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Decon Efficacy Testing of the DryDecon™ Defense D50 Decontaminant Dispersion System

FINAL TECHNICAL REPORT

10 May 2024

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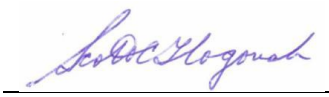
Scott Glogowski		5/10/2024
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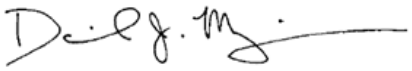
David Mangino		5/10/2024
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LIST OF ACRONYMS

Acronym	Definition
ACTF	Avarint Chemical Test Facility
AMC	U.S. Army Materiel Command
cm^3	Cubic Centimeter
CWA	Chemical Warfare Agent
D3	DryDecon™ Defense
EtAc	Ethyl Acetate
g/m^2	Grams Per Square Meter
GC-MS	Gas Chromatography Mass Spectrometry
HD	Sulfur Mustard
IPA	Isopropyl Alcohol
L	Liter
$MeCl_2$	Methylene Chloride
mg	Milligrams
mg/m^3	Milligrams Per Cubic Meter
MTBE	Methyl tert-Butyl Ether
ng	Nanograms
oz	Ounce
PAA	Peracetic Acid
PVC	Polyvinyl Chloride
RH	Relative Humidity

1.0 INTRODUCTION AND EXECUTIVE SUMMARY

Avarint provided laboratory test services to DryDecon™ (DryDecon) Defense (D3) to evaluate the efficacy of the D50 decontaminant dispersion system against chemical warfare agent HD (sulfur mustard). Small test coupons of four material types (CARC, military webbing, non-skid surface, and stainless steel) were contaminated with liquid HD and subjected to a peracetic acid (PAA) aerosol for up to a four-hour decontamination period. Following decontamination, test coupons were analyzed for residual HD by solvent extraction and gas chromatography-mass spectrometry (GC-MS). Decontamination efficacy was determined as the percentage of residual HD remaining on or within the samples.

The DryDecon D50 decontamination system was designed to work within a room or enclosed space with dimensions significantly larger than what can be achieved in a live-agent laboratory setting. During the test planning stages of this project, the focus was to employ the D50 system using a small test chamber and modify the test set-up to avoid particle condensation and wetting of the chamber or sample surfaces. This was achieved by integrating an exhaust fan with the exposure chamber to provide continuous removal of aerosolized PAA particles as new particles were introduced by the D50. As part of the project, DryDecon Defense was interested in assessing several different phases of D50 operation to include an initial "light aerosol" profile followed by gradual increases in aerosol concentration over the course of the experiment.

The starting HD challenge levels ranged from 1.25 to 1.75 g/m^2 that were applied as one or two 1.0-µL droplets onto the coupon surfaces. Near complete decontamination was observed for the CARC and stainless steel (> 99.9%) coupons after four hours of PAA treatment using the D50 system. The process achieved 96.5% decontamination efficacy for the military webbing and 85% decontamination for the non-skid surface after four hours.

Testing was performed at the Avarint Chemical Test Facility (ACTF), which operates under a Provisioning Agreement with the U.S. Army Materiel Command (AMC). The testing was conducted in March 2024 and was guided by Avarint Proposal A7342 Revision 1 (20 February 2024) and by direct communication with DryDecon technical personnel. All efforts were performed under an accredited ISO9001:2015 Quality Management System.

2.0 EQUIPMENT AND MATERIALS

2.1 DryDecon™ Defense D50

The DryDecon Defense D50 operates by converting a decontaminant solution into a sub-micron aerosol vapor which, due to its smaller particle size, diffuses throughout an enclosed space evenly and can penetrate into small cracks to reach contaminants that may be trapped.

The D50 is compatible with a wide range of decontaminant solutions and provides versatility to decontaminate several biological and chemical threats. The aerosol vapor emanates from a three-inch diameter output port on the top of the unit and flows through a hose or duct into the target space.

