.00 ± 0.00	≥7.00 ± 0.11
						8.00	Carpet	3.61 ± 0.50 x 10^7	1.21 ± 2.10 x 10^4	6.03 ± 2.98
						12.00			0.00 ± 0.00	7.55 ± 0.05
						16.00			0.00 ± 0.00	7.55 ± 0.05
						20.00			0.00 ± 0.00	7.55 ± 0.05
						24.00			0.00 ± 0.00	7.55 ± 0.05
						1.00	Painted Wallboard Paper	2.92 ± 1.15 x 10^7	3.96 ± 4.26 x 10^5	2.65 ± 1.90
						2.00			0.00 ± 0.00	≥7.42 ± 0.21
						4.00			1.45 ± 2.49 x 10^2	6.55 ± 1.74
						5.00			0.00 ± 0.00	≥7.42 ± 0.21
						6.00			0.00 ± 0.00	≥7.42 ± 0.21
						8.00	Unpainted Concrete	8.02 ± 2.60 x 10^6	1.58 ± 1.32 x 10^6	0.78 ± 0.41
						12.00			1.34 ± 0.35 x 10^6	0.77 ± 0.20
						16.00			4.67 ± 5.05 x 10^6	1.38 ± 0.53
						20.00			1.14 ± 0.51 x 10^6	0.85 ± 0.25
						24.00			1.50 ± 1.24 x 10^6	0.80 ± 0.41
						1.00	Ceiling Tile	1.76 ± 0.85 x 10^7	3.45 ± 1.46 x 10^5	1.70 ± 0.30
						2.00			1.90 ± 2.48 x 10^3	4.98 ± 2.22
						4.00			0.00 ± 0.00	≥7.21 ± 0.18
						5.00			0.00 ± 0.00	≥7.21 ± 0.18
						6.00			0.00 ± 0.00	≥7.21 ± 0.18

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-9. Inactivation of *B. anthracis* Ames Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
9	25.22 ± 1.64	Bubbler	23.77 ± 0.40	91.64 ± 6.33	8.80E+07	1.00	Glass	3.67 ± 0.61 x 10^7	3.95 ± 0.52 x 10^6	0.97 ± 0.10
						2.00			6.18 ± 4.24 x 10^5	1.88 ± 0.49
						6.00			0.00 ± 0.00	≥7.56 ± 0.07
						8.00			0.00 ± 0.00	≥7.56 ± 0.07
						12.00			0.00 ± 0.00	≥7.56 ± 0.07
						8.00	Pine Wood	1.84 ± 1.82 x 10^7	1.42 ± 1.70 x 10^5	2.35 ± 0.95
						12.00			9.54 ± 6.01 x 10^4	2.25 ± 0.49
						16.00			8.68 ± 2.97 x 10^4	2.22 ± 0.33
						20.00			4.80 ± 7.97 x 10^4	3.23 ± 1.24
						24.00			2.66 ± 3.77 x 10^3	4.86 ± 2.30
						8.00	Carpet	8.07 ± 0.81 x 10^7	7.67 ± 2.23 x 105	2.04 ± 0.16
						12.00			8.19 ± 2.03 x 10^5	2.00 ± 0.12
						16.00			0.00 ± 0.00	7.91 ± 0.04
						20.00			0.00 ± 0.00	7.91 ± 0.04
						24.00			0.00 ± 0.00	7.91 ± 0.04
						1.00	Painted Wallboard Paper	5.65 ± 0.77 x 10^7	7.57 ± 3.07 x 10^5	1.89 ± 0.19
						2.00			3.50 ± 6.06 x 10^4	6.08 ± 3.28
						6.00			0.00 ± 0.00	≥7.75 ± 0.05
						8.00			0.00 ± 0.00	≥7.75 ± 0.05
						12.00			0.00 ± 0.00	≥7.75 ± 0.05
						8.00	Unpainted Concrete	2.36 ± 1.36 x 10^7	7.85 ± 3.16 x 10^5	1.45 ± 0.28
						12.00			3.42 ± 2.19 x 10^6	0.87 ± 0.46
						16.00			1.59 ± 1.58 x 10^6	1.26 ± 0.52
						20.00			4.55 ± 2.71 x 10^5	1.71 ± 0.34
						24.00			5.94 ± 5.06 x 10^5	1.83 ± 0.90
						1.00	Ceiling Tile	1.26 ± 0.22 x 10^7	6.07 ± 2.51 x 10^6	0.34 ± 0.25
						2.00			1.13 ± 0.46 x 10^5	1.07 ± 0.25
						6.00			0.00 ± 0.00	≥7.09 ± 0.06
						8.00			1.14 ± 1.98 x 10^3	5.92 ± 2.31
						12.00			0.00 ± 0.00	≥7.09 ± 0.06

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-10. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
1	250	STERIS 1000ED	23.0 ± 0.04	38.1 ± 4.3	8.97E+07	0.25	Glass	1.17 ± 0.48 x 10^7	1.18 ± 1.86 x 10^1	6.52 ± 1.02
						0.50			1.54 ± 2.45 x 10^4	4.34 ± 2.73
						1.00			0.00 ± 0.00	≥7.03 ± 0.21
						2.00			0.00 ± 0.00	≥7.03 ± 0.21
						3.00			2.56 ± 3.09 x 10^2	5.36 ± 1.68
						0.25	Pine Wood	4.43 ± 2.09 x 10^6	2.71 ± 3.69 x 10^4	2.47 ± 0.76
						0.50			1.04 ± 1.53 x 10^4	3.05 ± 0.99
						1.00			1.03 ± 1.79 x 10^3	5.43 ± 2.29
						2.00			1.18 ± 1.86 x 10^1	6.08 ± 1.02
						3.00			5.45 ± 9.14 x 10^2	5.01 ± 1.83
						0.25	Carpet	1.20 ± 0.12 x 10^7	1.20 ± 0.40 x 10^6	1.02 ± 0.18
						0.50			7.69 ± 5.32 x 10^6	0.30 ± 0.46
						1.00			5.74 ± 0.62 x 10^4	2.32 ± 0.07
						2.00			1.09 ± 0.95 x 10^3	4.94 ± 2.10
						3.00			3.78 ± 2.22 x 10^2	4.55 ± 0.27
						0.25	Painted Wallboard Paper	4.25 ± 5.44 x 10^7	7.18 ± 6.92 x 10^5	2.90 ± 2.96
						0.50			1.22 ± 1.48 x 10^5	2.55 ± 0.71
						1.00			0.00 ± 0.00	≥7.42 ± 0.38
						2.00			0.00 ± 0.00	≥7.42 ± 0.38
						3.00			0.00 ± 0.00	≥7.42 ± 0.38
						0.25	Unpainted Concrete	1.92 ± 2.78 x 10^6	1.56 ± 2.07 x 10^5	1.06 ± 1.07
						0.50			1.33 ± 2.23 x 10^5	1.58 ± 1.42
						1.00			8.33 ± 2.67 x 10^2	2.97 ± 0.65
						2.00			4.00 ± 6.93 x 10^3	4.52 ± 2.74
						3.00			2.10 ± 1.15 x 10^3	2.59 ± 0.68
						0.25	Ceiling Tile	1.38 ± 1.43 x 10^6	1.18 ± 1.86 x 10^1	5.44 ± 1.07
						0.50			3.37 ± 3.29 x 10^1	4.83 ± 1.18
						1.00			0.00 ± 0.00	≥5.95 ± 0.40
						2.00			0.00 ± 0.00	≥5.95 ± 0.40
						3.00			0.00 ± 0.00	≥5.95 ± 0.40

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-11. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
2	10.42 ± 0.60	Bubbler	23.6 ± 0.26	58.5 ± 9.12	1.15E+08	4.00	Glass	$6.81 \pm 3.03 \times 10^6$	$2.06 \pm 3.56 \times 10^6$	3.47 ± 3.85
						8.00			$0.67 \pm 1.15 \times 10^3$	5.69 ± 2.17
						12.00			0.00 ± 0.00	≥6.79 ± 0.19
						16.00			0.00 ± 0.00	≥6.79 ± 0.19
						20.00			0.00 ± 0.00	≥6.79 ± 0.19
						4.00	Pine Wood	$1.84 \pm 1.33 \times 10^6$	$1.31 \pm 1.84 \times 10^4$	2.44 ± 0.89
						8.00			$0.97 \pm 1.59 \times 10^4$	3.69 ± 2.58
						12.00			$2.67 \pm 4.05 \times 10^2$	4.61 ± 1.67
						16.00			$2.29 \pm 3.79 \times 10^1$	5.56 ± 1.22
						20.00			$2.29 \pm 3.79 \times 10^1$	5.56 ± 1.22
						4.00	Carpet	$6.70 \pm 0.28 \times 10^6$	$3.93 \pm 0.55 \times 10^6$	0.23 ± 0.07
						8.00			$6.10 \pm 0.94 \times 10^5$	1.04 ± 0.08
						12.00			$8.78 \pm 6.70 \times 10^2$	4.06 ± 0.64
						16.00			$9.98 \pm 1.51 \times 10^2$	3.83 ± 0.08
						20.00			$1.00 \pm 1.45 \times 10^2$	5.51 ± 1.39
						4.00	Painted Wallboard Paper	$1.95 \pm 2.99 \times 10^7$	$0.93 \pm 1.60 \times 10^6$	2.41 ± 1.86
						8.00			$4.48 \pm 5.01 \times 10^1$	5.83 ± 1.26
						12.00			$1.11 \pm 1.92 \times 10^3$	5.83 ± 2.34
						16.00			0.00 ± 0.00	≥7.00 ± 0.42
						20.00			0.00 ± 0.00	≥7.00 ± 0.42
						4.00	Unpainted Concrete	$0.90 \pm 1.47 \times 10^6$	$4.62 \pm 3.26 \times 10^4$	0.95 ± 0.80
						8.00			$1.45 \pm 1.20 \times 10^5$	0.44 ± 0.75
						12.00			$1.39 \pm 0.28 \times 10^4$	1.36 ± 0.63
						16.00			$2.32 \pm 2.06 \times 10^3$	2.24 ± 0.74
						20.00			$1.91 \pm 1.25 \times 10^4$	1.29 ± 0.73
						4.00	Ceiling Tile	$3.25 \pm 1.23 \times 10^5$	$1.62 \pm 1.18 \times 10^3$	2.38 ± 0.47
						8.00			0.00 ± 0.00	≥5.49 ± 0.14
						12.00			0.00 ± 0.00	≥5.49 ± 0.14
						16.00			0.00 ± 0.00	≥5.49 ± 0.14
						20.00			0.00 ± 0.00	≥5.49 ± 0.14

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-12. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
3	9.29 ± 1.02	Bubbler	27.4 ± 0.84	76.1 ± 5.43	9.13E+07	4.00	Glass	6.90 ± 1.99 x 10^6	0.00 ± 0.00	≥6.83 ± 0.11
						8.00			0.00 ± 0.00	≥6.83 ± 0.11
						12.00			0.00 ± 0.00	≥6.83 ± 0.11
						16.00			0.00 ± 0.00	≥6.83 ± 0.11
						20.00			0.00 ± 0.00	≥6.83 ± 0.11
						4.00	Pine Wood	4.19 ± 1.21 x 10^5	1.19 ± 1.83 x 10^4	2.36 ± 1.54
						8.00			6.33 ± 2.03 x 10^2	2.83 ± 0.20
						12.00			0.00 ± 0.00	≥5.61 ± 0.10
						16.00			1.18 ± 1.86 x 10^1	5.10 ± 1.00
						20.00			5.59 ± 5.04 x 10^1	4.34 ± 1.26
						4.00	Carpet	6.91 ± 6.16 x 10^6	8.69 ± 2.55 x 10^5	0.91 ± 0.15
						8.00			4.51 ± 0.32 x 10^4	2.18 ± 0.05
						12.00			1.73 ± 0.24 x 10^2	3.60 ± 0.08
						16.00			2.22 ± 1.92 x 10^2	5.16 ± 1.65
						20.00			0.00 ± 0.00	≥6.84 ± 0.03
						4.00	Painted Wallboard Paper	4.71 ± 0.31 x 10^6	3.47 ± 6.00 x 10^3	5.33 ± 2.63
						8.00			0.00 ± 0.00	≥6.67 ± 0.03
						12.00			0.00 ± 0.00	≥6.67 ± 0.03
						16.00			0.00 ± 0.00	≥6.67 ± 0.03
						20.00			0.00 ± 0.00	≥6.67 ± 0.03
						4.00	Unpainted Concrete	9.57 ± 4.80 x 10^6	4.39 ± 1.50 x 10^5	1.30 ± 0.29
						8.00			1.14 ± 1.70 x 10^4	4.26 ± 2.68
						12.00			2.39 ± 2.33 x 10^4	2.68 ± 0.51
						16.00			3.61 ± 5.33 x 10^4	2.78 ± 0.86
						20.00			2.89 ± 3.90 x 10^2	5.26 ± 1.70
						4.00	Ceiling Tile	8.02 ± 2.16 x 10^4	2.44 ± 1.93 x 10^2	2.58 ± 0.37
						8.00			0.00 ± 0.00	≥4.89 ± 0.11
						12.00			0.00 ± 0.00	≥4.89 ± 0.11
						16.00			0.00 ± 0.00	≥4.89 ± 0.11
						20.00			0.00 ± 0.00	≥4.89 ± 0.11

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-13. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
4	25.7 ± 1.41	STERIS 1000ED	22.9 ± 0.05	32.6 ± 22.4	8.63E+07	2.00	Glass	$3.77 \pm 1.10 \times 10^6$	$4.50 \pm 7.62 \times 10^1$	5.85 ± 1.39
						4.00			$4.48 \pm 5.05 \times 10^1$	5.39 ± 1.19
						6.00			$5.63 \pm 9.58 \times 10^1$	5.82 ± 1.46
						8.00			0.00 ± 0.00	≥6.56 ± 0.11
						12.00			0.00 ± 0.00	≥6.56 ± 0.11
						8.00	Pine Wood	$3.83 \pm 1.64 \times 10^6$	$0.96 \pm 1.60 \times 10^4$	3.63 ± 1.67
						12.00			$3.78 \pm 4.11 \times 10^2$	4.26 ± 0.82
						16.00			$0.92 \pm 1.13 \times 10^3$	3.93 ± 0.88
						20.00			$4.48 \pm 5.05 \times 10^1$	5.38 ± 1.19
						24.00			$5.10 \pm 8.06 \times 10^3$	3.50 ± 1.17
						8.00	Carpet	$0.91 \pm 1.22 \times 10^7$	$4.22 \pm 3.34 \times 10^4$	2.22 ± 0.74
						12.00			$3.15 \pm 1.90 \times 10^4$	2.25 ± 0.55
						16.00			$7.78 \pm 1.78 \times 10^3$	2.80 ± 0.45
						20.00			$3.12 \pm 5.38 \times 10^2$	5.69 ± 1.99
						24.00			$2.34 \pm 3.47 \times 10^2$	5.14 ± 1.62
						2.00	Painted Wallboard Paper	$4.80 \pm 0.95 \times 10^6$	$4.64 \pm 7.16 \times 10^5$	1.51 ± 0.94
						4.00			$3.00 \pm 2.60 \times 10^2$	4.90 ± 1.74
						6.00			0.00 ± 0.00	≥6.67 ± 0.08
						8.00			0.00 ± 0.00	≥6.67 ± 0.08
						12.00			0.00 ± 0.00	≥6.67 ± 0.08
						8.00	Unpainted Concrete	$1.28 \pm 0.75 \times 10^6$	$1.50 \pm 1.49 \times 10^4$	2.01 ± 0.56
						12.00			$3.04 \pm 2.80 \times 10^3$	3.60 ± 2.40
						16.00			$1.45 \pm 2.04 \times 10^4$	2.22 ± 0.80
						20.00			$3.20 \pm 1.58 \times 10^3$	2.58 ± 0.40
						24.00			$5.50 \pm 1.07 \times 10^3$	2.30 ± 0.28
						2.00	Ceiling Tile	$5.84 \pm 3.32 \times 10^5$	$2.32 \pm 0.58 \times 10^3$	2.32 ± 0.33
						4.00			$4.48 \pm 5.05 \times 10^1$	4.51 ± 1.22
						6.00			$1.18 \pm 1.86 \times 10^1$	5.17 ± 1.04
						8.00			0.00 ± 0.00	≥5.68 ± 0.30
						12.00			0.00 ± 0.00	≥5.68 ± 0.30

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-14. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
5	25.5 ± 0.98	STERIS 1000ED	23.9 ± 0.10	62.4 ± 23.9	9.03E+07	2.00	Glass	3.31 ± 1.42 x 10^6	1.90 ± 3.27 x 10^2	5.56 ± 1.81
						4.00			0.00 ± 0.00	≥6.48 ± 0.19
						6.00			0.00 ± 0.00	≥6.48 ± 0.19
						8.00			0.00 ± 0.00	≥6.48 ± 0.19
						12.00			0.00 ± 0.00	≥6.48 ± 0.19
						8.00	Pine Wood	3.30 ± 2.35 x 10^6	2.45 ± 3.95x 10^2	4.94 ± 1.65
						12.00			1.23 ± 2.11 x 10^2	5.54 ± 1.71
						16.00			2.23 ± 3.29 x 10^2	4.86 ± 1.63
						20.00			1.46 ± 2.52 x 10^3	5.18 ± 2.40
						24.00			0.71 ± 1.23 x 10^3	5.29 ± 2.20
						8.00	Carpet	0.80 ± 1.02 x 10^6	7.18 ± 3.10 x 10^4	0.89 ± 0.43
						12.00			1.54 ± 0.20 x 10^3	2.53 ± 0.35
						16.00			5.32 ± 6.92 x 10^2	3.26 ± 0.76
						20.00			0.89 ± 1.26 x 10^2	4.42 ± 1.40
						24.00			0.00 ± 0.00	≥5.71 ± 0.35
						8.00	Painted Wallboard Paper	3.84 ± 0.43 x 10^6	2.34 ± 1.71 x 10^4	2.35 ± 0.55
						12.00			0.00 ± 0.00	≥6.58 ± 0.04
						16.00			0.00 ± 0.00	≥6.58 ± 0.04
						20.00			0.00 ± 0.00	≥6.58 ± 0.04
						24.00			0.00 ± 0.00	≥6.58 ± 0.04
						8.00	Unpainted Concrete	6.00 ± 4.40 x 10^5	7.77 ± 5.53 x 10^3	1.91 ± 0.68
						12.00			5.87 ± 6.59 x 10^3	3.06 ± 2.58
						16.00			3.10 ± 1.47 x 10^3	2.19 ± 0.41
						20.00			4.75 ± 2.79 x 10^3	2.03 ± 0.46
						24.00			8.35 ± 1.69 x 10^3	1.74 ± 0.36
						8.00	Ceiling Tile	3.35 ± 1.85 x 10^5	3.18 ± 4.09 x 10^3	2.32 ± 0.33
						12.00			1.18 ± 1.86 x 10^1	4.65 ± 1.03
						16.00			0.00 ± 0.00	≥5.46 ± 0.25
						20.00			0.00 ± 0.00	≥5.46 ± 0.25
						24.00			0.00 ± 0.00	≥5.46 ± 0.25

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-15. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
6	50.3 ± 1.51	STERIS 1000ED	23.5 ± 0.28	25.9 ± 1.93	8.67E+07	2.00	Glass	2.96 ± 0.01 x 10^6	1.18 ± 1.86 x 10^1	5.96 ± 1.00
						4.00			0.00 ± 0.00	≥6.48 ± 0.01
						6.00			0.00 ± 0.00	≥6.48 ± 0.01
						8.00			3.34 ± 5.77 x 10^2	5.47 ± 1.96
						12.00			0.00 ± 0.00	≥6.48 ± 0.01
						8.00	Pine Wood	3.13 ± 0.35 x 10^6	1.13 ± 1.00 x 10^3	4.34 ± 2.11
						12.00			0.78 ± 1.34 x 10^2	5.70 ± 1.55
						16.00			2.29 ± 3.79 x 10^1	5.89 ± 1.19
						20.00			2.29 ± 3.79 x 10^3	5.89 ± 1.19
						24.00			0.00 ± 0.00	≥6.49 ± 0.04
						8.00	Carpet	3.47 ± 0.75 x 10^6	3.01 ± 0.29 x 10^4	1.06 ± 0.08
						12.00			1.84 ± 0.74 x 10^3	3.30 ± 0.24
						16.00			1.34 ± 2.03 x 10^2	5.17 ± 1.46
						20.00			6.69 ± 6.60 x 10^1	5.22 ± 1.30
						24.00			0.00 ± 0.00	≥6.53 ± 0.07
						8.00	Painted Wallboard Paper	4.28 ± 1.13 x 10^6	2.62 ± 0.24 x 10^3	3.20 ± 0.11
						12.00			1.56 ± 1.84 x 10^2	4.65 ± 0.62
						16.00			0.00 ± 0.00	≥6.62 ± 0.10
						20.00			0.00 ± 0.00	≥6.62 ± 0.10
						24.00			0.00 ± 0.00	≥6.62 ± 0.10
						8.00	Unpainted Concrete	1.12 ± 0.64 x 10^6	1.23 ± 0.50 x 10^4	1.90 ± 0.35
						12.00			3.29 ± 2.86 x 10^3	3.51 ± 2.43
						16.00			8.69 ± 3.41 x 10^3	2.06 ± 0.36
						20.00			2.12 ± 1.55x 10^3	2.74 ± 0.53
						24.00			1.37 ± 0.58 x 10^3	2.86 ± 0.37
						8.00	Ceiling Tile	3.59 ± 2.28 x 10^5	0.00 ± 0.00	≥5.49 ± 0.22
						12.00			0.00 ± 0.00	≥5.49 ± 0.22
						16.00			0.00 ± 0.00	≥5.49 ± 0.22
						20.00			0.00 ± 0.00	≥5.49 ± 0.22
						24.00			0.00 ± 0.00	≥5.49 ± 0.22

