

BACKGROUND

Spray application of sporicidal liquids directly to surfaces contaminated with spores of *Bacillus anthracis* can be effective yet labor intensive, hazardous, and potentially generate large volumes of decontaminant waste solution. The use of fogging technology to disseminate sporicidal solutions has the potential to be a less arduous, more economical, and effective alternative for surfaces and volumetric decontamination for areas contaminated with *B. anthracis*. This investigation evaluated the efficacy of an off-the-shelf fogger using chlorine-based sporicidal liquids for decontaminating an office environment.

Test Facility



- All tests were conducted in 24 m³ Consequence Management and Decontamination Evaluation Room, or COMMANDER, using a mock office set up.
- Temperature, relative humidity (RH), air pressures, and flow rates within the decontamination chamber were controlled and/or their data logged continuously using a supervisory control and data acquisition (SCADA) system.



SAMPLE LOCATIONS

Three replicates of each the material placed under the desk, on the desk, and above the ceiling.



TEST SEQUENCE & CONDITIONS

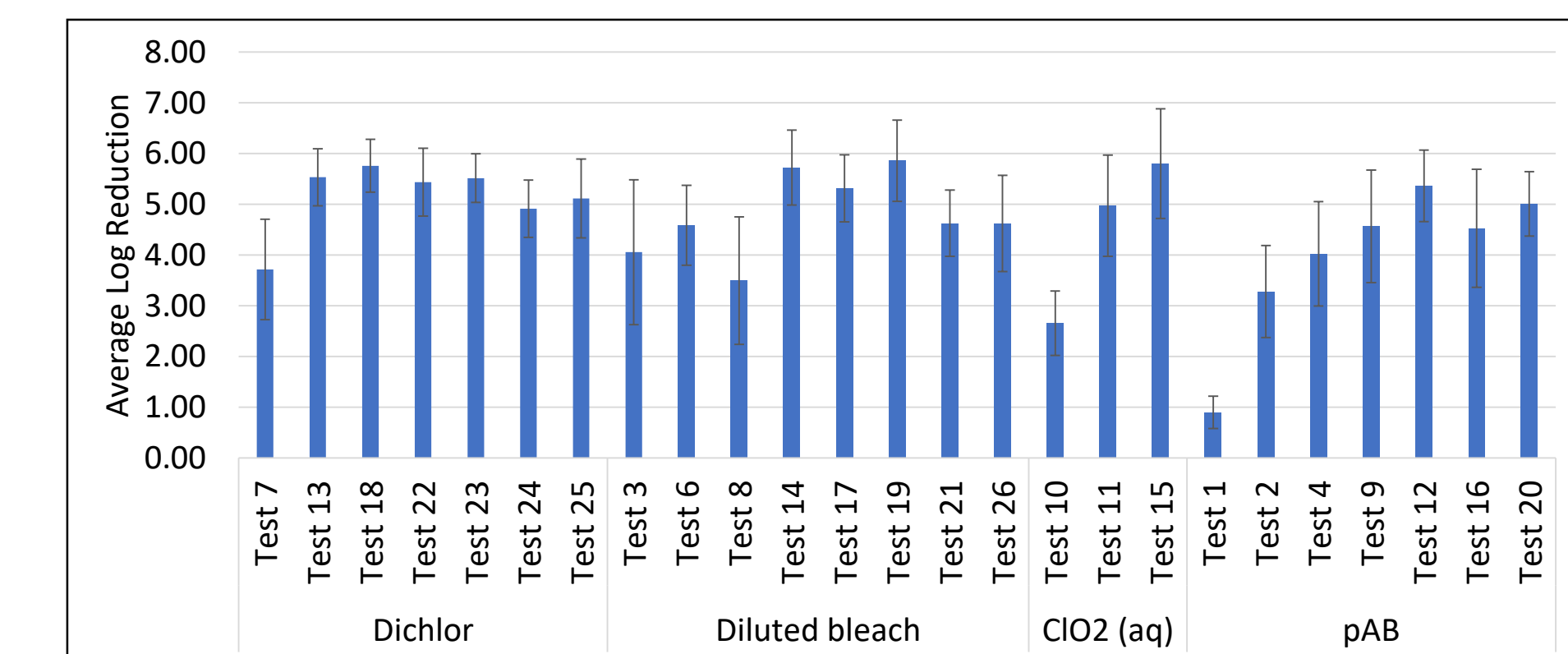