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-16. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
7	50.0 ± 1.10	STERIS 1000ED	23.77 ± 3.86	60.07 ± 3.86	1.29E+08	1.00	Glass	$1.20 \pm 0.11 \times 10^7$	$9.31 \pm 2.22 \times 10^4$	2.12 ± 0.13
						2.00			$5.55 \pm 3.85 \times 10^1$	5.39 ± 0.31
						4.00			0.00 ± 0.00	≥7.08 ± 0.04
						5.00			0.00 ± 0.00	≥7.08 ± 0.04
						6.00			0.00 ± 0.00	≥7.08 ± 0.04
						8.00	Pine Wood	$1.59 \pm 1.03 \times 10^6$	$6.57 \pm 4.30 \times 10^3$	2.43 ± 0.52
						12.00			$1.48 \pm 2.36 \times 10^3$	3.66 ± 1.22
						16.00			0.00 ± 0.00	≥6.14 ± 0.21
						20.00			0.00 ± 0.00	≥6.14 ± 0.21
						24.00			$1.18 \pm 1.86 \times 10^1$	5.63 ± 1.02
						8.00	Carpet	$6.26 \pm 2.34 \times 10^6$	$2.07 \pm 1.51 \times 10^3$	3.54 ± 0.38
						12.00			$1.02 \pm 0.92 \times 10^3$	3.95 ± 0.64
						16.00			$5.59 \pm 5.04 \times 10^1$	5.50 ± 1.26
						20.00			$5.63 \pm 9.58 \times 10^1$	6.04 ± 1.46
						24.00			0.00 ± 0.00	≥6.78 ± 0.12
						1.00	Painted Wallboard Paper	$7.29 \pm 1.03 \times 10^6$	$1.18 \pm 0.28 \times 10^5$	1.80 ± 0.13
						2.00			$0.92 \pm 1.60 \times 10^3$	5.71 ± 2.25
						4.00			$1.18 \pm 1.86 \times 10^1$	6.35 ± 1.00
						5.00			0.00 ± 0.00	≥6.86 ± 0.05
						6.00			0.00 ± 0.00	≥6.86 ± 0.05
						8.00	Unpainted Concrete	$2.35 \pm 2.74 \times 10^6$	$1.59 \pm 0.85 \times 10^4$	1.80 ± 0.71
						12.00			$7.88 \pm 2.32 \times 10^3$	2.07 ± 0.68
						16.00			$1.02 \pm 0.22 \times 10^4$	1.96 ± 0.67
						20.00			$3.11 \pm 2.56 \times 10^3$	2.57 ± 0.79
						24.00			$5.96 \pm 3.12 \times 10^3$	2.23 ± 0.74
						1.00	Ceiling Tile	$4.14 \pm 0.52 \times 10^5$	$1.76 \pm 0.55 \times 10^3$	2.38 ± 0.16
						2.00			$6.67 \pm 0.00 \times 10^1$	3.79 ± 0.05
						4.00			0.00 ± 0.00	≥5.61 ± 0.05
						5.00			0.00 ± 0.00	≥5.61 ± 0.05
						6.00			0.00 ± 0.00	≥5.61 ± 0.05

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-17. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
8	43.50 ± 12.61	STERIS 1000ED	22.98 ± 0.43	76.91 ± 5.45	7.07E+07	1.00	Glass	6.09 ± 1.90 x 10^6	3.37 ± 3.29 x 10^1	5.65 ± 1.11
						2.00			0.00 ± 0.00	≥6.77 ± 0.13
						4.00			0.00 ± 0.00	≥6.77 ± 0.13
						5.00			0.00 ± 0.00	≥6.77 ± 0.13
						6.00			0.00 ± 0.00	≥6.77 ± 0.13
						8.00	Pine Wood	3.75 ± 0.74 x 10^6	2.29 ± 3.79 x 10^1	5.96 ± 1.20
						12.00			2.29 ± 3.79 x 10^1	5.96 ± 1.20
						16.00			2.89 ± 2.22 x 10^2	4.31 ± 0.72
						20.00			6.69 ± 6.60 x 10^1	5.25 ± 1.30
						24.00			0.00 ± 0.00	≥6.57 ± 0.08
						8.00	Carpet	6.85 ± 1.66 x 10^6	8.90 ± 6.96 x 10^1	4.97 ± 0.41
						12.00			0.00 ± 0.00	≥6.83 ± 0.08
						16.00			0.00 ± 0.00	≥6.83 ± 0.08
						20.00			0.00 ± 0.00	≥6.83 ± 0.08
						24.00			0.00 ± 0.00	≥6.83 ± 0.08
						1.00	Painted Wallboard Paper	3.99 ± 1.15 x 10^6	3.25 ± 1.97 x 10^5	1.14 ± 0.35
						2.00			5.87 ± 4.82 x 10^4	2.13 ± 0.94
						4.00			0.00 ± 0.00	≥6.59 ± 0.10
						5.00			0.00 ± 0.00	≥6.59 ± 0.10
						6.00			0.00 ± 0.00	≥6.59 ± 0.10
						8.00	Unpainted Concrete	1.88 ± 1.90 x 10^6	3.05 ± 1.37 x 10^3	2.60 ± 0.50
						12.00			4.27 ± 4.47 x 10^3	2.58 ± 0.66
						16.00			6.11 ± 1.07 x 10^2	3.28 ± 0.45
						20.00			1.52 ± 0.62 x 10^3	2.90 ± 0.49
						24.00			3.55 ± 1.56 x 10^3	2.54 ± 0.51
						1.00	Ceiling Tile	3.11 ± 0.61 x 10^5	3.73 ± 0.75 x 10^4	0.92 ± 0.12
						2.00			4.54± 0.89 x 10^2	1.83 ± 0.12
						4.00			0.00 ± 0.00	≥5.49 ± 0.07
						5.00			0.00 ± 0.00	≥5.49 ± 0.07
						6.00			0.00 ± 0.00	≥5.49 ± 0.07

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Table A-18. Inactivation of *B. anthracis* Vollum Spores using low level HPV[a] *(Continued)*

Test Number	Concentration (ppm)	Equipment	Temp (°C)	%RH	Inoculum (CFU/coupon)	Contact Time (hours)	Material	Mean Recovered *B. anthracis* (CFU/coupon)		Efficacy ± CI[d]
								Positive Control[b]	Test Coupon[c]	
9	25.22 ± 1.64	Bubbler	23.77 ± 0.40	91.94 ± 14.52	1.24E+08	1.00	Glass	7.01 ± 3.80 x 10^6	1.54 ± 1.01 x 10^5	1.67 ± 0.39
						2.00			2.29 ± 3.79 x 10^1	6.19 ± 1.21
						6.00			0.00 ± 0.00	≥6.79 ± 0.21
						8.00			0.00 ± 0.00	≥6.79 ± 0.21
						12.00			0.00 ± 0.00	≥6.79 ± 0.21
						8.00	Pine Wood	3.69 ± 2.31 x 10^6	2.22 ± 1.35 x 10^2	4.20 ± 0.42
						12.00			3.01 ± 4.37 x 10^4	2.91 ± 1.81
						16.00			1.90 ± 2.13 x 10^3	3.53 ± 0.91
						20.00			1.00 ± 1.56 x 10^3	4.09 ± 1.14
						24.00			2.82 ± 2.81 x 10^3	4.08 ± 2.38
						8.00	Carpet	6.23 ± 1.59 x 10^6	5.78 ± 3.17 x 10^2	4.07 ± 0.32
						12.00			2.11 ± 1.95 x 10^2	4.59 ± 0.48
						16.00			0.00 ± 0.00	≥6.78 ± 0.10
						20.00			0.00 ± 0.00	≥6.78 ± 0.10
						24.00			0.00 ± 0.00	≥6.78 ± 0.10
						1.00	Painted Wallboard Paper	8.19 ± 0.78 x 10^6	6.64 ± 1.98 x 10^5	1.10 ± 0.14
						2.00			1.64 ± 1.12 x 10^5	1.76 ± 0.33
						6.00			0.00 ± 0.00	≥6.91 ± 0.04
						8.00			0.00 ± 0.00	≥6.91 ± 0.04
						12.00			0.00 ± 0.00	≥6.91 ± 0.04
						8.00	Unpainted Concrete	7.78 ± 4.42 x 10^6	4.04 ± 0.65 x 10^4	2.23 ± 0.24
						12.00			1.17 ± 0.15 x 10^4	2.77 ± 0.23
						16.00			3.56 ± 2.72 x 10^2	4.36 ± 0.42
						20.00			5.62 ± 4.90 x 10^3	3.42 ± 1.00
						24.00			2.11 ± 0.84 x 10^2	4.53 ± 0.30
						1.00	Ceiling Tile	1.09 ± 1.48 x 10^6	6.33 ± 1.34 x 10^4	1.02 ± 0.39
						2.00			8.89 ± 2.31 x 10^3	1.88 ± 0.40
						6.00			0.00 ± 0.00	≥5.82 ± 0.38
						8.00			0.00 ± 0.00	≥5.82 ± 0.38
						12.00			0.00 ± 0.00	≥5.82 ± 0.38

[a] Data expressed as the mean (± SD) of the logs of the number of spores (CFU) observed on individual samples and decontamination efficacy (log reduction).

[b] Positive Controls = samples inoculated, not decontaminated.

[c] Test Coupons = samples inoculated, decontaminated.

[d] CI = confidence interval (± 1.96 × SE). Results highlighted in yellow signify ≥ 6 LR, and green signifies complete inactivation.

Appendix B

Efficacy Results Figures

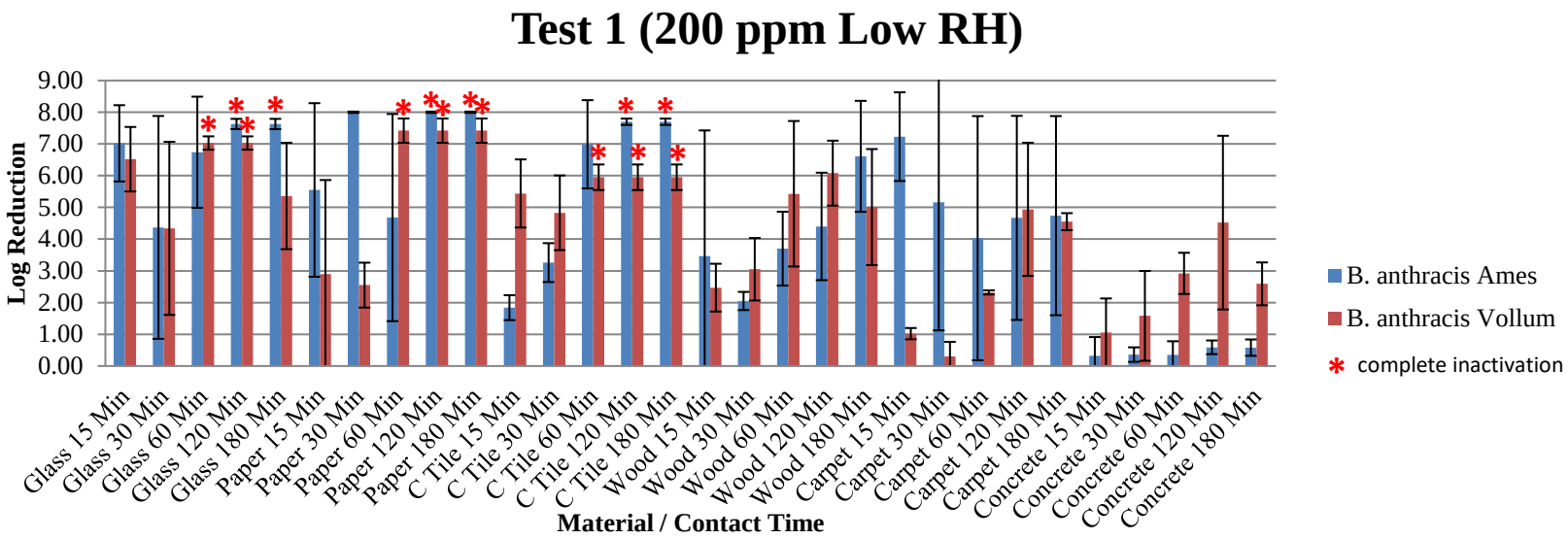

Figure B-1. Summary of efficacy results at 200 ppm and Low RH against *B. anthracis* Ames and Vollum.

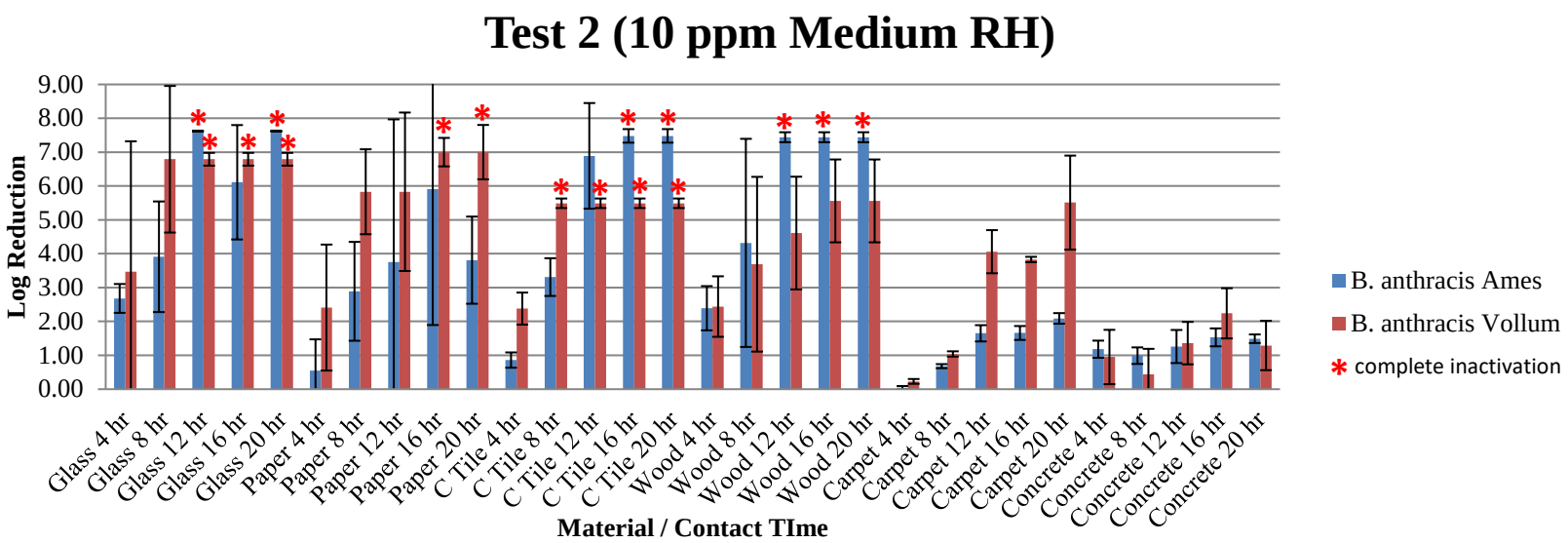

Figure B-2. Summary of efficacy results at 10 ppm and Medium RH against *B. anthracis* Ames and Vollum.

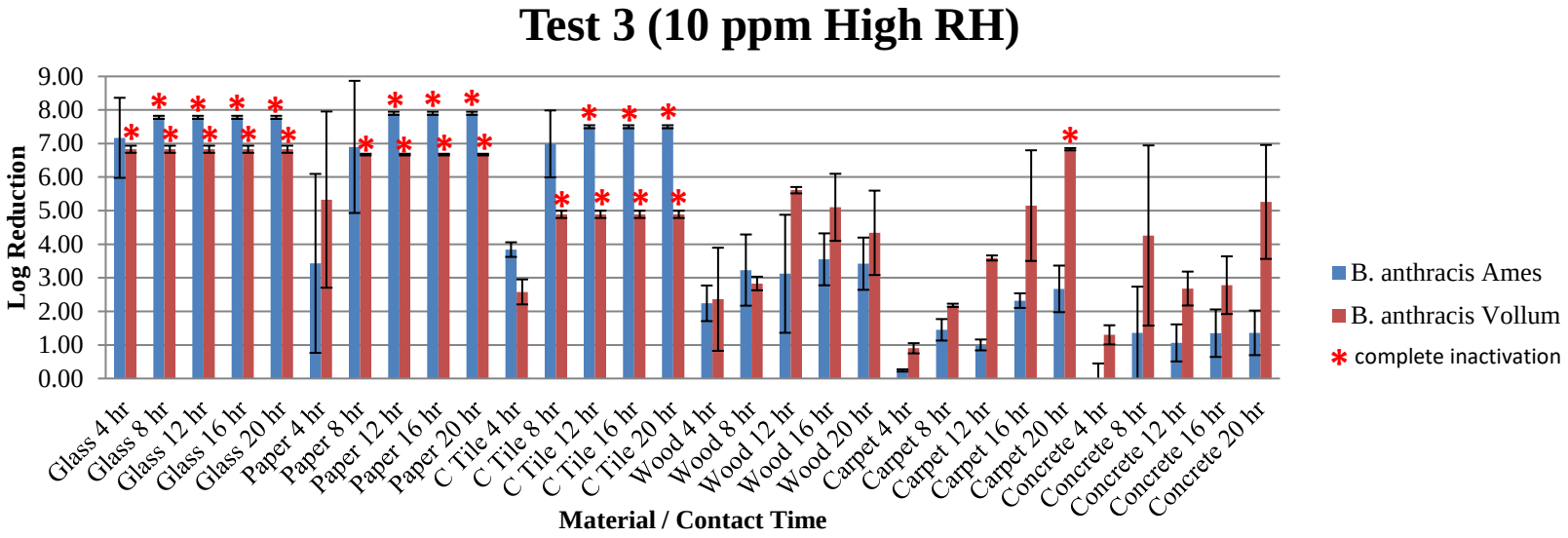

Figure B-3. Summary of efficacy results at 10 ppm and High RH against *B. anthracis* Ames and Vollum.

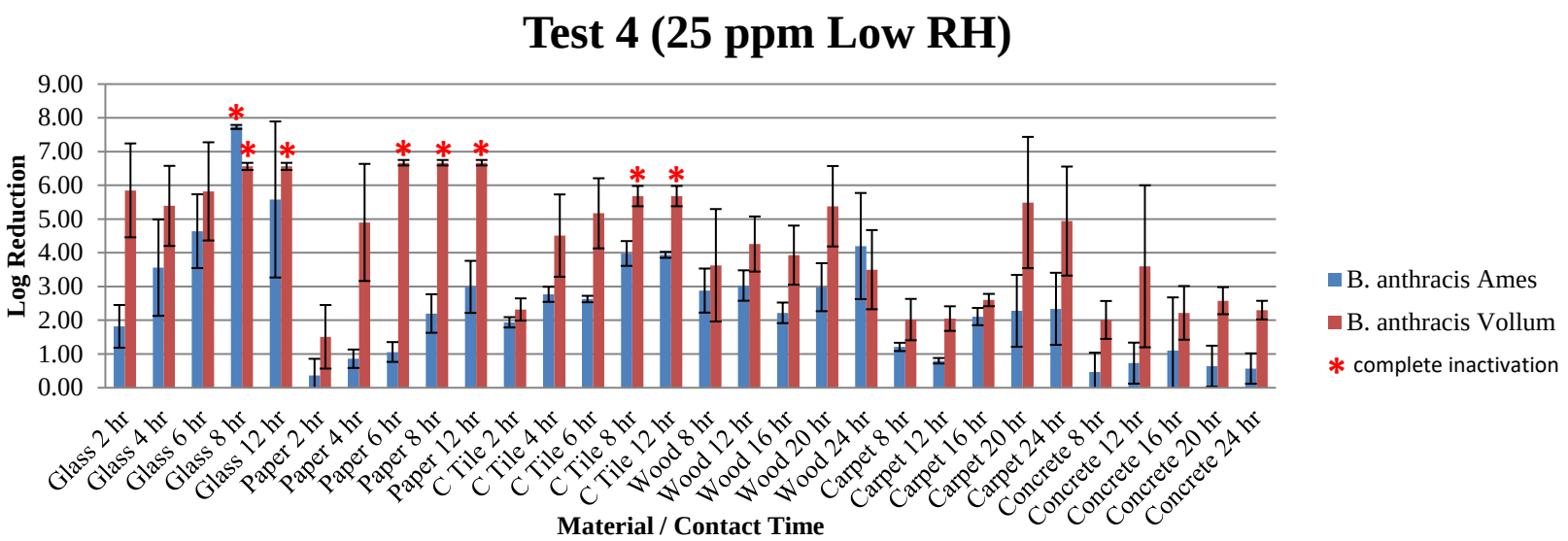

Figure B-4. Summary of efficacy results at 25 ppm and Low RH against *B. anthracis* Ames and Vollum.

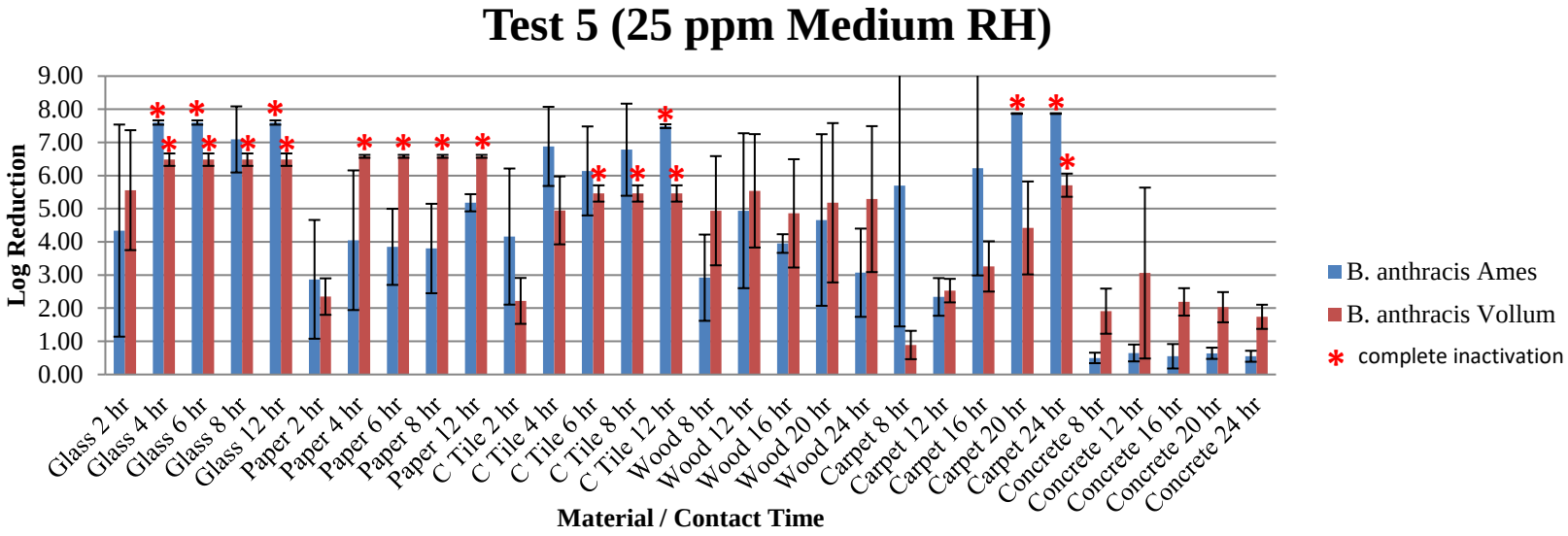

Figure B-5. Summary of efficacy results at 25 ppm and Medium RH against *B. anthracis* Ames and Vollum.

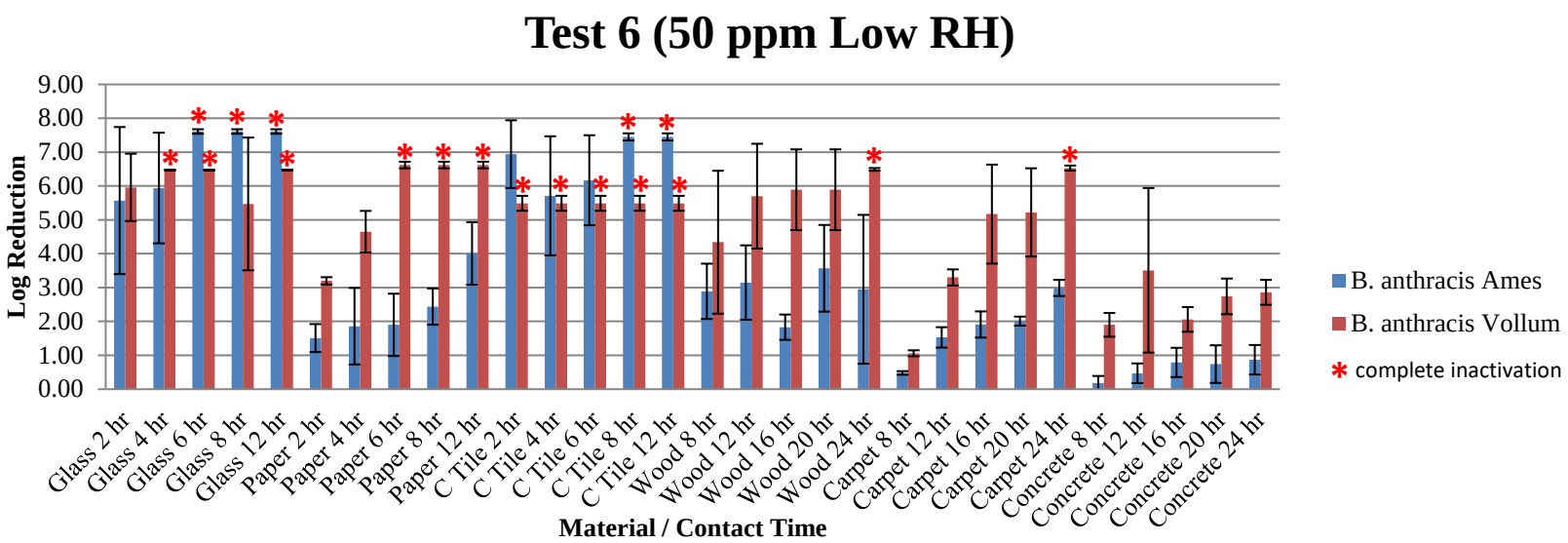

Figure B-6. Summary of efficacy results at 50 ppm and Low RH against *B. anthracis* Ames and Vollum.

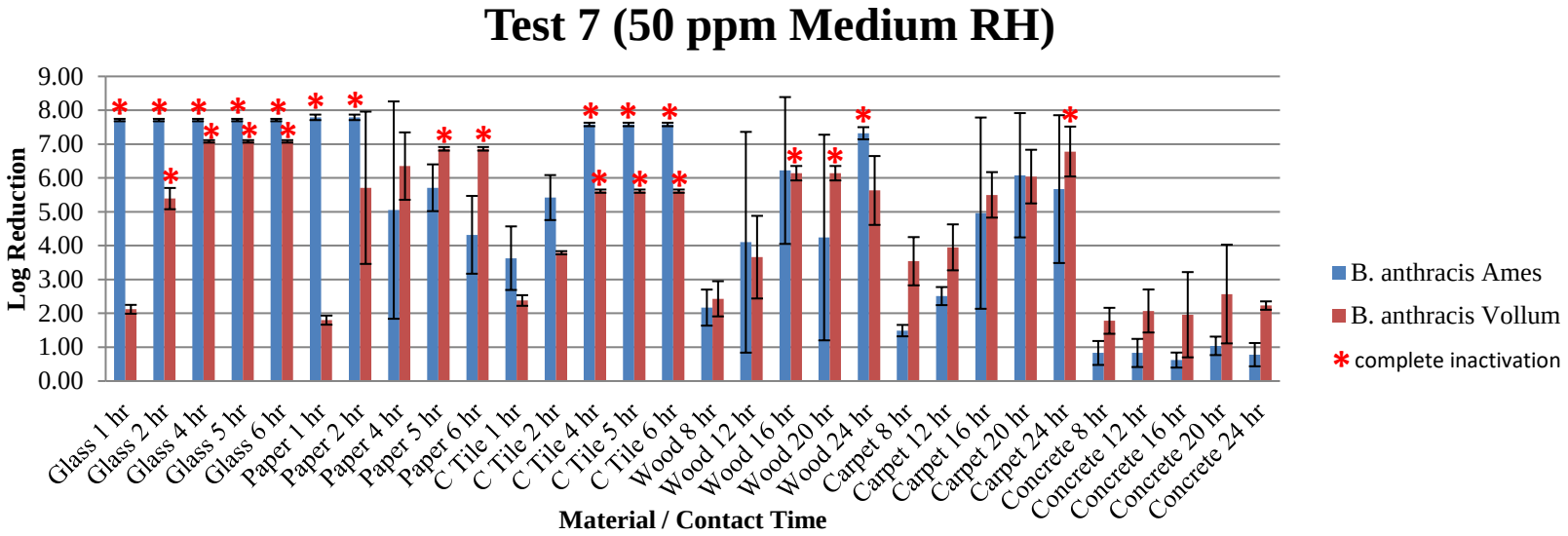

Figure B-7. Summary of efficacy results at 50 ppm and Medium RH against *B. anthracis* Ames and Vollum.

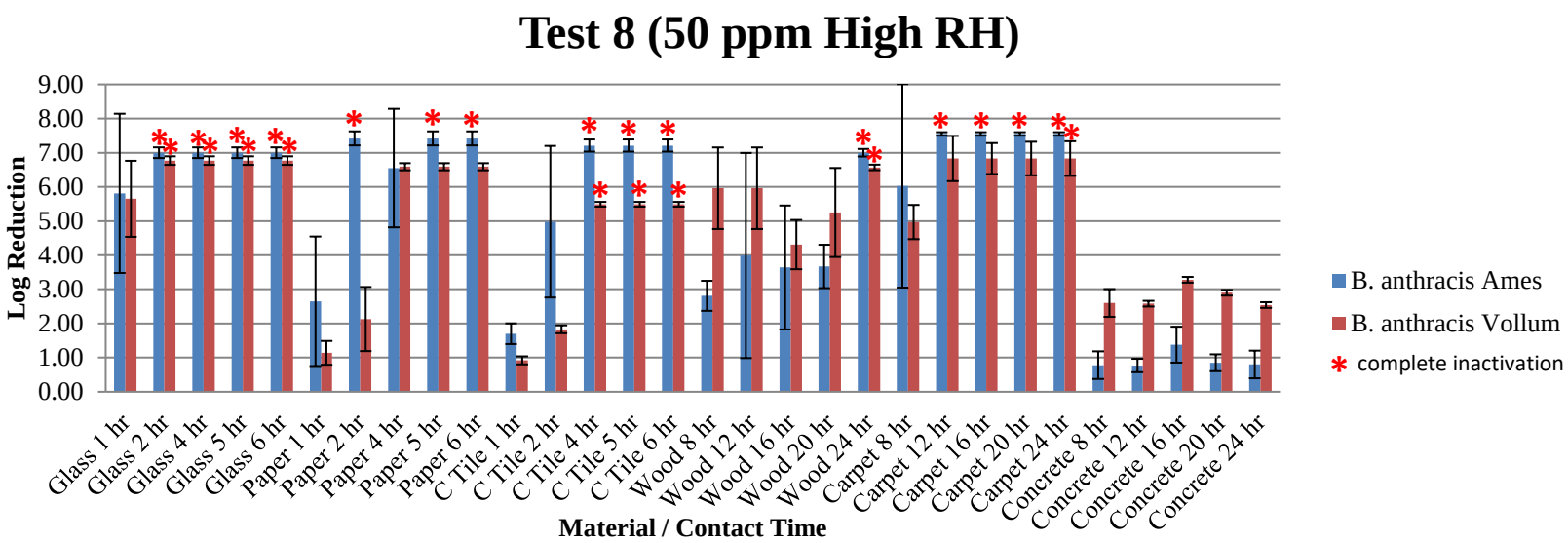

Figure B-8. Summary of efficacy results at 50 ppm and High RH against *B. anthracis* Ames and Vollum.

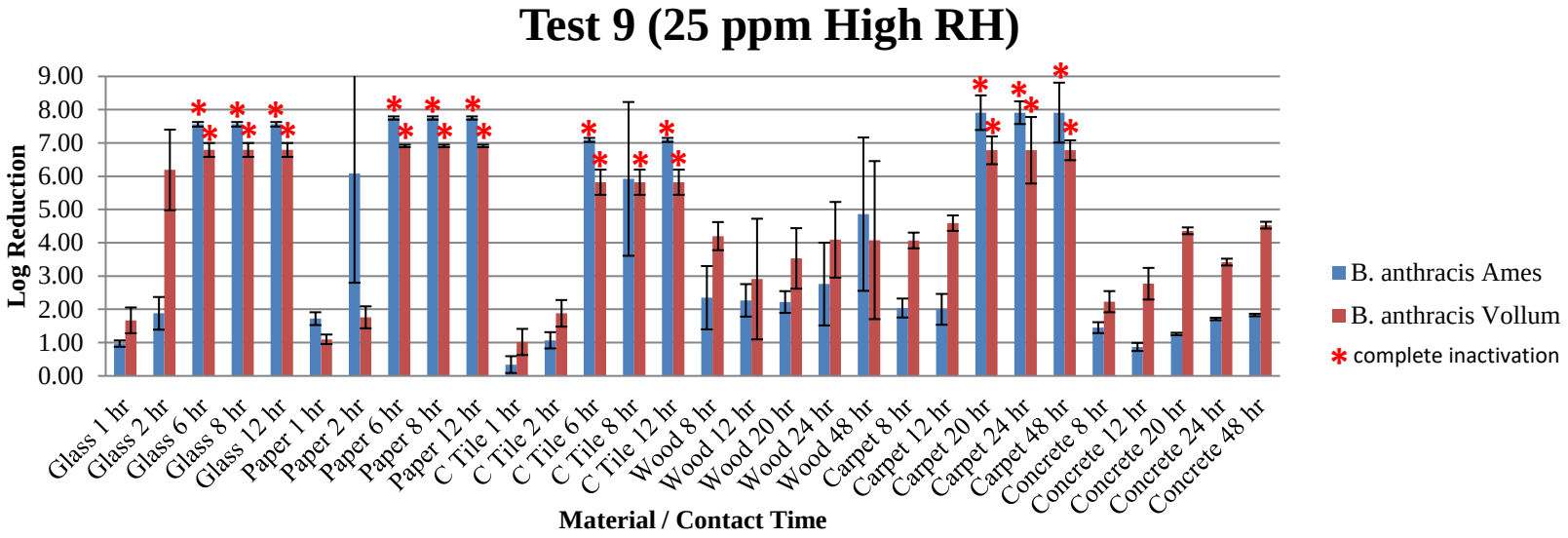

Figure B-9. Summary of efficacy results at 25 ppm and High RH against *B. anthracis* Ames and Vollum.

Appendix C
HPV Dose Requirements for Effective Decontamination

Table C-1. Minimum dose in ppm*hours demonstrating effective decontamination for Ames strain

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 9	Test 6	Test 7	Test 8	Range
Average HPV ppm	222	9-10		25-26			44-50			
Average % RH	38	58	76	33	62	92	26	60	77	
	Minimum Dose in ppm*hours									
Glass	56	120	80	200	100	150	300	50	100	50-200
PW Paper	111	>200	80	>600	>600	50	>1200	100	100	50 - >1200
Ceiling Tile	444	120	80	>600	100	150	100	200	200	80 - >600
Pine Wood	666	120	>200	>600	>600	>1200	>1200	800	1200	120 - >1200
Carpet	56	>200	>200	>600	400	500	>1200	1000	400	>200 - >1200
Concrete	>666	>200	>200	>600	>600	>1200	>1200	>1200	>1200	>200 - >1200

Table C-2. Minimum dose in ppm*hours demonstrating effective decontamination for Vollum strain

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 9	Test 6	Test 7	Test 8	Range
Average HPV ppm	222	9-10		25-26			44-50			
average % RH	38	58	76	33	62	92	26	60	77	
	Minimum Dose in ppm*hours									
Glass	56	80	40	200	100	50	200	200	100	40-200
PW Paper	222	160	80	150	100	150	300	200	200	80-300
Ceiling Tile	222	80	80	200	150	150	100	200	200	80-222
Pine Wood	444	>200	>200	>600	>600	>1200	1200	800	1200	444->1200
Carpet	>666	>200	200	>600	600	500	1200	1000	600	200 - 1200
Concrete	>666	>200	>200	>600	>600	>1200	>1200	>1200	>1200	>200 - >1200

Appendix D

Detailed Statistical Analysis

Introduction

This report contains the statistical analysis of *B. anthracis Ames* (*Ba*A) and *B. anthracis Vollum* (*Ba*V) decontamination data for different decontamination conditions (contact time, HPV concentration, Average RH) on a variety of materials. The study design is presented in Text Table 1. Data were collected in support of EPA Task Order 14 study conducted at the Battelle Biomedical Research Center (BBRC).

Text Table D1. Study Design

Test Number	Equipment	Test Organism	HPV ppm	Temp (ºC)	Average RH	Easy[1] Material Contact Times (h)	Difficult[2] Material Contact Time (h)	Material
1	STERIS (direct)	*Ba* Ames and vollum	200	23	Low	0.25,0.50,1,2,3		Glass, PW Paper, Ceiling Tile, Pine Wood, Carpet, Concrete
2	Bubbler		10	23	Medium	4, 8, 12, 16, 20		
3	Bubbler		10	23	High	4, 8, 12, 16, 20		
4	STERIS (dual chamber)		25	23	Low	2,4,6,8,12	8,12,16,20,24	
5	STERIS (dual chamber)		25	23	Medium	2,4,6,8,12	8,12,16,20,24	
6	STERIS (dual chamber)		50	23	Low	2,4,6,8,12	8,12,16,20,24	
7	STERIS (dual chamber)		50	23	Medium	1,2,4,5,6	8,12,16,20,24	
8	STERIS (single pass)		50	23	High	1,2,4,5,6	8,12,16,20,24	
9	Bubbler		25	23	High	1,2,6,8,12	8,12,20,24, 48	

[1] Glass, PW Paper and Ceiling Tile
[2] Pine Wood, Carpet, Concrete

Statistical Methods

A binary response based on log reduction in spores was the primary endpoint. For this endpoint, a trial was recorded as a success or pass if either: 1) the log10 reduction was greater than or equal to 6, or 2) the log10 recovery was equal to or less than the average control recovery (complete kill). The proportion of tests that pass and 95 percent Clopper-Pearson confidence

intervals were computed by strain (Ames or Vollum), material, contact time, relative humidity, and HPV concentration.
A logistic regression model was fitted to the full data to test whether the proportions of successes are significantly associated with any effects included in the model. The logistic regression model included main effects for strain (Ames or Vollum), material, dose (defined as contact time times HPV concentration), and relative humidity; the model also included all two-factor interactions and the three-factor interactions for dose, strain, and material. An implicit assumption in the analysis is that the effect of dose is the same for any concentration and time used to achieve it.

Results

Text Table 2 contains the proportions of tests that pass for each strain, material, contact time, relative humidity, and HPV concentration with 95 percent Clopper-Pearson confidence intervals.

The joint tests for all effects included in the logistic regression model are presented in Text Table 3. A joint test for an effect of interest is a test that the values of the parameters associated with that effect are zero. As can be seen in Text Table 3, the main effect for material was statistically significant; the two-factor interactions for strain and material, strain and average RH, material and average RH, dose and material, and dose and average RH were also statistically significant as well as the three-factor interaction for dose, strain, and material. Odds ratios were calculated for each effect conditional on the values of the other effects. Figure D1 through Figure D20 present plots of the odds ratios. In these figures, the lines extend to different doses based on the range of doses studied for a given condition; the lines are constrained so as not to extrapolate the odds ratio outside the studied ranges.

Conclusions

Presence of a statistically significant three-factor interaction complicates interpretation of the results, as all results for one of the three factors must be interpreted with respect to the levels of the other two factors. While the main effects for strain, average RH, and dose are not statistically significant, the two-factor interactions involving these factors are statistically significant. Therefore, these factors do impact the probability of a complete kill, but that impact is dependent on the level of another factor. For example, the effect of average RH is dependent on the strain, the material, and the dose.