Test	Sporicidal Solution	Actual Sporicidal Solution Volume Disseminated (mL)	AIC in Aqueous Solution (mg/L)	pH	Mean AIC in Chamber Air (ppm)	Mean RH (%)	Mean T (°C)	Air Exchange (fraction of chamber volume replaced each hour)
1	pAB	887	6440	6.8	3	68	28	0
2	pAB	2921	6480	7.0	7	67	26	0
3	DB	2891	17401	11.4	8	77	28	0
4	pAB	3941	7840	6.8	7	64	27	0
6	DB	4840	16721	NA	10	42	28	0
7	Dichlor	5873	20601	NA	4	76	22	0
8	DB	5300	15920	12.01	27	64	26	0
9	pAB	5891	15701	7.20	35	69	26	0
10	ClO ₂	1910	5906	2.04	59	72	25	0
11	ClO ₂	3960	4763	2.24	73	96	24	0
12	pAB	5817	18301	6.67	89	97	28	0
13	Dichlor	7165	20701	7.82	12	91	28	0
14	B	7642	19001	11.14	34	100	26	0
15	ClO ₂	7738	5907	1.66	36	90	26	0
16	pAB	7229	17401	6.24	131	80	27	0
17	DB	7776	24201	11.15	48	87	29	0
18	Dichlor	7915	21301	6.61	20	81	30	0
19	DB	7766	23701	11.12	46	90	27	0
20	pAB	7860	18701	6.28	52	68	26	0
21	DB	7780	23001	11.31	9	73	24	0
22	Dichlor	7778	21901	6.52	11	69	25	0.75
23	Dichlor	7396	20701	NA	14	84	25	0
24	Dichlor	3141	32502	6.74	8	56	27	0.75
25	Dichlor	5406	20801	6.57	9	65	27	0.75
26	DB	7674	22201	11.13	16	66	29	0.75

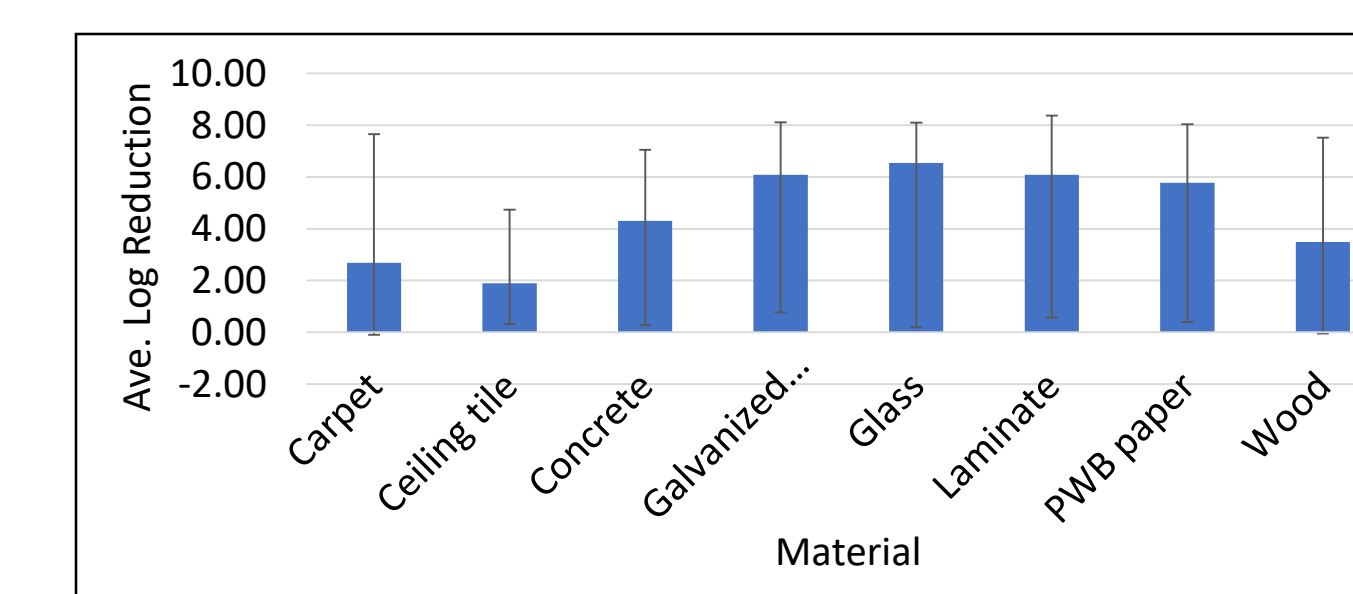
AIC= Active ingredient concentration (either Cl₂ or ClO₂ gas; DB= diluted bleach)