For all conclusions, a higher odds ratio greater than one is indicative of greater odds of a complete kill for level 1 of the factor compared to level 2. For odds ratios less than one, there are greater odds of a complete kill for level 2 of the factor compared to level 1. An odds ratio equal to one indicates the odds of a complete kill are approximately the same for both levels of the factor. The odds are defined as the ratio of probability of complete kill to the probability of an incomplete kill.

From Figure D1, the odds ratio for bare pine wood is roughly constant at slightly less than one for all levels of dose; thus, the odds ratio does not depend on dose. For bare pine wood, the odds

of a complete kill are greater for Vollum than for Ames. The odds ratio for carpet decreases from approximately 10 to approximately 0.1, indicating that at low dose the odds of a complete kill are greater for Ames while at high dose the odds of a complete kill are greater for Vollum. The odds ratio for unpainted concrete is slightly increasing as dose increases but is always less than one, indicating for all levels of dose the odds of complete kill are greater for Vollum than for Ames. For ceiling tile and painted wallboard paper, the odds ratio is steeply decreasing from between 1 and 10 to between 10^{-2} and 10^{-10}, indicating that at low dose the odds of a complete kill are greater for Ames while at high dose the odds of a complete kill are greater for Vollum. The steep decrease indicates that the ratio between Ames and Vollum decreases as dose increases; the decreasing ratio results in increasing discrepancy between the two strains. Finally, for glass, the odds ratio increases from less than 1 to approximately 100. In this case, the odds of a complete kill are greater for Vollum at low dose but greater for Ames at high dose. The increasing slope indicates the ratio is greater at higher dose. For all materials, the odds ratio is greatest at the medium RH and least at the low RH. This ratio does not indicate that the probability of a complete kill is greatest for the medium RH, only that the ratio of the odds for Ames to Vollum is the greatest, showing the greatest discrepancy between the two odds.

The odds ratios comparing the different materials vary (Figure D2 - Figure D16). For most comparisons, the odds ratio decreases with increasing dose; increasing odds ratios can be transformed to decreasing by reversing the order of the levels and taking the reciprocal of the odds ratio. Thus, the discrepancy between the two materials increases as dose increases. For a few cases, the odds ratio is flat with respect to dose: for Ames on bare pine wood compared to unpainted concrete, for Ames on carpet compared to unpainted concrete, and for Ames on ceiling tile compared to glass. For one case, the odds ratio is increasing with increasing dose: Ames on glass compared to painted wallboard paper. For cases where the odds ratios decrease with increasing dose, the rate of decrease varies between Ames and Vollum. In most cases, the rate of decrease is faster for Vollum than for Ames, indicating the discrepancy between the two materials gets larger faster for Vollum.

The odds ratios for high RH compared to low RH (Figure D17), high RH compared to medium RH (Figure D18), and low RH compared to medium RH (Figure D19) increase with dose. Rate of increase is relatively constant for all strain and material combinations. For each material, the odds ratio is greater for Ames than it is for Vollum. For bare pine wood and unpainted concrete, the odds ratio for high RH to low RH increases from less than 1 to greater than 1 as dose increases, indicating that at low dose the odds of a complete kill are greater for low RH while at high dose the odds of a complete kill are greater for high RH. For all other materials, the odds ratio is always greater than 1, indicating greater odds of a complete kill at high RH compared to low RH. Again, comparing high RH to medium RH, for bare pine wood and unpainted concrete, the odds ratio increases from less than 1 to greater than 1; for all other materials, the odds ratio is always greater than 1. Comparing low RH to medium RH, the odds ratio decreases from greater than 1 to less than 1 for carpet and unpainted concrete. For these materials, the odds of a complete kill are greater for low RH at low dose and are greater for medium RH at high dose. The odds ratio is strictly less than 1 for all other materials, indicating greater odds of a complete kill at medium RH compared to low RH.

Figure D20 investigates the interactions between material, strain, and RH based on a fixed change in dose. The odds ratio for dose compared to a 100-unit increase is greater than 1 for all materials, strains, and RH levels. Thus, the odds of a complete kill are greater as dose increases. The largest odds ratios are observed for ceiling tile and painted wallboard paper, indicating the greatest effect of increasing dose on the odds of a complete kill for these materials. The odds ratio increases as average RH increases.

Text Table D2. Summary of Kill Proportions by Strain, Material, Contact Time, Average RH and HPV Concentration

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Bare Pine Wood	0.25 h	Low	200	1/3	0.33 (0.01, 0.91)
Ames	Bare Pine Wood	0.5 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	12 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	12 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	12 h	High	50	1/3	0.33 (0.01, 0.91)
Ames	Bare Pine Wood	12 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	12 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	12 h	Medium	10	3/3	1.00 (0.29, 1.00)
Ames	Bare Pine Wood	12 h	Medium	25	1/3	0.33 (0.01, 0.91)
Ames	Bare Pine Wood	12 h	Medium	50	1/3	0.33 (0.01, 0.91)
Ames	Bare Pine Wood	16 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	16 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	16 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	16 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	16 h	Medium	10	3/3	1.00 (0.29, 1.00)
Ames	Bare Pine Wood	16 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	16 h	Medium	50	2/3	0.67 (0.09, 0.99)
Ames	Bare Pine Wood	1 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	20 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	20 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	20 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	20 h	Low	25	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Bare Pine Wood	20 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	20 h	Medium	10	3/3	1.00 (0.29, 1.00)
Ames	Bare Pine Wood	20 h	Medium	25	1/3	0.33 (0.01, 0.91)
Ames	Bare Pine Wood	20 h	Medium	50	1/3	0.33 (0.01, 0.91)
Ames	Bare Pine Wood	24 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	24 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Bare Pine Wood	24 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	24 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	24 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	24 h	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Bare Pine Wood	2 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	3 h	Low	200	2/3	0.67 (0.09, 0.99)
Ames	Bare Pine Wood	48 h	High	25	1/3	0.33 (0.01, 0.91)
Ames	Bare Pine Wood	4 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	8 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	8 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	8 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	8 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	8 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Bare Pine Wood	8 h	Medium	10	1/3	0.33 (0.01, 0.91)
Ames	Bare Pine Wood	8 h	Medium	25	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Bare Pine Wood	8 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Carpet	0.25 h	Low	200	2/3	0.67 (0.09, 0.99)
Ames	Carpet	0.5 h	Low	200	2/3	0.67 (0.09, 0.99)
Ames	Carpet	12 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	12 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Carpet	12 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Carpet	12 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Carpet	12 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Carpet	12 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	12 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Carpet	12 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Carpet	16 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	16 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Carpet	16 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Carpet	16 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Carpet	16 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	16 h	Medium	25	2/3	0.67 (0.09, 0.99)
Ames	Carpet	16 h	Medium	50	1/3	0.33 (0.01, 0.91)
Ames	Carpet	1 h	Low	200	1/3	0.33 (0.01, 0.91)
Ames	Carpet	20 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	20 h	High	25	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Carpet	20 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Carpet	20 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Carpet	20 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	20 h	Medium	25	3/3	1.00 (0.29, 1.00)
Ames	Carpet	20 h	Medium	50	1/3	0.33 (0.01, 0.91)
Ames	Carpet	24 h	High	25	3/3	1.00 (0.29, 1.00)
Ames	Carpet	24 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Carpet	24 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Carpet	24 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Carpet	24 h	Medium	25	3/3	1.00 (0.29, 1.00)
Ames	Carpet	24 h	Medium	50	1/3	0.33 (0.01, 0.91)
Ames	Carpet	2 h	Low	200	1/3	0.33 (0.01, 0.91)
Ames	Carpet	3 h	Low	200	1/3	0.33 (0.01, 0.91)
Ames	Carpet	48 h	High	25	3/3	1.00 (0.29, 1.00)
Ames	Carpet	4 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	8 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	8 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Carpet	8 h	High	50	2/3	0.67 (0.09, 0.99)
Ames	Carpet	8 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Carpet	8 h	Low	50	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Carpet	8 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Carpet	8 h	Medium	25	2/3	0.67 (0.09, 0.99)
Ames	Carpet	8 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	0.25 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	0.5 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	12 h	High	10	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	12 h	High	25	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	12 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	12 h	Low	50	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	12 h	Medium	10	2/3	0.67 (0.09, 0.99)
Ames	Ceiling Tile	12 h	Medium	25	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	16 h	High	10	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	16 h	Medium	10	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	1 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	1 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	1 h	Low	200	2/3	0.67 (0.09, 0.99)
Ames	Ceiling Tile	1 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	20 h	High	10	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	20 h	Medium	10	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	2 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	2 h	High	50	1/3	0.33 (0.01, 0.91)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Ceiling Tile	2 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	2 h	Low	50	2/3	0.67 (0.09, 0.99)
Ames	Ceiling Tile	2 h	Low	200	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	2 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	2 h	Medium	50	1/3	0.33 (0.01, 0.91)
Ames	Ceiling Tile	3 h	Low	200	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	4 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	4 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	4 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	4 h	Low	50	1/3	0.33 (0.01, 0.91)
Ames	Ceiling Tile	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	4 h	Medium	25	2/3	0.67 (0.09, 0.99)
Ames	Ceiling Tile	4 h	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	5 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	5 h	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	6 h	High	25	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	6 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	6 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	6 h	Low	50	1/3	0.33 (0.01, 0.91)
Ames	Ceiling Tile	6 h	Medium	25	1/3	0.33 (0.01, 0.91)
Ames	Ceiling Tile	6 h	Medium	50	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Ceiling Tile	8Hr	High	10	2/3	0.67 (0.09, 0.99)
Ames	Ceiling Tile	8Hr	High	25	2/3	0.67 (0.09, 0.99)
Ames	Ceiling Tile	8Hr	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	8Hr	Low	50	3/3	1.00 (0.29, 1.00)
Ames	Ceiling Tile	8Hr	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Ceiling Tile	8Hr	Medium	25	2/3	0.67 (0.09, 0.99)
Ames	Glass	0.25Hr	Low	200	2/3	0.67 (0.09, 0.99)
Ames	Glass	0.5Hr	Low	200	1/3	0.33 (0.01, 0.91)
Ames	Glass	12Hr	High	10	3/3	1.00 (0.29, 1.00)
Ames	Glass	12Hr	High	25	3/3	1.00 (0.29, 1.00)
Ames	Glass	12Hr	Low	25	1/3	0.33 (0.01, 0.91)
Ames	Glass	12Hr	Low	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	12Hr	Medium	10	3/3	1.00 (0.29, 1.00)
Ames	Glass	12Hr	Medium	25	3/3	1.00 (0.29, 1.00)
Ames	Glass	16Hr	High	10	3/3	1.00 (0.29, 1.00)
Ames	Glass	16Hr	Medium	10	2/3	0.67 (0.09, 0.99)
Ames	Glass	1Hr	High	25	0/3	0.00 (0.00, 0.71)
Ames	Glass	1Hr	High	50	2/3	0.67 (0.09, 0.99)
Ames	Glass	1Hr	Low	200	2/3	0.67 (0.09, 0.99)
Ames	Glass	1Hr	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	20Hr	High	10	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Glass	20 h	Medium	10	3/3	1.00 (0.29, 1.00)
Ames	Glass	2 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Glass	2 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	2 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Glass	2 h	Low	50	1/3	0.33 (0.01, 0.91)
Ames	Glass	2 h	Low	200	3/3	1.00 (0.29, 1.00)
Ames	Glass	2 h	Medium	25	1/3	0.33 (0.01, 0.91)
Ames	Glass	2 h	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	3 h	Low	200	3/3	1.00 (0.29, 1.00)
Ames	Glass	4 h	High	10	2/3	0.67 (0.09, 0.99)
Ames	Glass	4 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	4 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Glass	4 h	Low	50	1/3	0.33 (0.01, 0.91)
Ames	Glass	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Glass	4 h	Medium	25	3/3	1.00 (0.29, 1.00)
Ames	Glass	4 h	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	5Hr	High	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	5Hr	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	6Hr	High	25	3/3	1.00 (0.29, 1.00)
Ames	Glass	6Hr	High	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	6Hr	Low	25	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Glass	6 h	Low	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	6 h	Medium	25	3/3	1.00 (0.29, 1.00)
Ames	Glass	6 h	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	8 h	High	10	3/3	1.00 (0.29, 1.00)
Ames	Glass	8 h	High	25	3/3	1.00 (0.29, 1.00)
Ames	Glass	8 h	Low	25	3/3	1.00 (0.29, 1.00)
Ames	Glass	8 h	Low	50	3/3	1.00 (0.29, 1.00)
Ames	Glass	8 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Glass	8 h	Medium	25	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	0.25 h	Low	200	1/3	0.33 (0.01, 0.91)
Ames	Painted Wallboard Paper	0.5 h	Low	200	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	12 h	High	10	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	12 h	High	25	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	12 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	12 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	12 h	Medium	10	1/3	0.33 (0.01, 0.91)
Ames	Painted Wallboard Paper	12 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	16 h	High	10	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	16 h	Medium	10	2/3	0.67 (0.09, 0.99)
Ames	Painted Wallboard Paper	1 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	1 h	High	50	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Painted Wallboard Paper	1 h	Low	200	1/3	0.33 (0.01, 0.91)
Ames	Painted Wallboard Paper	1 h	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	20 h	High	10	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	20 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	2 h	High	25	2/3	0.67 (0.09, 0.99)
Ames	Painted Wallboard Paper	2 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	2 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	2 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	2 h	Low	200	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	2 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	2 h	Medium	50	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	3 h	Low	200	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	4 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	4 h	High	50	2/3	0.67 (0.09, 0.99)
Ames	Painted Wallboard Paper	4 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	4 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	4 h	Medium	25	1/3	0.33 (0.01, 0.91)
Ames	Painted Wallboard Paper	4 h	Medium	50	1/3	0.33 (0.01, 0.91)
Ames	Painted Wallboard Paper	5 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	5 h	Medium	50	1/3	0.33 (0.01, 0.91)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Painted Wallboard Paper	6 h	High	25	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	6 h	High	50	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	6 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	6 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	6 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	6 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	8 h	High	10	2/3	0.67 (0.09, 0.99)
Ames	Painted Wallboard Paper	8 h	High	25	3/3	1.00 (0.29, 1.00)
Ames	Painted Wallboard Paper	8 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	8 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	8 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Painted Wallboard Paper	8 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	0.25 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	0.5 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	12 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	12 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	12 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	12 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	12 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	12 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	12 h	Medium	25	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Unpainted Concrete	12 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	16 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	16 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	16 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	16 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	16 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	16 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	16 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	1 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	20 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	20 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	20 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	20 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	20 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	20 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	20 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	20 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	24 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	24 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	24 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	24 h	Low	50	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Ames	Unpainted Concrete	24 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	24 h	Medium	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	2 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	3 h	Low	200	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	48 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	4 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	8 h	High	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	8 h	High	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	8 h	High	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	8 h	Low	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	8 h	Low	50	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	8 h	Medium	10	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	8 h	Medium	25	0/3	0.00 (0.00, 0.71)
Ames	Unpainted Concrete	8 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	0.25 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	0.5 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	12 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Bare Pine Wood	12 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	12 h	High	50	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	12 h	Low	25	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Bare Pine Wood	12 h	Low	50	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	12 h	Medium	10	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	12 h	Medium	25	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	12 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	16 h	High	10	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	16 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	16 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	16 h	Low	50	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	16 h	Medium	10	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	16 h	Medium	25	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	16 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Bare Pine Wood	1 h	Low	200	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	20 h	High	10	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	20 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	20 h	High	50	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	20 h	Low	25	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	20 h	Low	50	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	20 h	Medium	10	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	20 h	Medium	25	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	20 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Bare Pine Wood	24 h	High	25	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Bare Pine Wood	24 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Bare Pine Wood	24 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	24 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Bare Pine Wood	24 h	Medium	25	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	24 h	Medium	50	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	2 h	Low	200	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	3 h	Low	200	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	48 h	High	25	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	4 h	High	10	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	8 h	High	10	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	8 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	8 h	High	50	2/3	0.67 (0.09, 0.99)
Voll	Bare Pine Wood	8 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Bare Pine Wood	8 h	Low	50	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	8 h	Medium	10	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	8 h	Medium	25	1/3	0.33 (0.01, 0.91)
Voll	Bare Pine Wood	8 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Carpet	0.25 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Carpet	0.5 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Carpet	12 h	High	10	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Carpet	12 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Carpet	12 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Carpet	12 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Carpet	12 h	Low	50	0/3	0.00 (0.00, 0.71)
Voll	Carpet	12 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Carpet	12 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Carpet	12 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Carpet	16 h	High	10	1/3	0.33 (0.01, 0.91)
Voll	Carpet	16 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Carpet	16 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Carpet	16 h	Low	50	1/3	0.33 (0.01, 0.91)
Voll	Carpet	16 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Carpet	16 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Carpet	16 h	Medium	50	1/3	0.33 (0.01, 0.91)
Voll	Carpet	1 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Carpet	20 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Carpet	20 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Carpet	20 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Carpet	20 h	Low	25	2/3	0.67 (0.09, 0.99)
Voll	Carpet	20 h	Low	50	1/3	0.33 (0.01, 0.91)
Voll	Carpet	20 h	Medium	10	1/3	0.33 (0.01, 0.91)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Carpet	20 h	Medium	25	1/3	0.33 (0.01, 0.91)
Voll	Carpet	20 h	Medium	50	2/3	0.67 (0.09, 0.99)
Voll	Carpet	24 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Carpet	24 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Carpet	24	Low	25	1/3	0.33 (0.01, 0.91)
Voll	Carpet	24 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Carpet	24 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Carpet	24 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Carpet	2 h	Low	200	1/3	0.33 (0.01, 0.91)
Voll	Carpet	3 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Carpet	48 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Carpet	4 h	High	10	0/3	0.00 (0.00, 0.71)
Voll	Carpet	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Carpet	8 h	High	10	0/3	0.00 (0.00, 0.71)
Voll	Carpet	8 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Carpet	8 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Carpet	8 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Carpet	8 h	Low	50	0/3	0.00 (0.00, 0.71)
Voll	Carpet	8 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Carpet	8 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Carpet	8 h	Medium	50	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Ceiling Tile	0.25 h	Low	200	2/3	0.67 (0.09, 0.99)
Voll	Ceiling Tile	0.5 h	Low	200	1/3	0.33 (0.01, 0.91)
Voll	Ceiling Tile	12 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	12 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	12 h	Low	25	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	12 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	12 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	12 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	16 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	16 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	1 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	1 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	1 h	Low	200	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	1 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	20 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	20 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	2 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	2 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	2 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	2 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	2 h	Low	200	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Ceiling Tile	2 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	2 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	3 h	Low	200	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	4 h	High	10	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	4 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	4 h	Low	25	1/3	0.33 (0.01, 0.91)
Voll	Ceiling Tile	4 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Ceiling Tile	4 h	Medium	25	2/3	0.67 (0.09, 0.99)
Voll	Ceiling Tile	4 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	5 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	5 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	6 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	6 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	6 h	Low	25	2/3	0.67 (0.09, 0.99)
Voll	Ceiling Tile	6 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	6 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	6 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	8 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	8 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	8 h	Low	25	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Ceiling Tile	8 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	8 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Ceiling Tile	8 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	0.25 h	Low	200	2/3	0.67 (0.09, 0.99)
Voll	Glass	0.5 h	Low	200	1/3	0.33 (0.01, 0.91)
Voll	Glass	12 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Glass	12 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	12 h	Low	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	12 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Glass	12 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Glass	12 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	16 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Glass	16 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Glass	1 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Glass	1 h	High	50	1/3	0.33 (0.01, 0.91)
Voll	Glass	1 h	Low	200	3/3	1.00 (0.29, 1.00)
Voll	Glass	1 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Glass	20 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Glass	20 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Glass	2 h	High	25	2/3	0.67 (0.09, 0.99)
Voll	Glass	2 h	High	50	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Glass	2 h	Low	25	2/3	0.67 (0.09, 0.99)
Voll	Glass	2 h	Low	50	2/3	0.67 (0.09, 0.99)
Voll	Glass	2 h	Low	200	3/3	1.00 (0.29, 1.00)
Voll	Glass	2 h	Medium	25	2/3	0.67 (0.09, 0.99)
Voll	Glass	2 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Glass	3 h	Low	200	1/3	0.33 (0.01, 0.91)
Voll	Glass	4 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Glass	4 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Glass	4 h	Low	25	1/3	0.33 (0.01, 0.91)
Voll	Glass	4 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Glass	4 h	Medium	10	1/3	0.33 (0.01, 0.91)
Voll	Glass	4 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	4 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Glass	5 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Glass	5 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Glass	6 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	6 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Glass	6 h	Low	25	2/3	0.67 (0.09, 0.99)
Voll	Glass	6 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Glass	6 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	6 h	Medium	50	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Glass	8 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Glass	8 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	8 h	Low	25	3/3	1.00 (0.29, 1.00)
Voll	Glass	8 h	Low	50	2/3	0.67 (0.09, 0.99)
Voll	Glass	8 h	Medium	10	2/3	0.67 (0.09, 0.99)
Voll	Glass	8 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	0.25 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	0.5 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	12 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	12 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	12 h	Low	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	12 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	12 h	Medium	10	2/3	0.67 (0.09, 0.99)
Voll	Painted Wallboard Paper	12 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	16 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	16 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	1 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	1 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	1 h	Low	200	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	1 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	20 h	High	10	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Painted Wallboard Paper	20 h	Medium	10	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	2 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	2 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	2 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	2 h	Low	50	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	2 h	Low	200	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	2 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	2 h	Medium	50	2/3	0.67 (0.09, 0.99)
Voll	Painted Wallboard Paper	3 h	Low	200	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	4 h	High	10	2/3	0.67 (0.09, 0.99)
Voll	Painted Wallboard Paper	4 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	4 h	Low	25	1/3	0.33 (0.01, 0.91)
Voll	Painted Wallboard Paper	4 h	Low	50	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Painted Wallboard Paper	4 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	4 h	Medium	50	2/3	0.67 (0.09, 0.99)
Voll	Painted Wallboard Paper	5 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	5 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	6 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	6 h	High	50	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	6 h	Low	25	3/3	1.00 (0.29, 1.00)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Painted Wallboard Paper	6 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	6 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	6 h	Medium	50	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	8 h	High	10	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	8 h	High	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	8 h	Low	25	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	8 h	Low	50	3/3	1.00 (0.29, 1.00)
Voll	Painted Wallboard Paper	8 h	Medium	10	1/3	0.33 (0.01, 0.91)
Voll	Painted Wallboard Paper	8 h	Medium	25	3/3	1.00 (0.29, 1.00)
Voll	Unpainted Concrete	0.25 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	0.5 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	12 h	High	10	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	12 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	12 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	12 h	Low	25	1/3	0.33 (0.01, 0.91)
Voll	Unpainted Concrete	12 h	Low	50	1/3	0.33 (0.01, 0.91)
Voll	Unpainted Concrete	12 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	12 h	Medium	25	1/3	0.33 (0.01, 0.91)
Voll	Unpainted Concrete	12 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	16 h	High	10	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	16 h	High	50	0/3	0.00 (0.00, 0.71)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Unpainted Concrete	16 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	16 h	Low	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	16 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	16 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	16 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	1 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	20 h	High	10	1/3	0.33 (0.01, 0.91)
Voll	Unpainted Concrete	20 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	20 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	20 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	20 h	Low	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	20 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	20 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	20 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	24 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	24 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	24 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	24 h	Low	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	24 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	24 h	Medium	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	2 h	Low	200	2/3	0.67 (0.09, 0.99)

Text Table D2. Continued.

Strain	Material	Contact Time	Average RH	HPV ppm	Kills/ Trials	Proportion of Kills (95 Percent Confidence Interval)
Voll	Unpainted Concrete	3 h	Low	200	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	48 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	4 h	High	10	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	4 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	8 h	High	10	1/3	0.33 (0.01, 0.91)
Voll	Unpainted Concrete	8 h	High	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	8 h	High	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	8 h	Low	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	8 h	Low	50	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	8 h	Medium	10	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	8 h	Medium	25	0/3	0.00 (0.00, 0.71)
Voll	Unpainted Concrete	8 h	Medium	50	0/3	0.00 (0.00, 0.71)

Text Table D3. Joint Test for Logistic Regression Model Fit to Full Dataset

Effect	DF	Wald Test Statistic	p-value
Strain	1	0.0002	0.9878
Material	5	33.4403	<0.0001*
Average RH	2	1.3788	0.5019
Dose	1	0.0150	0.9025
Strain*Material	5	23.7072	0.0002*
Strain*Average RH	2	6.6379	0.0362*
Dose*Strain	1	0.0021	0.9631
Material*Average RH	10	55.1795	<0.0001*
Dose*Material	5	98.4537	<0.0001*
Dose*Average RH	2	18.6340	<0.0001*
Dose*Strain*Material	5	37.1099	<0.0001*

* Effect is statistically significant if the p-value is ≤ 0.05; DF = degrees of freedom

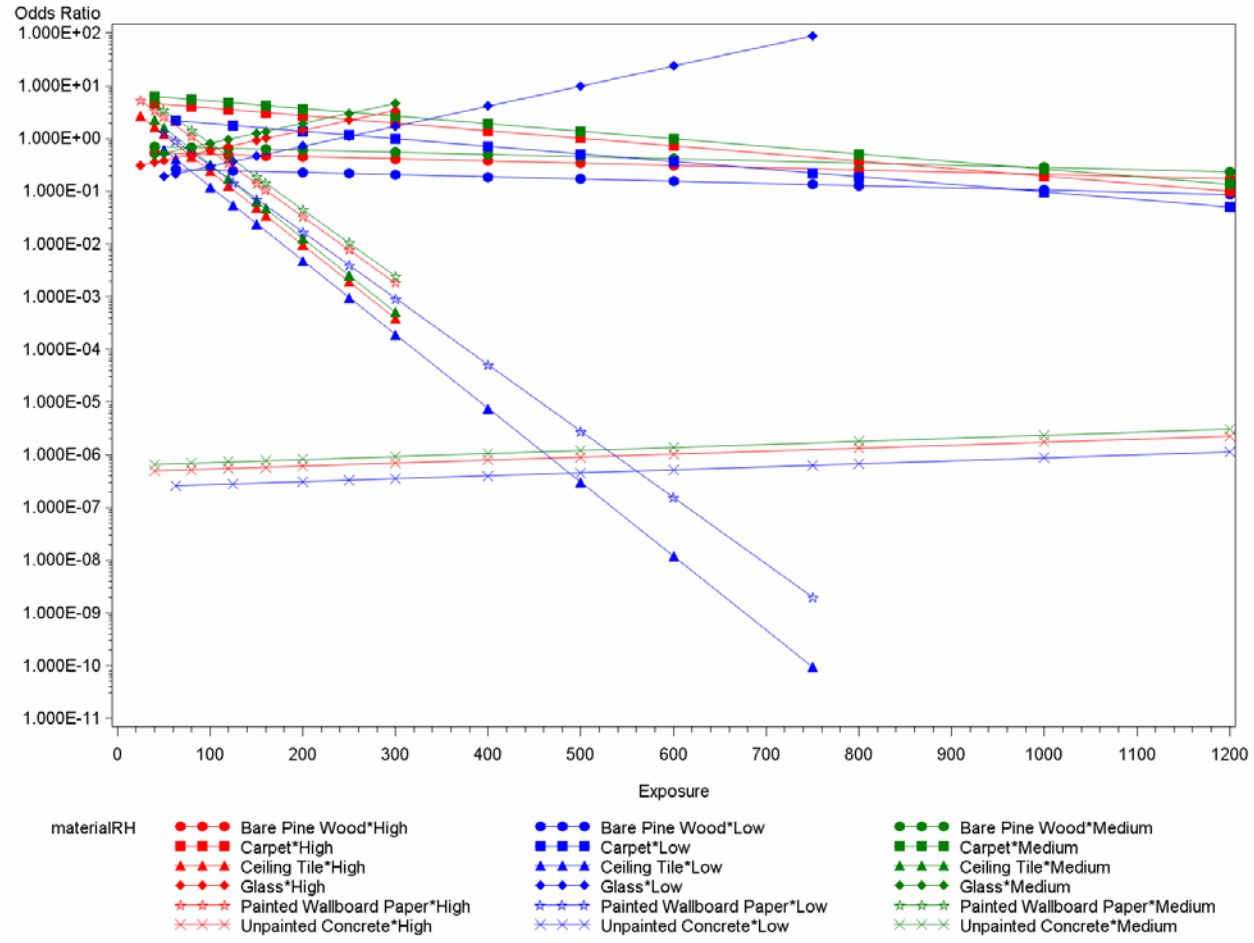

Figure D1. Odds Ratios Comparing Strains (Ames vs Vollum) which Varies by Material*RH

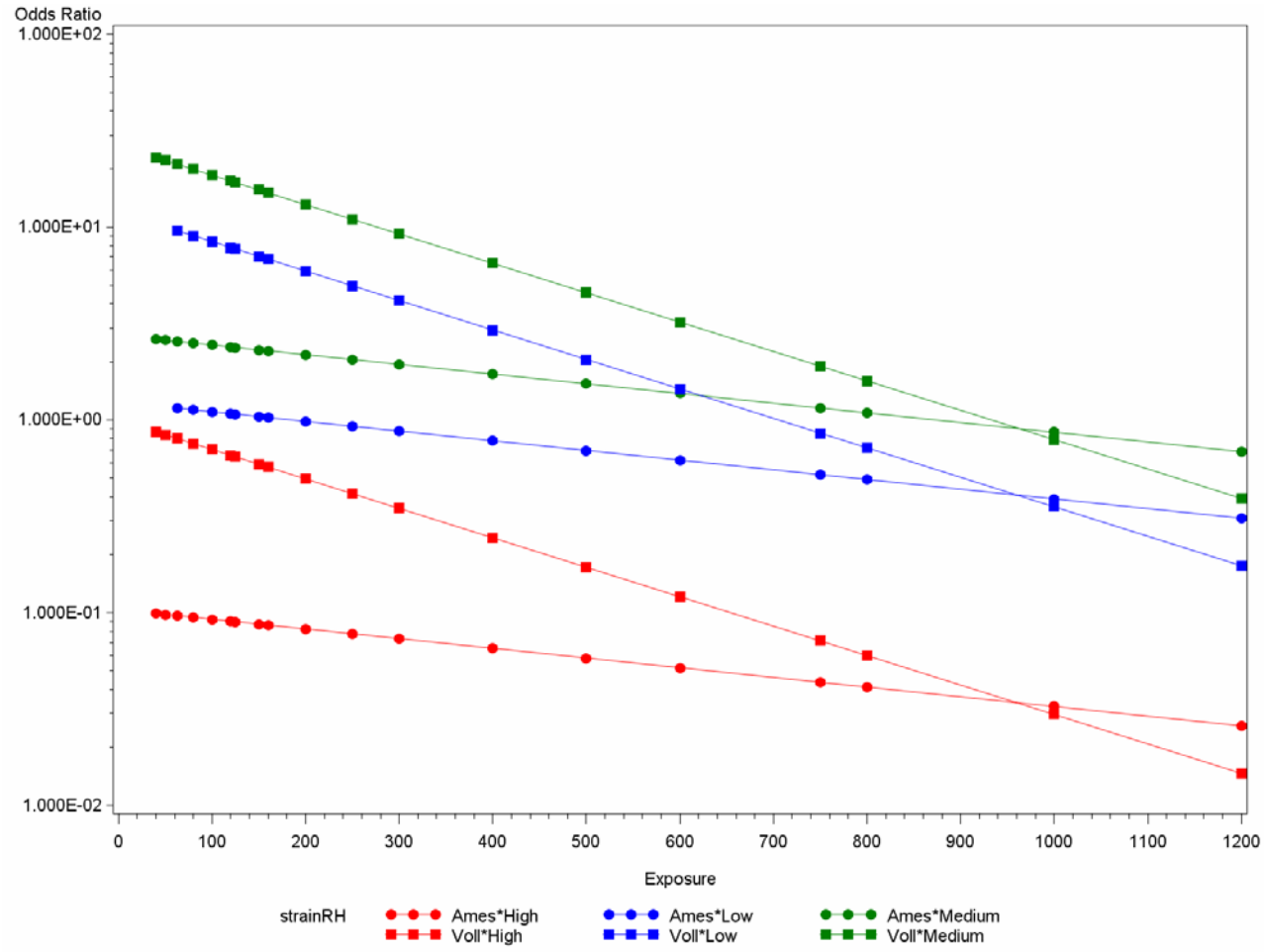

Figure D2. Odds Ratios Comparing Materials – Bare Pine Wood vs Carpet (Varying by Strain by RH)

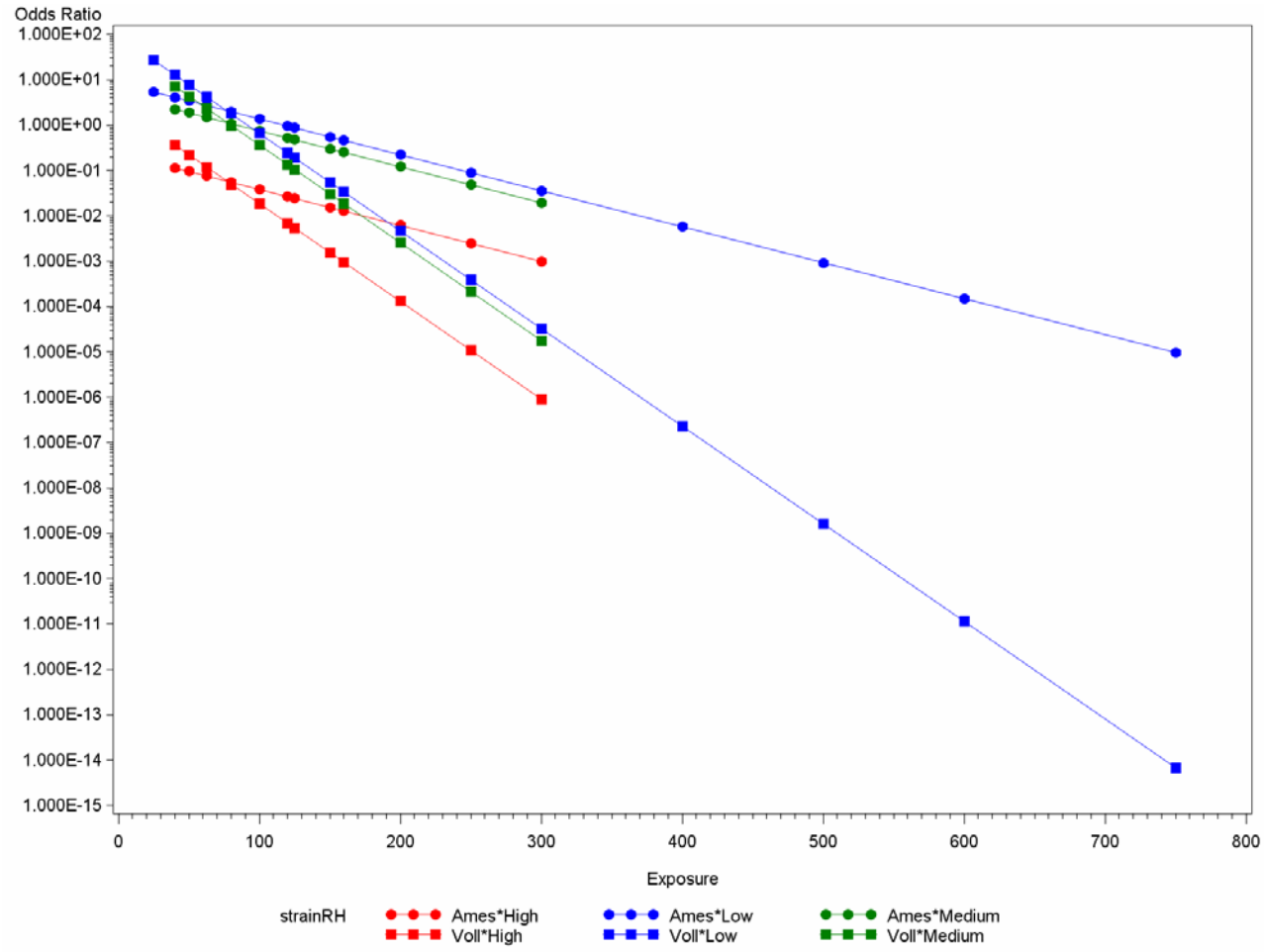

Figure D3. Odds Ratios Comparing Materials – Bare Pine Wood vs Ceiling Tile (Varying by Strain by RH)

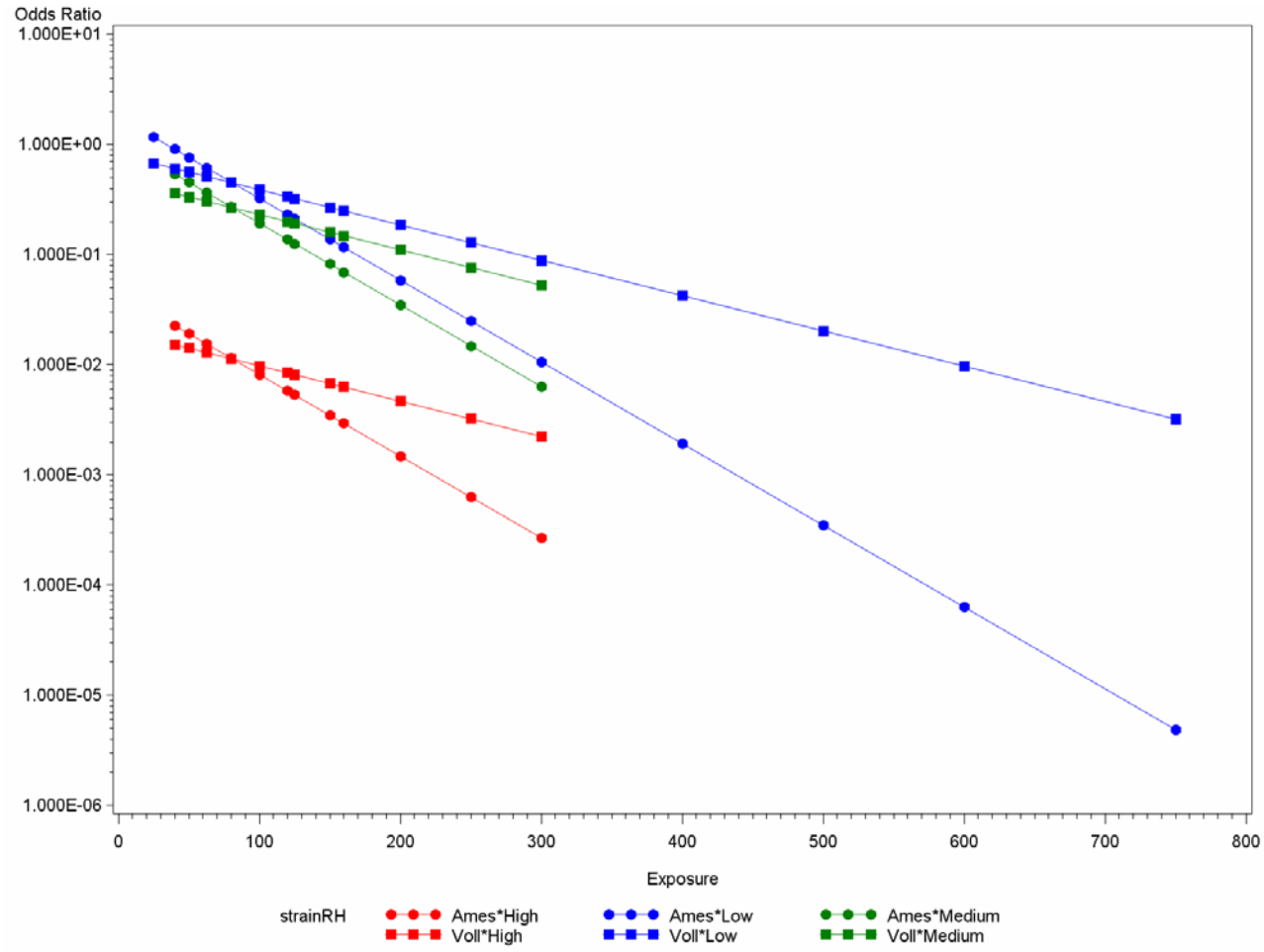

Figure D4. Odds Ratios Comparing Materials – Bare Pine Wood vs Glass (Varying by Strain by RH)