DECONTAMINATION EFFICACY RESULTS

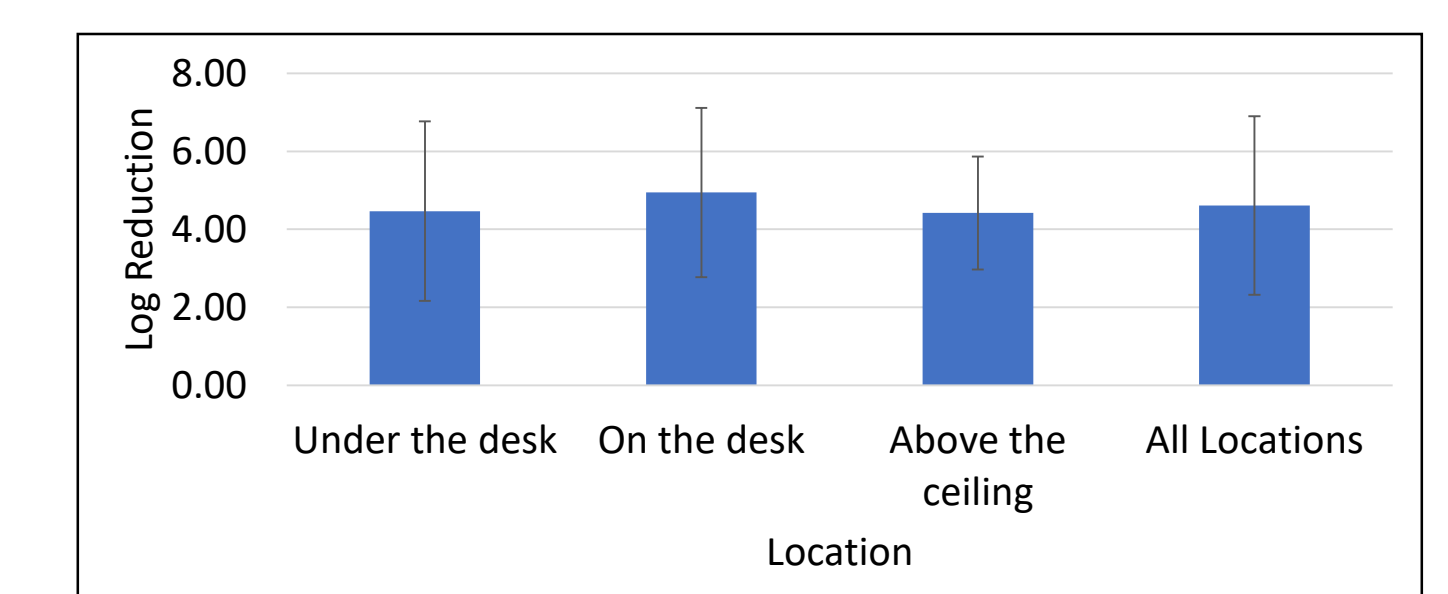
Average Log Reduction by Sporicide



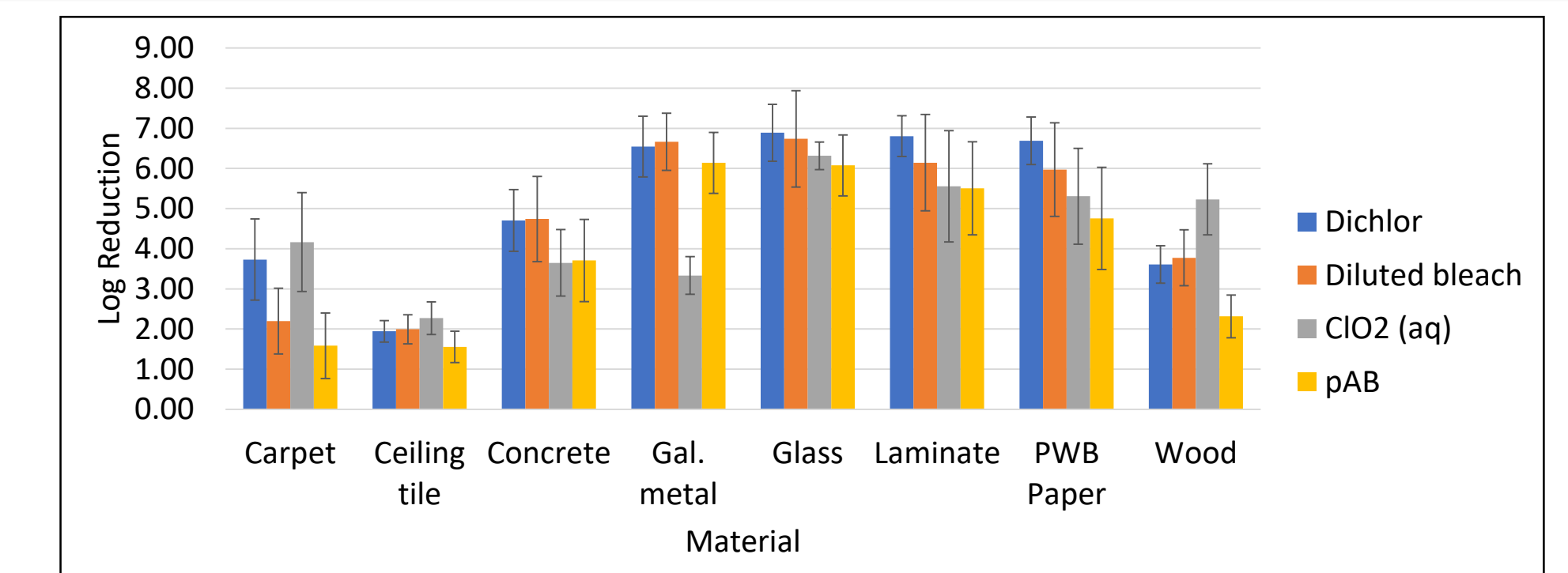
Average Log Reduction by Material



Average Log Reduction by Location



Average Log Reduction by Sporicide per Location



CHLORINE-BASED SPORICIDES

Sporicidal Solution	Active Ingredient
pH-adjusted bleach (pAB)	Sodium hypochlorite, hypochlorous acid
Diluted bleach	Sodium hypochlorite (~ 2% free avail. chorine)
Stabilized chlorinating granules (dichlor)	Sodium dichloro-s-triazinetrione Hydrated, hypochlorous acid
Aqueous ClO ₂	Aqueous chlorine dioxide



SPORE AND LOADING

The test surfaces were loaded with a target dose of 10⁷ colony-forming units (CFU) of *B. atrophaeus* spores, using a metered-dose inhaler (MDI) actuator. *B. atrophaeus* is a proven surrogate for *B. anthracis* when using chlorine-based decontaminants.