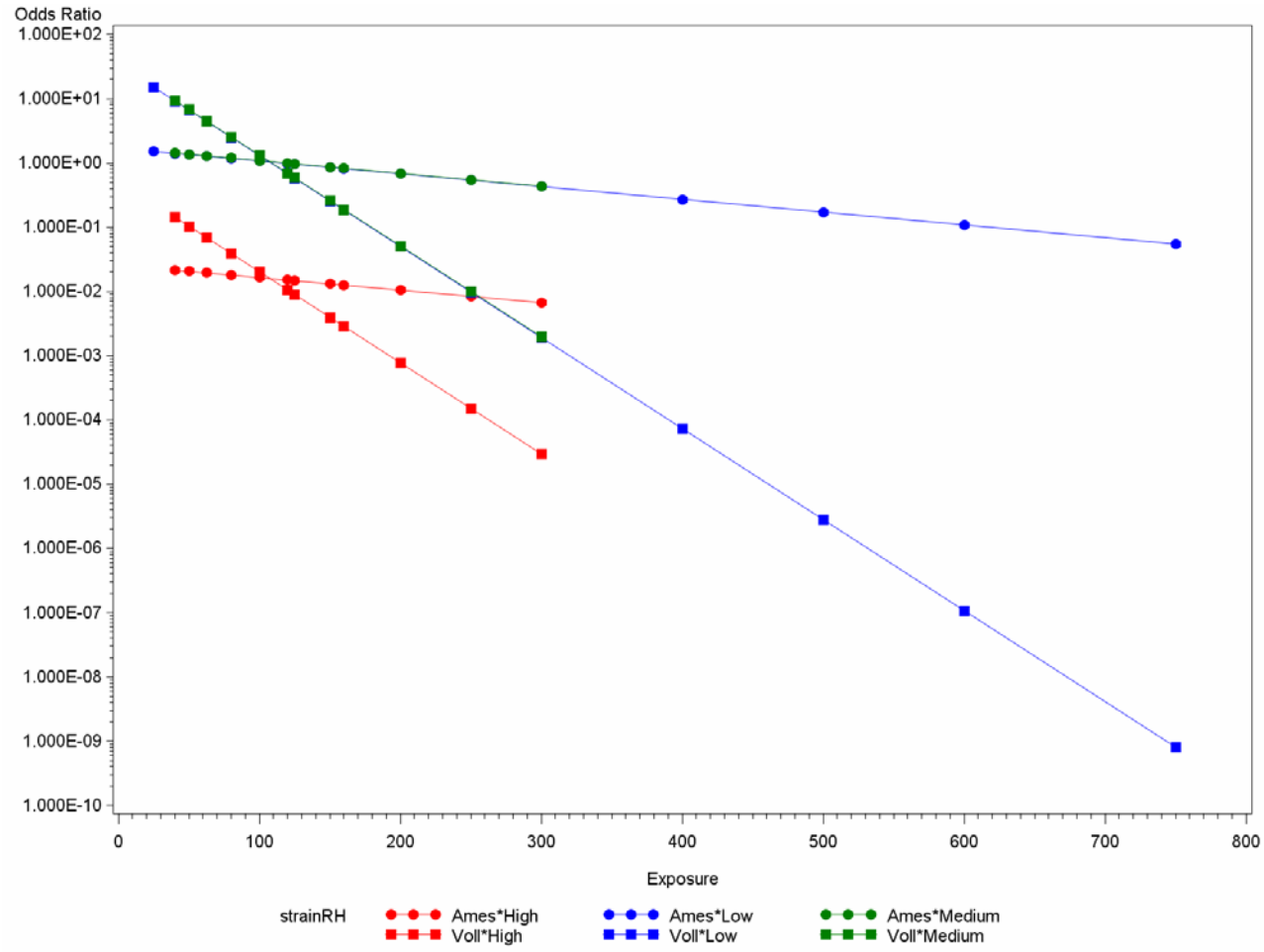

Figure D5. Odds Ratios Comparing Materials – Bare Pine Wood vs Painted Wallboard Paper (Varying by Strain by RH)

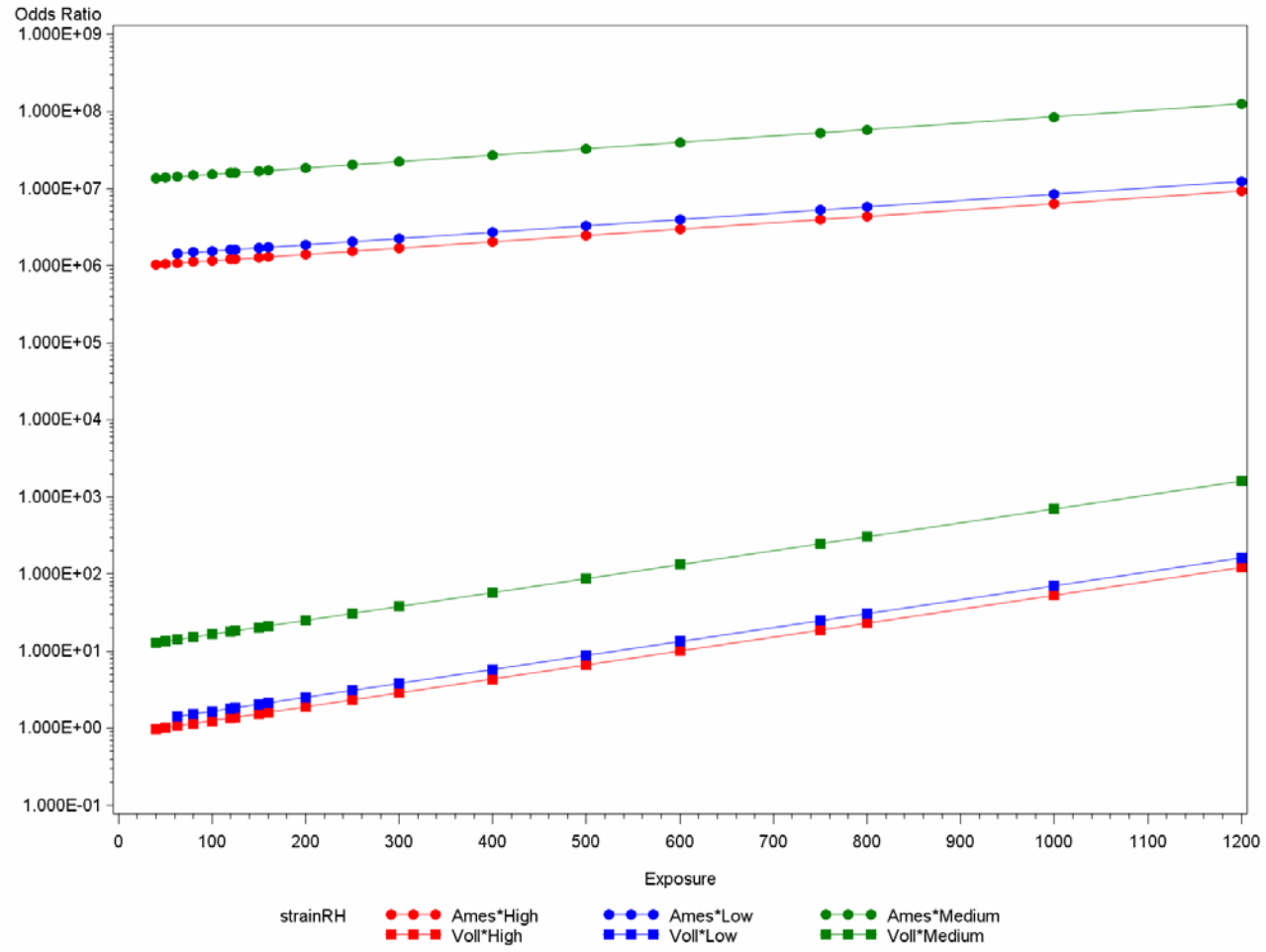

Figure D6. Odds Ratios Comparing Materials – Bare Pine Wood vs Unpainted Concrete (Varying by Strain by RH)

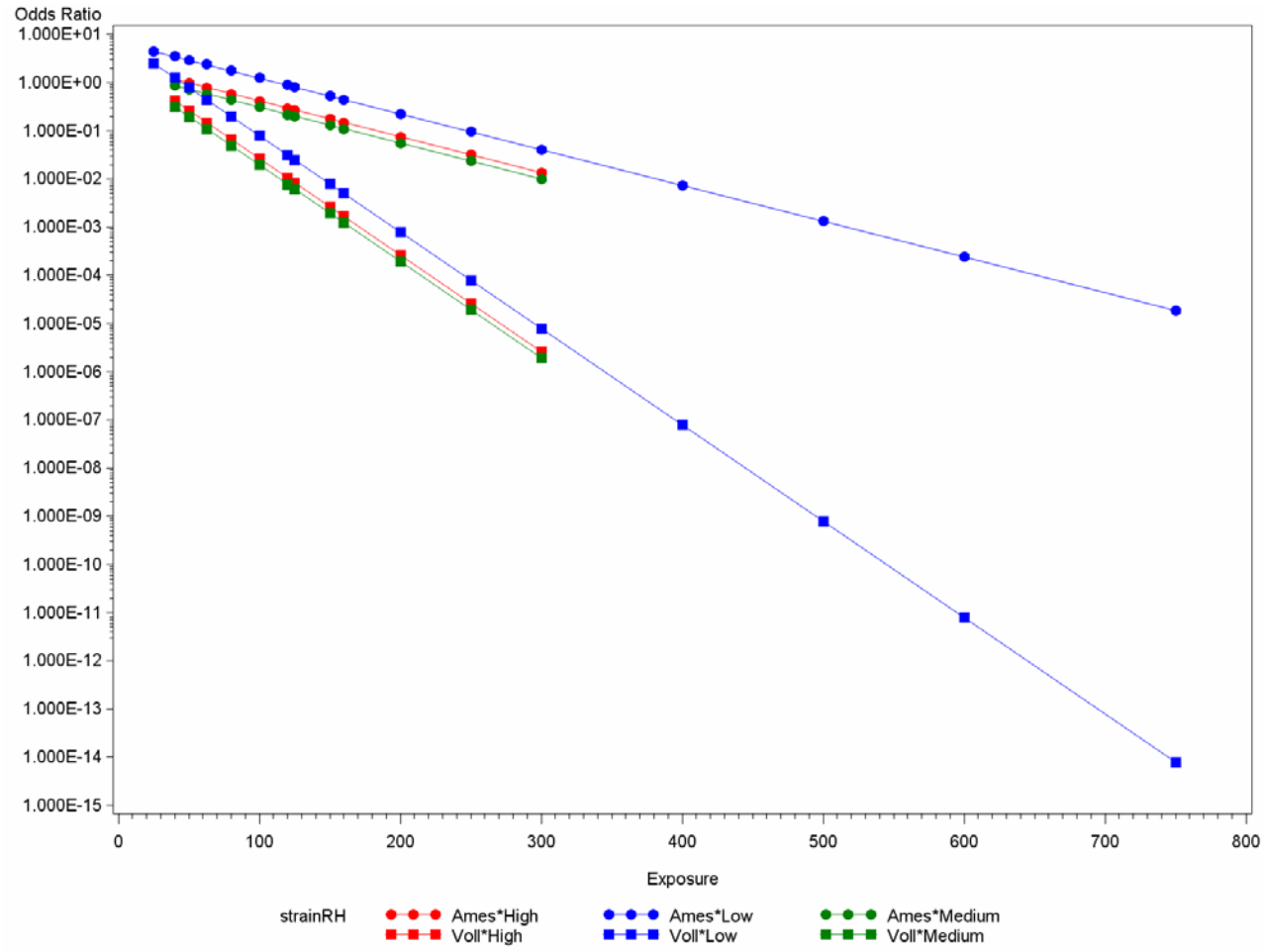

Figure D7. Odds Ratios Comparing Materials – Carpet vs Ceiling Tile (Varying by Strain by RH)

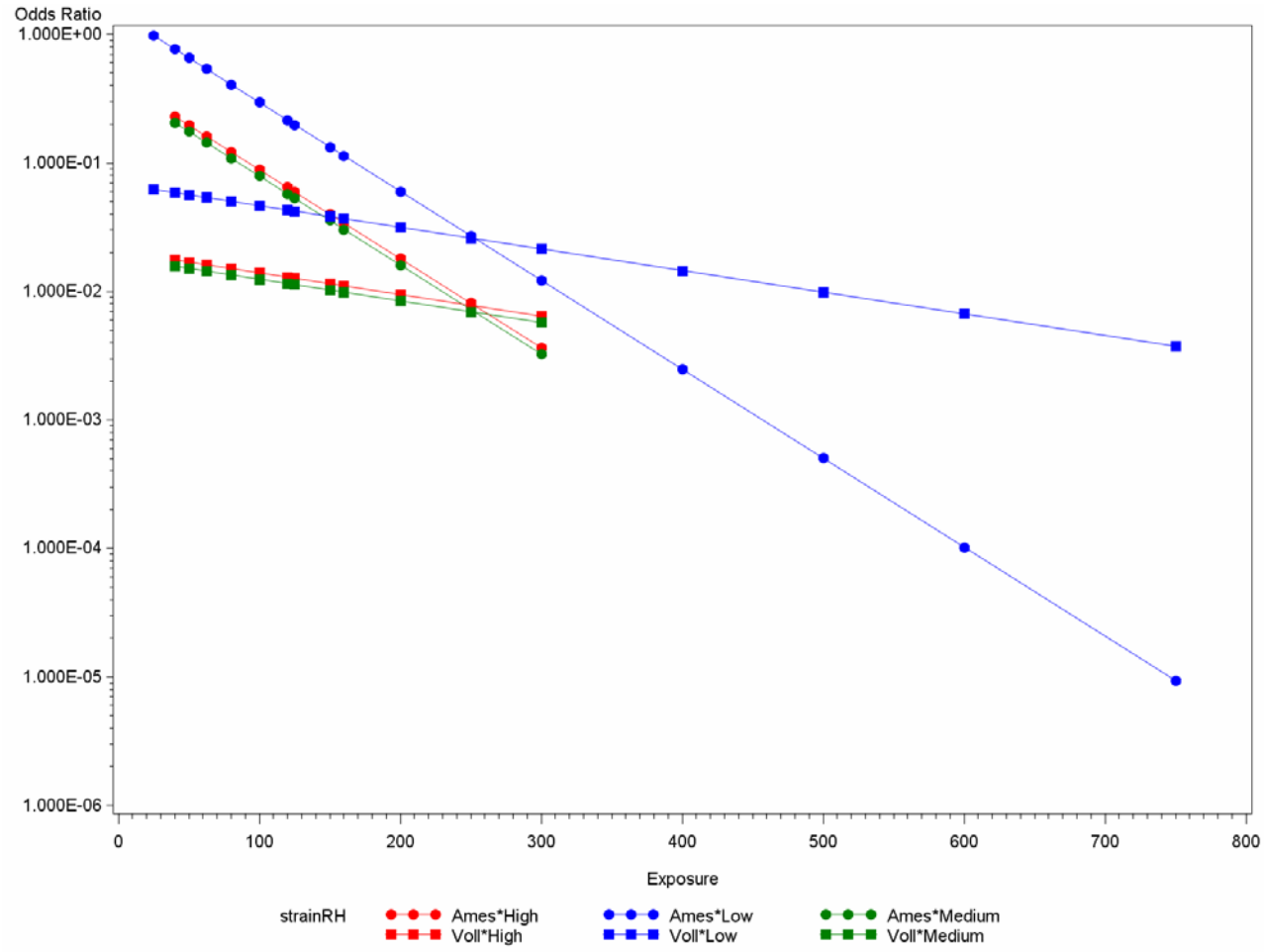

Figure D8. Odds Ratios Comparing Materials – Carpet vs Glass (Varying by Strain by RH)

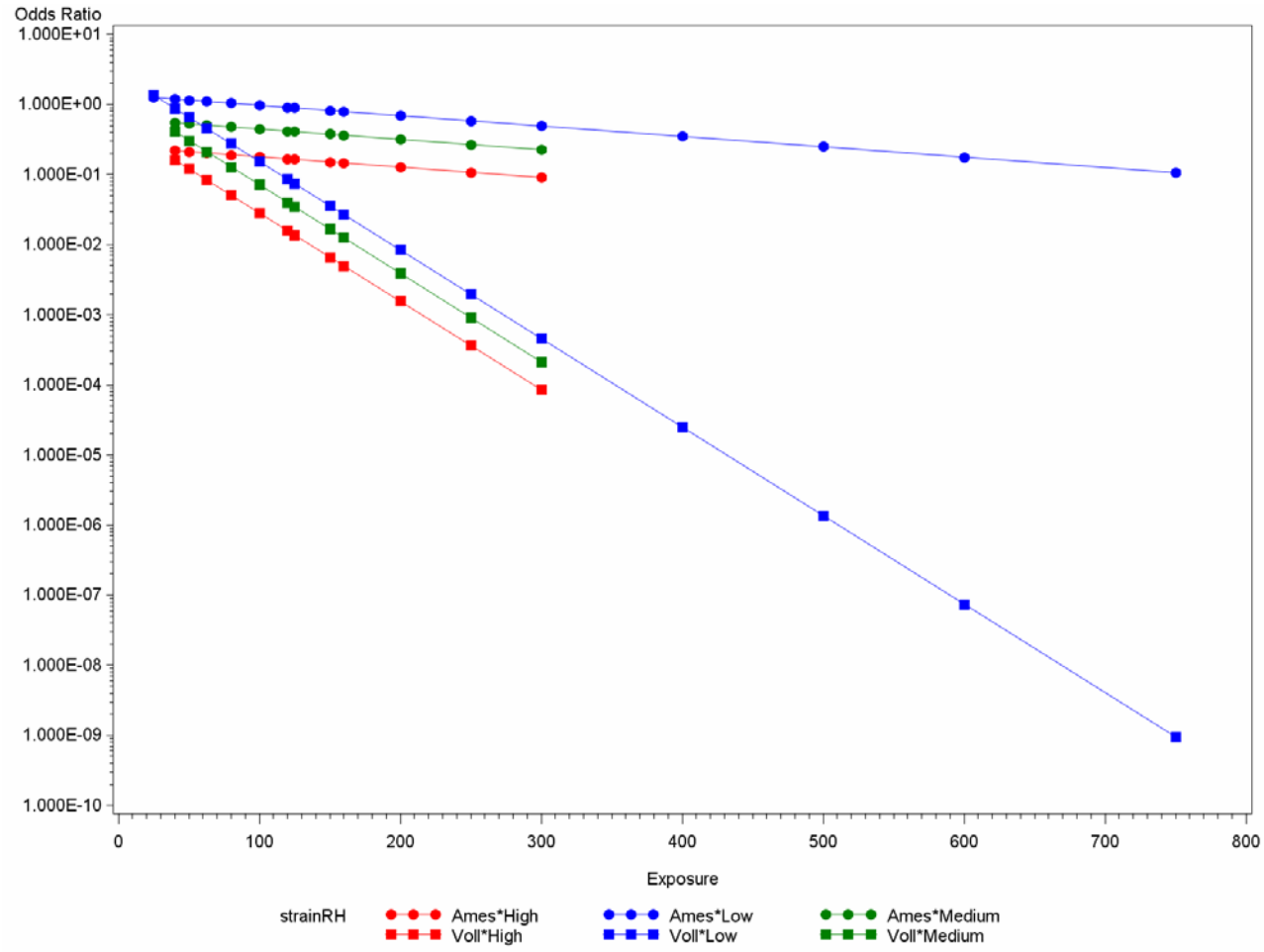

Figure D9. Odds Ratios Comparing Materials – Carpet vs Painted Wallboard Paper (Varying by Strain by RH)

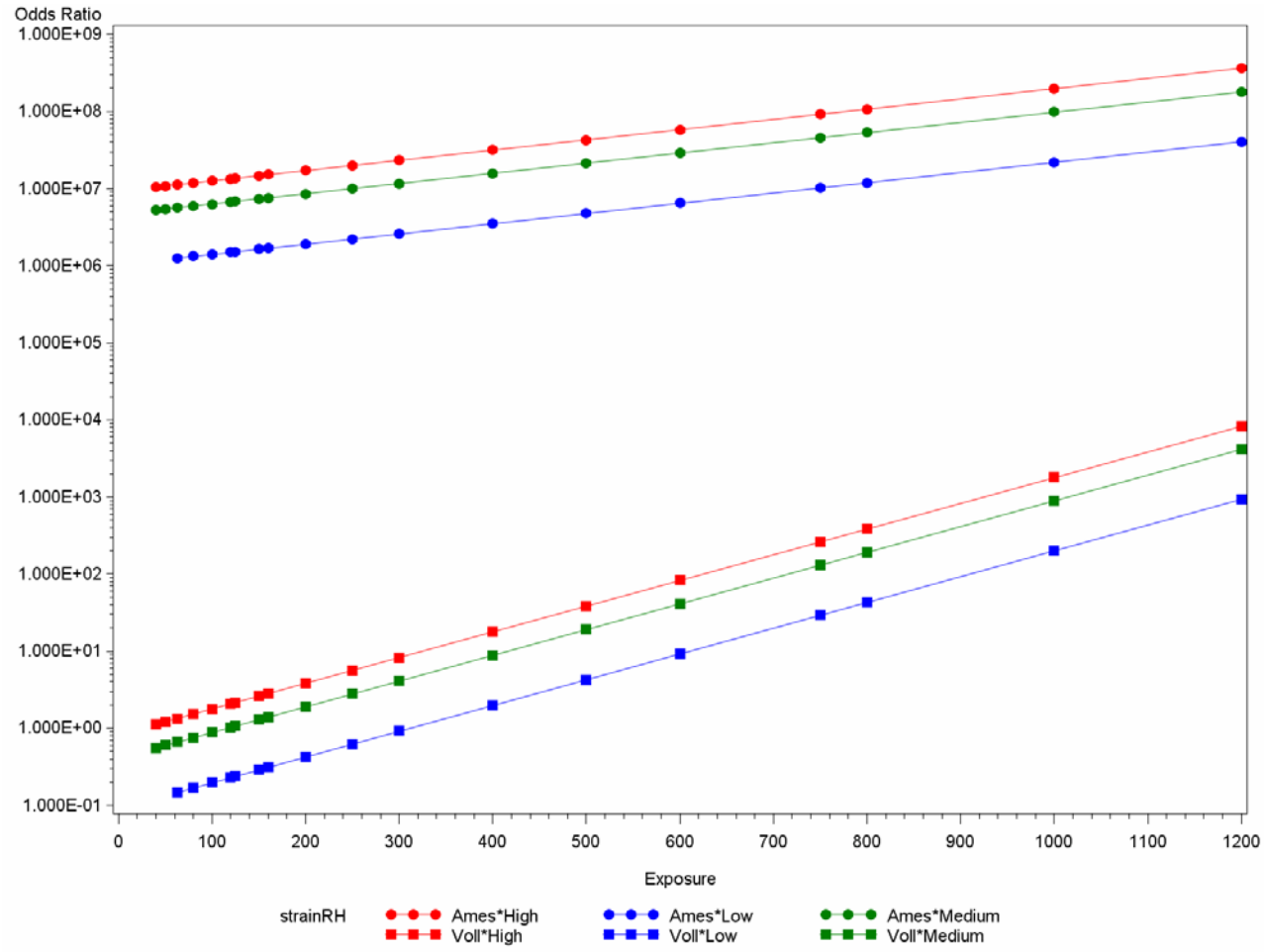

Figure D10. Odds Ratios Comparing Materials – Carpet vs Unpainted Concrete (Varying by Strain by RH)

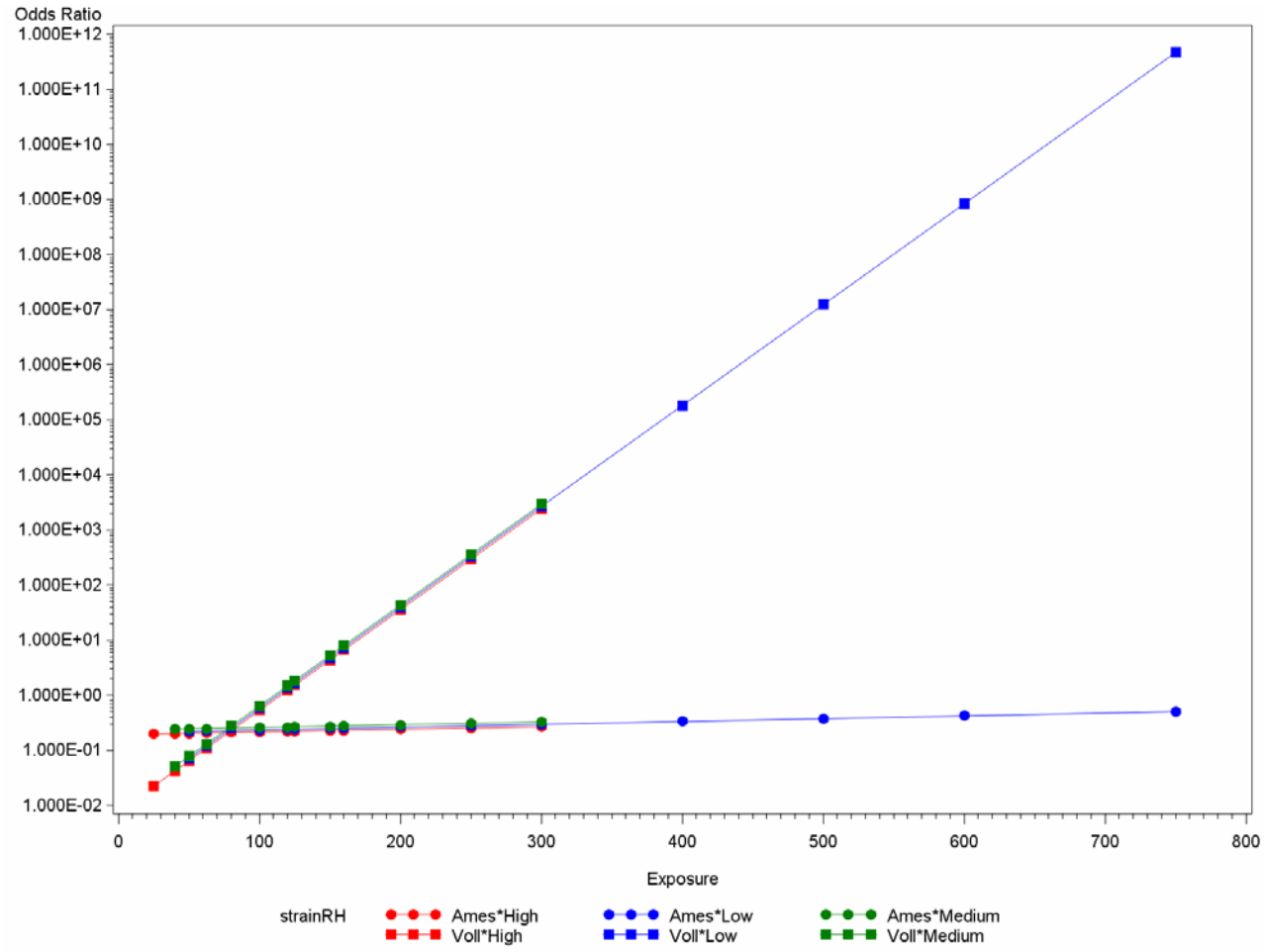

Figure D11. Odds Ratios Comparing Materials – Ceiling Tile vs Glass (Varying by Strain by RH)

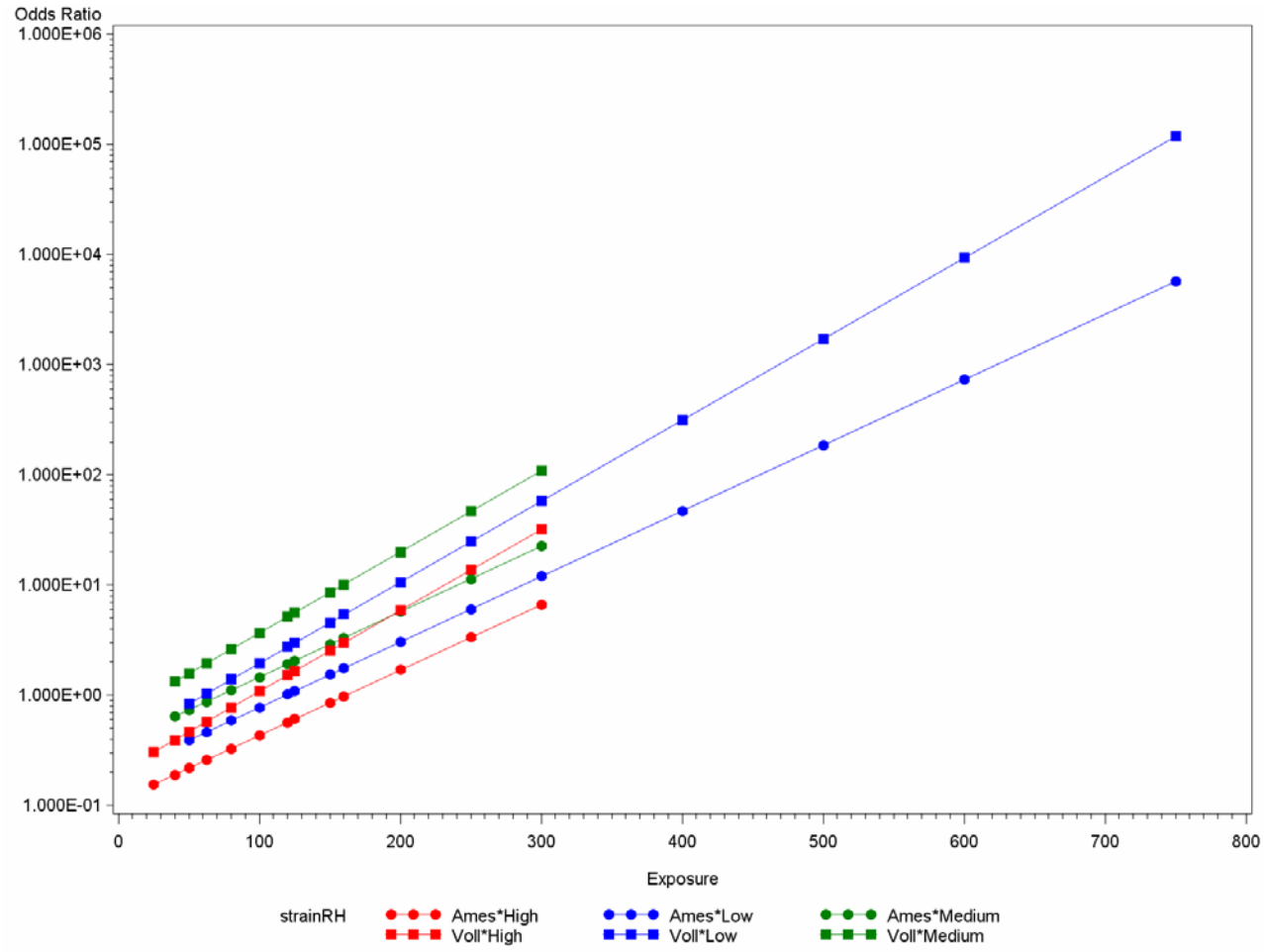

Figure D12. Odds Ratios Comparing Materials – Ceiling Tile vs Painted Wallboard Paper (Varying by Strain by RH)

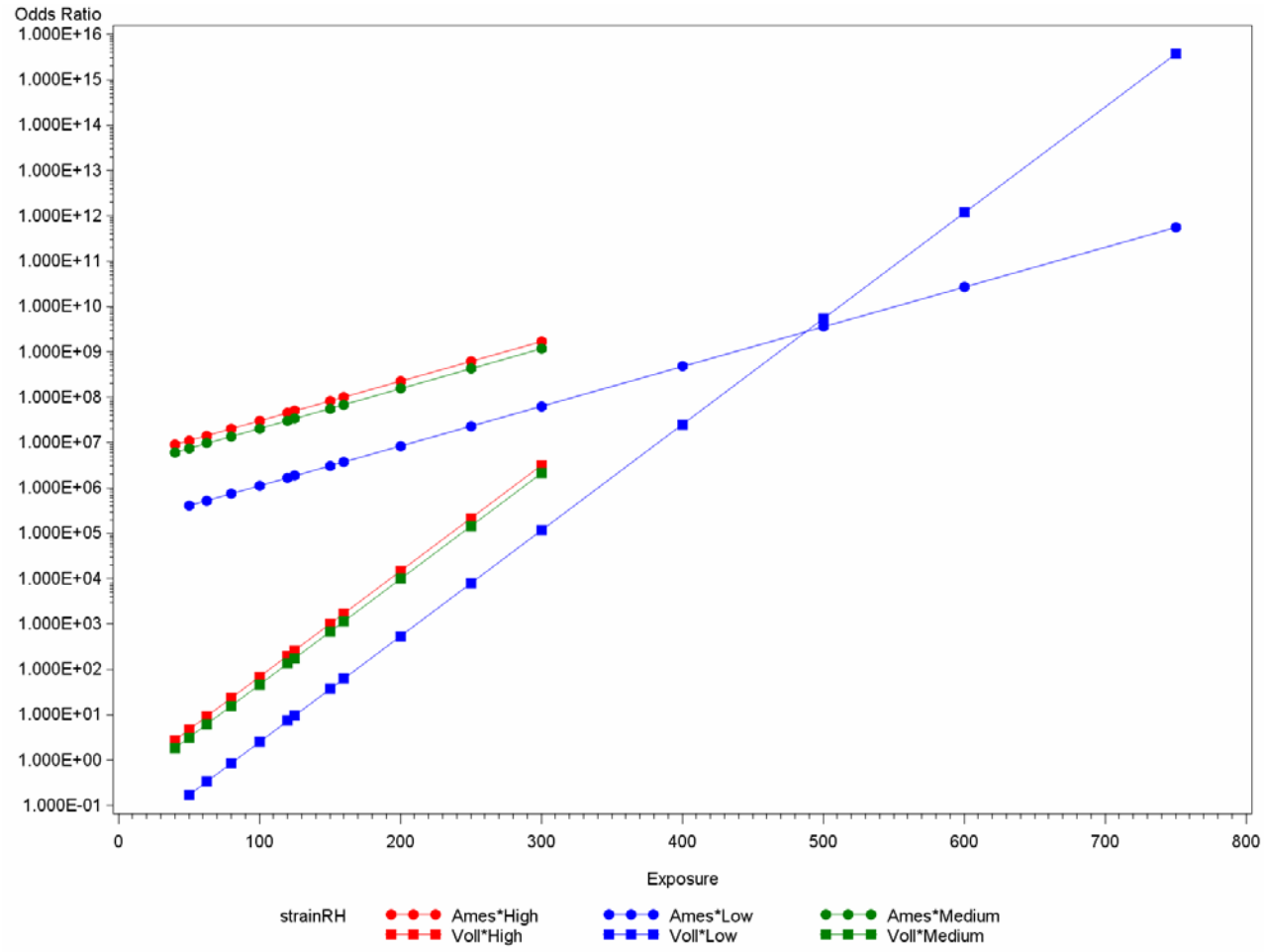

Figure D 13. Odds Ratios Comparing Materials – Ceiling Tile vs Unpainted Concrete (Varying by Strain by RH)

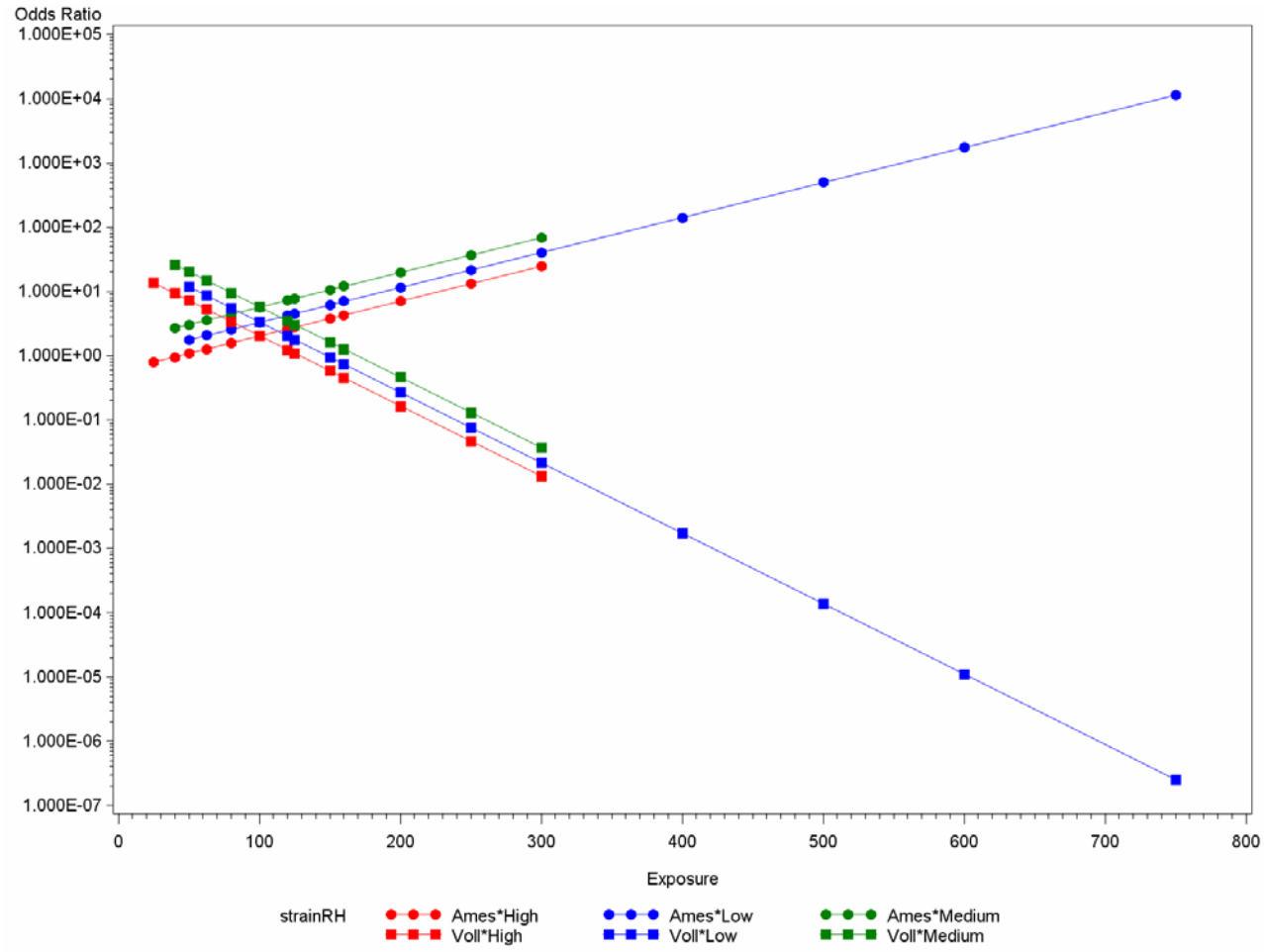

Figure D14. Odds Ratios Comparing Materials – Glass vs Painted Wallboard Paper (Varying by Strain by RH)

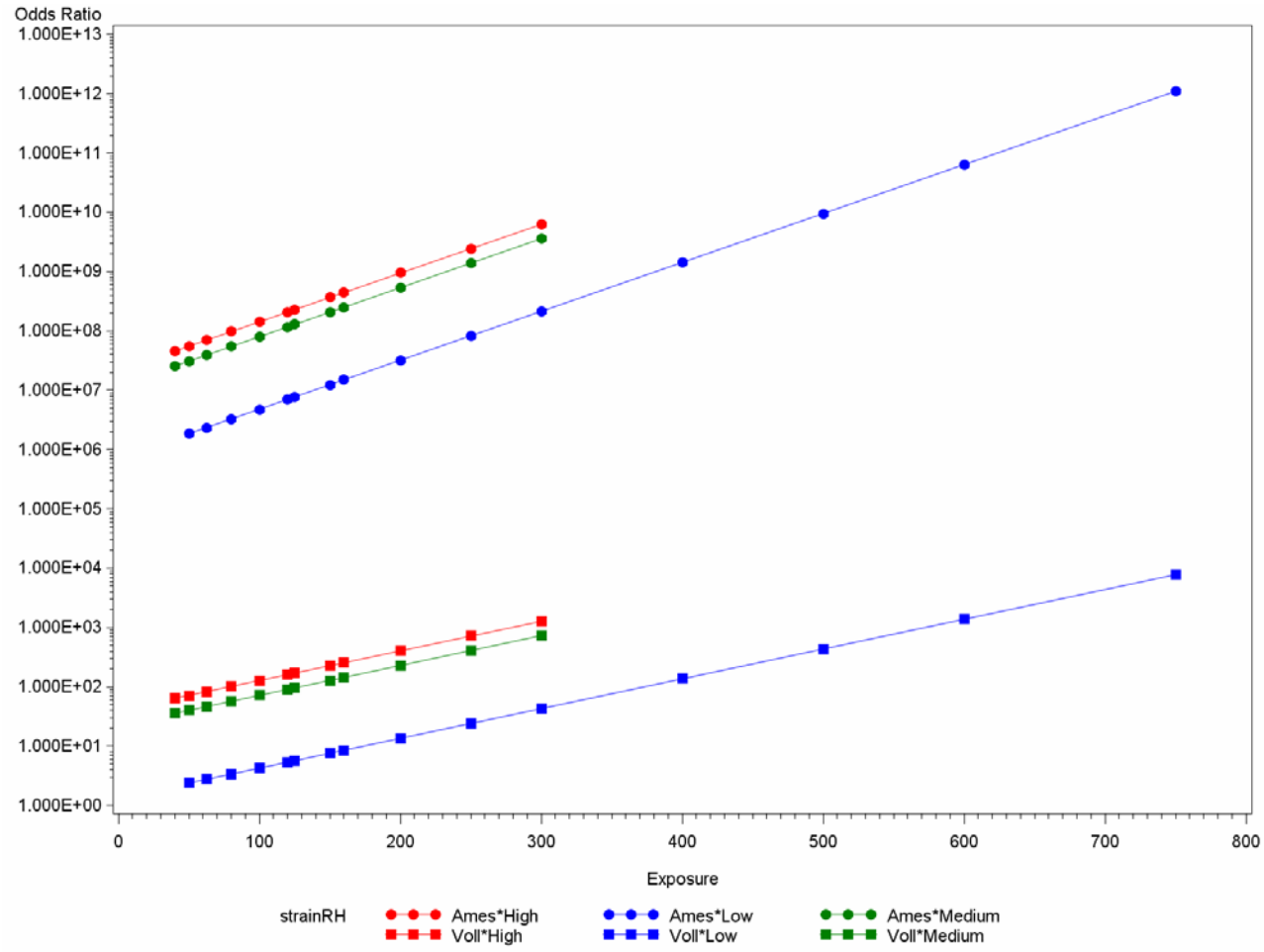

Figure D15. Odds Ratios Comparing Materials – Glass vs Unpainted Concrete (Varying by Strain by RH)