COUPON MATERIALS

Eight materials used for this study were as follows:

- Concrete
- Painted wall board (PWB) paper
- Ceiling Tile
- Oak wood
- Galvanized steel
- Laminate flooring
- Borosilicate glass
- Carpet

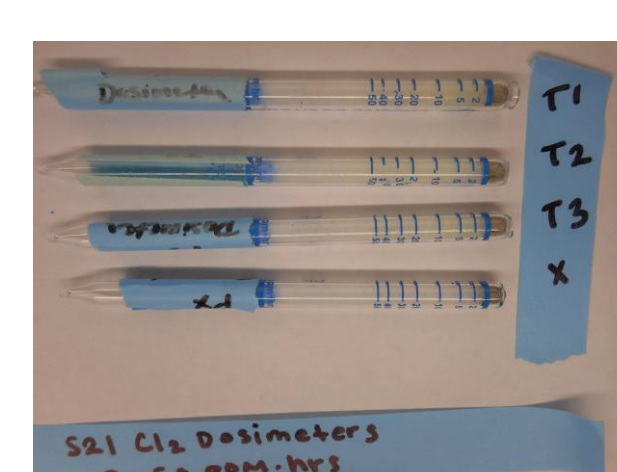
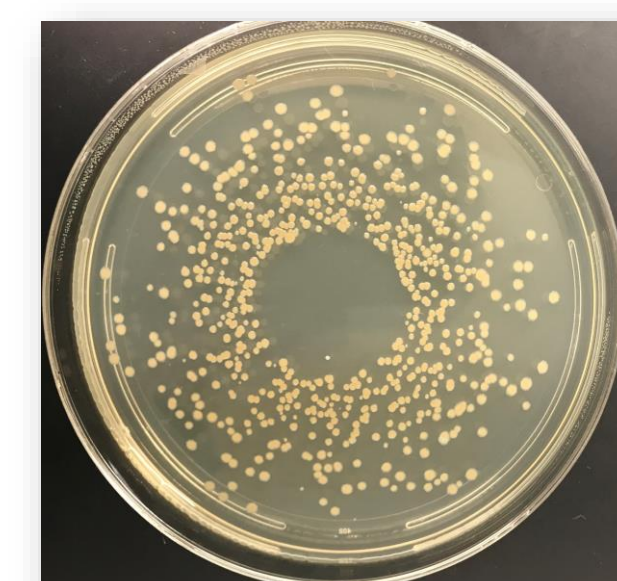


FOG EQUIPMENT

We used an ultra-low volume fogger (SANI-TIZER™, Curtis Dyna-fog, Ltd., Westfield, IN).

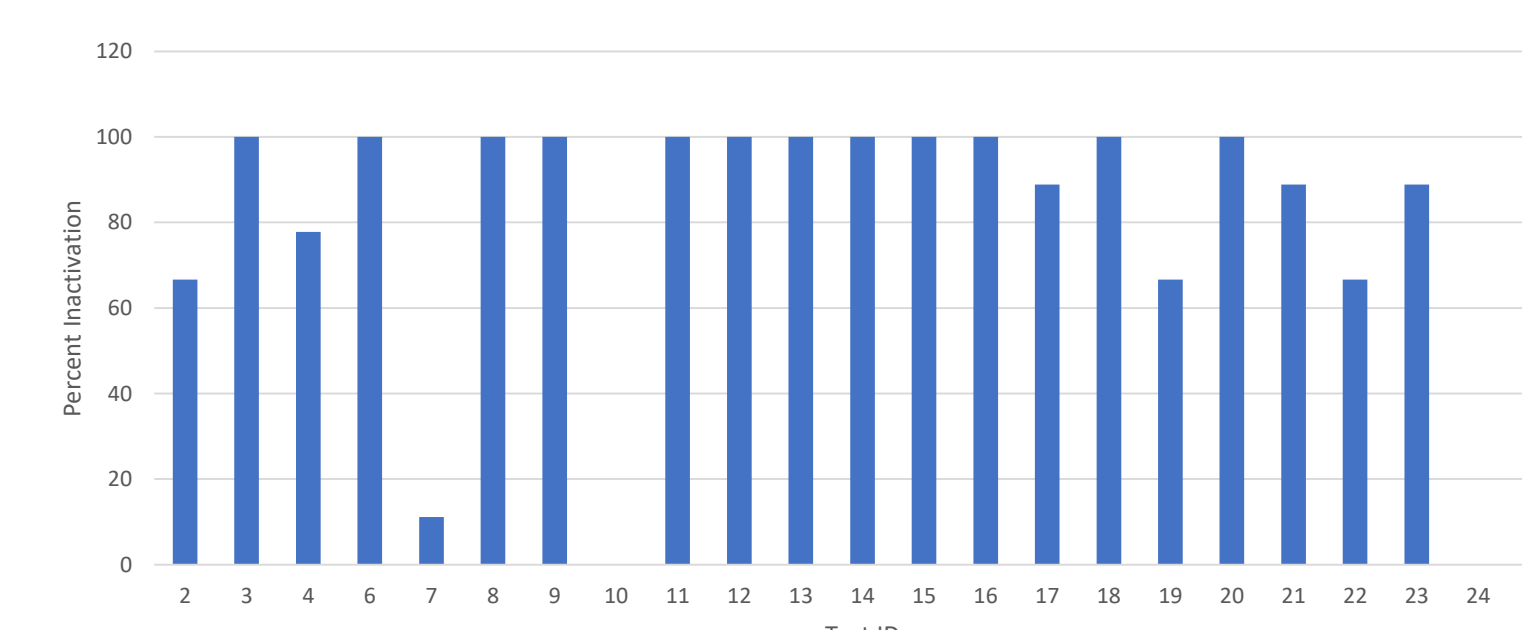


MATERIAL SAMPLING



Cl₂ gas dosimeters were evaluated for use

- Coupons were collected, and spores were extracted, serial plated, filter plated (if needed) and enumerated as CFU
- On average, 2.83E+07 (± 9.38E+06) CFU were recovered from coupon positive controls
- Decontamination efficacy for each material for each test was expressed in terms of log₁₀ reduction (LR), based on the difference in the average CFU recovered from positive controls (not exposed to the fog) compared to average CFU recovered from test coupons
- Biological indicators also used in most tests as another assay to assess efficacy



Percent of BIs inactivated for each test (n=9)

SUMMARY

- All materials were effectively decontaminated (≥ 6 LR) against the *B. anthracis* spore surrogate we used, in at least one test condition, except for carpet and ceiling tile.
- Nonporous materials were easier to decontaminate; materials that were porous and/or comprised of organic chemical constituents proved more difficult to effectively decontaminate.
- Galvanized metal, glass, laminate, and PWB were effectively decontaminated (≥ 6LR) in most tests.
- Fogging of the chlorinated decontaminants was moderately effective for concrete and wood (3-5.99 LR), with only one test achieving an average ≥ 6 LR on concrete, but several tests in which ≥ 5 LR was achieved.
- Maximizing the fogged solution quantity and the active ingredient concentration improved efficacy and produced similar results for all chlorine-based sporicides.
 - Average efficacy for all materials in these optimized tests was generally > 5 LR, independent of sporicide.
- Coupons positioned on the desk showed significant yet minor improvement (~ 0.5 LR) in spore inactivation compared to their counterparts located in the areas under the desk and above the ceiling.
- Dichlor produced a visible residue on materials, which would potentially require removal following its use.

ACKNOWLEDGEMENTS

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