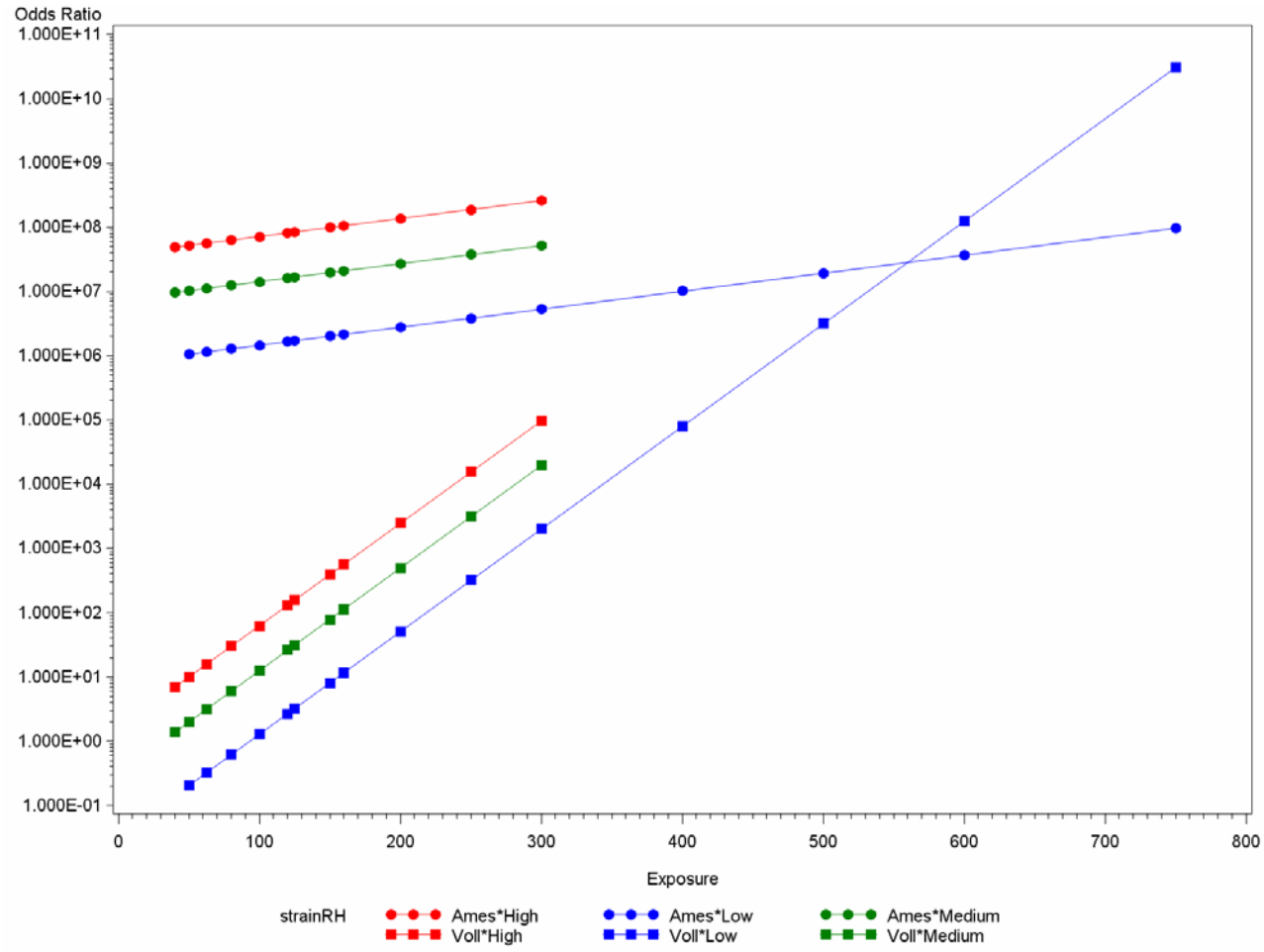

Figure D16. Odds Ratios Comparing Materials – Painted Wallboard Paper vs Unpainted Concrete (Varying by Strain by RH)

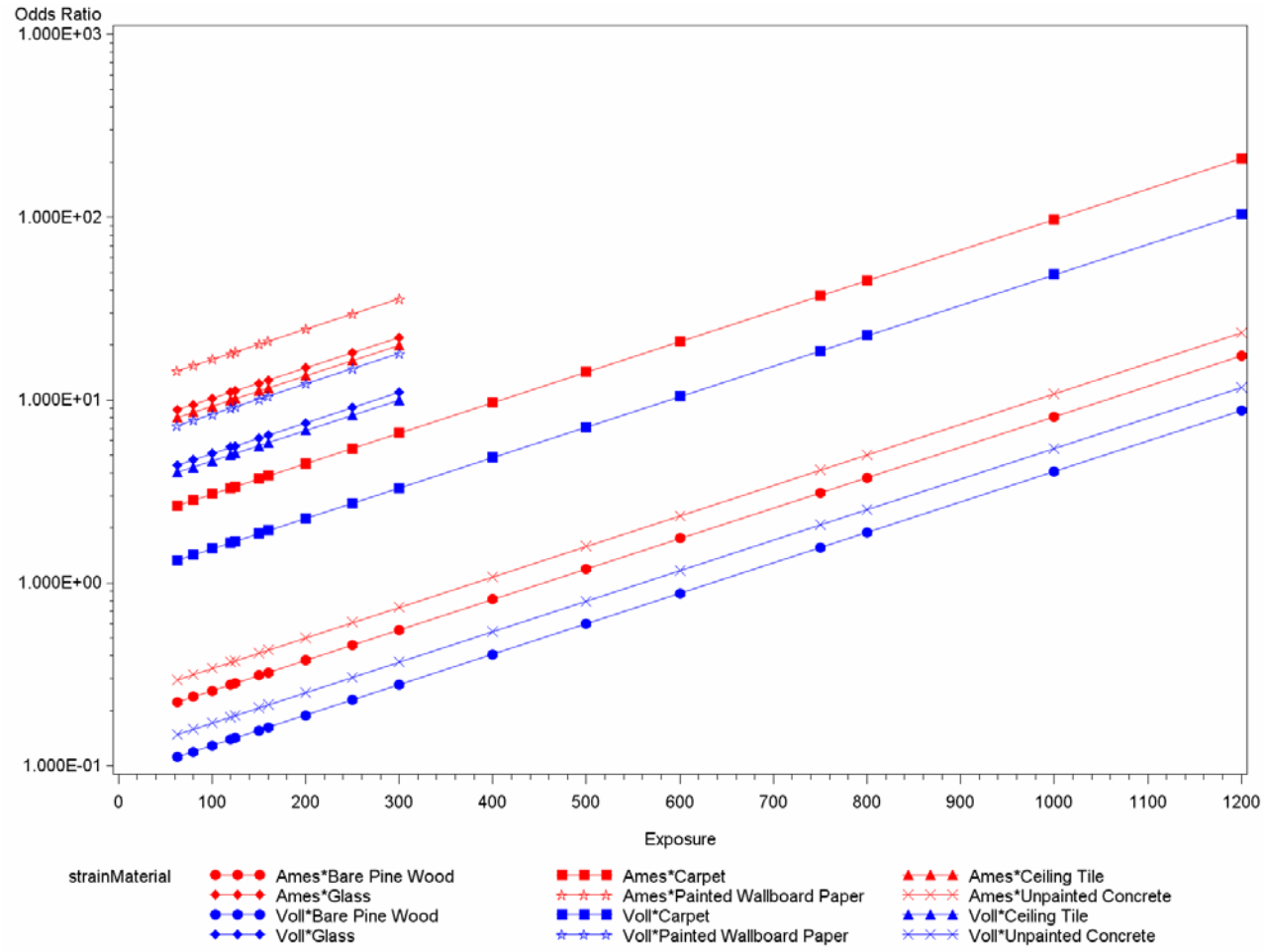

Figure D17. Odds Ratios Comparing RH – High vs Low (Varying by Strain by Material)

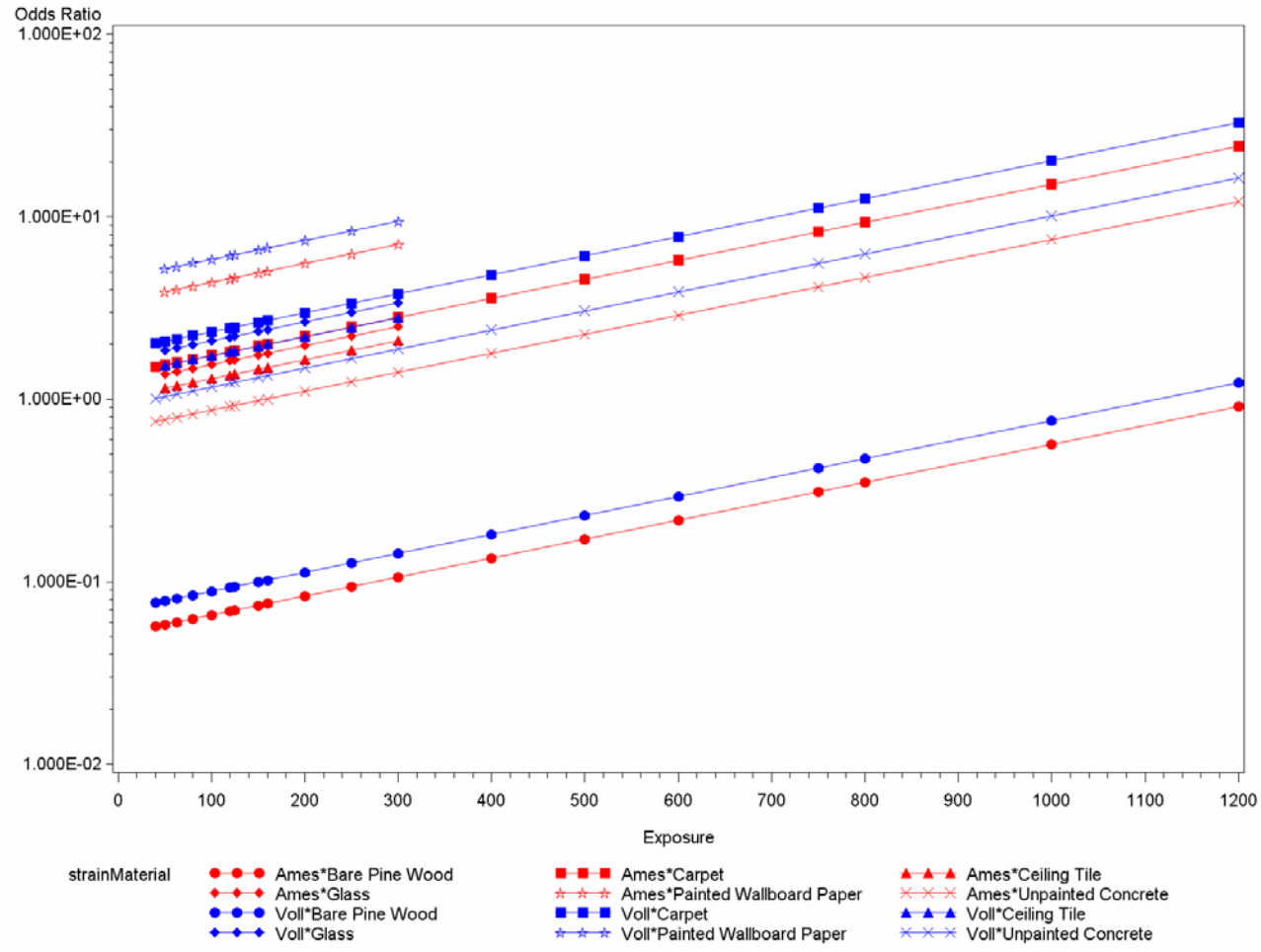

Figure D18. Odds Ratios Comparing RH – High vs Medium (Varying by Strain by Material)

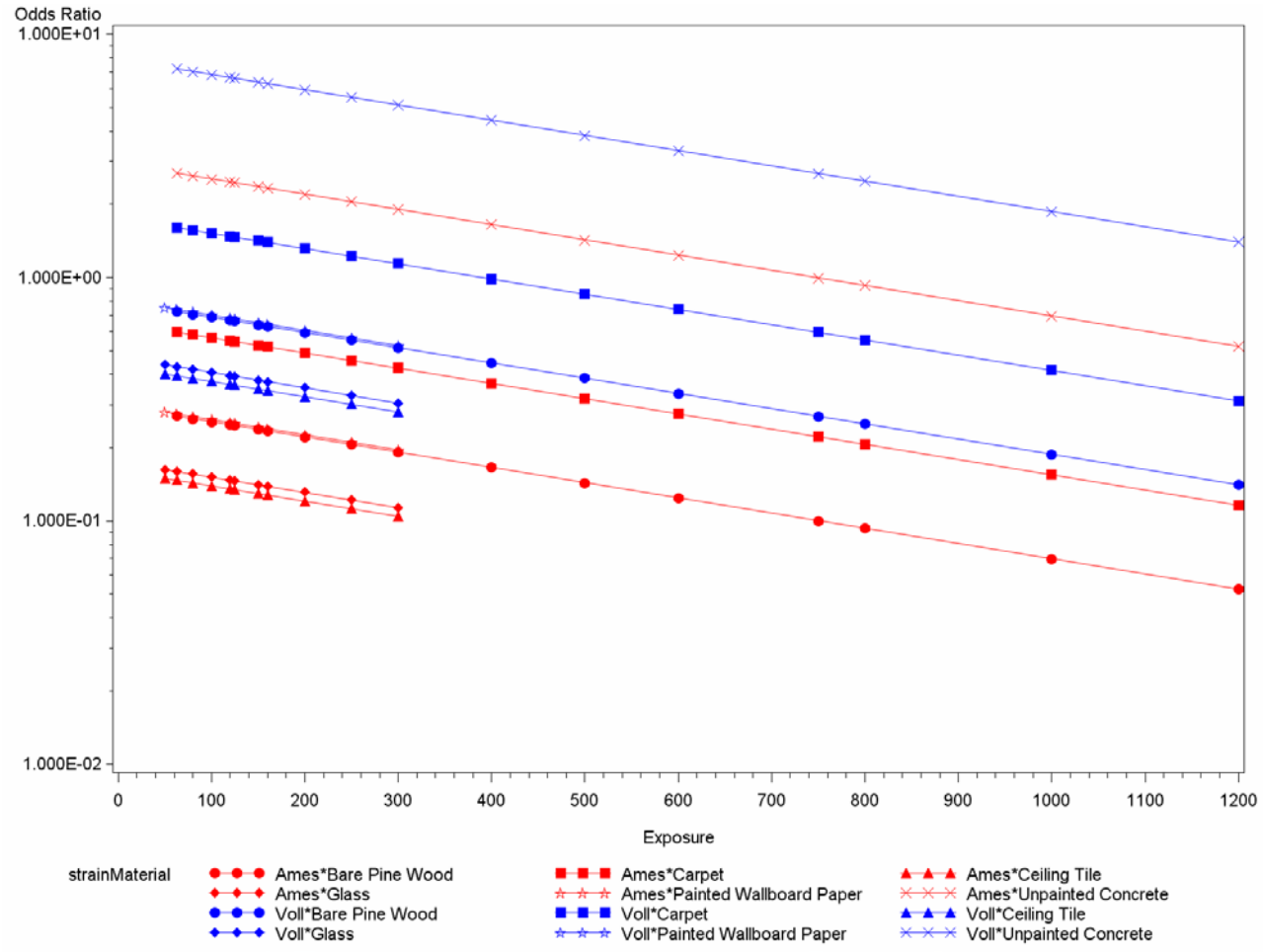

Figure D19. Odds Ratios Comparing RH – Low vs Medium (Varying by Strain by Material)

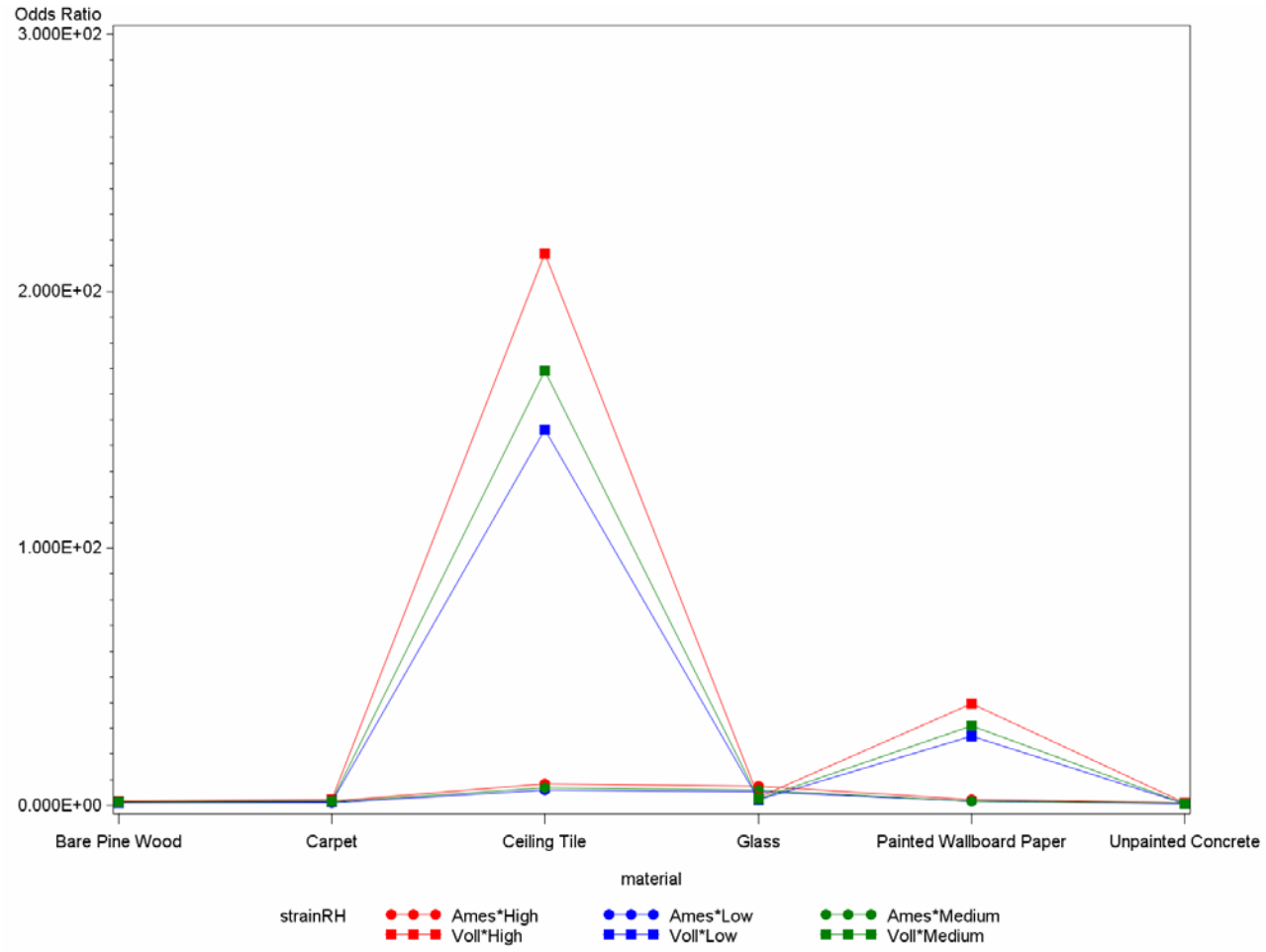

Figure D20. Odds Ratios per 100 Unit Increase in Dose

United States
Environmental Protection
Agency

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