2.2 Decontaminant

The decontaminant, peracetic acid (PAA), was procured from First Line Technology. The decontaminant mixture was prepared by slowly pouring the contents of one PAA packet into five liters of deionized water with continuous mixing to achieve a 1% (10,000 ppm) PAA solution. Mixing was performed with a portable drill and paint mixer until the powder was completely dissolved. The decontaminant was loaded into the D50 within ten minutes of preparation.

2.3 Decontamination Chamber

A small glove box (Cole-Parmer, item # EW-34788-00) having an internal volume of approximately 145 L was used as the decontamination chamber (Figure 1).

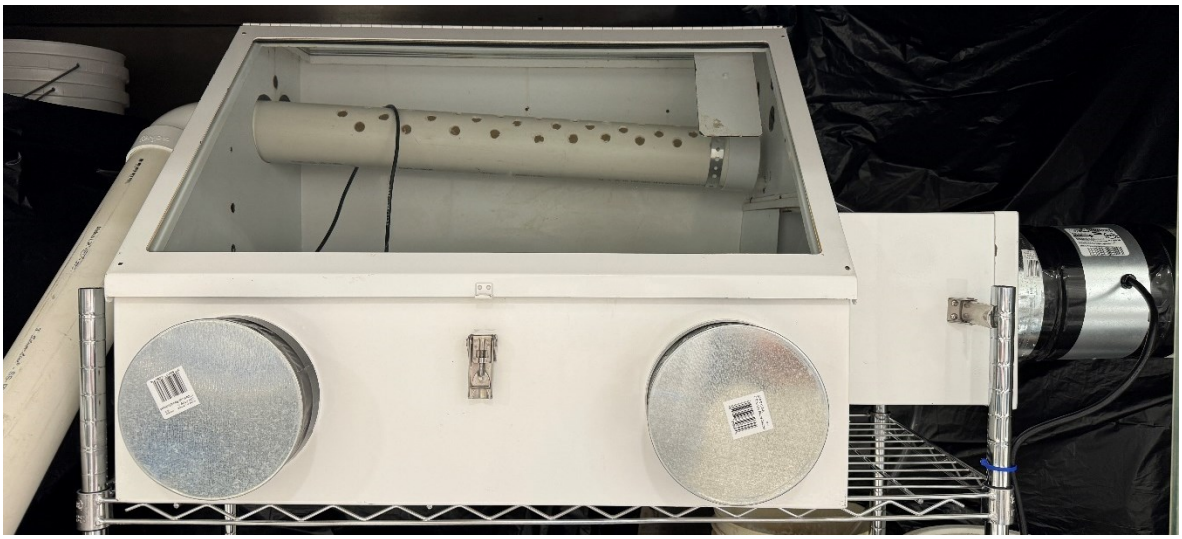


Figure 1: Decontamination Chamber

The chamber, with the glove-ports sealed and capped, was placed within a surety fume hood and aligned with the output tubing of the D50. The chamber contained several ports to allow make-up air to freely enter. A variable speed exhaust fan was attached to the side of the chamber to assist in regulating the environmental conditions during the experiments.

The output of the D50 was plumbed to the interior of the decontamination chamber with a three-

inch diameter PVC pipe. The length of the PVC pipe that extended into the interior of the chamber had an array of 0.5-inch holes to allow the aerosol to dispense evenly along the length of the chamber. The pipe was slanted slightly downward to allow condensate to drain out of the pipe. Test coupons were placed in glass trays and set into the chamber on a rack that was four inches above the chamber floor. The decontamination chamber contained two SEK-SPS30 environmental sensors (Sensirion, Inc.) suspended at each end of the chamber near the test samples. The sensor data was monitored and recorded by DryDecon personnel during the testing.

2.4 Chemical Warfare Agent HD

The sulfur mustard (HD) was synthesized by Avarint and had a purity of 98.4% by GC-MS analysis.

2.5 Material Coupons

The specifications for the materials used in this testing are presented in Table 1. Photographs of the materials are shown in Figure 2.

Table 1 – Material Coupon Specifications

Material	Supplier	Specifications
CARC-Painted Metal	Cardinal Scientific, Inc. Waldorf, MD	6061-T6 Aluminum w/ topcoat MIL-DTL-64159, Tan 686A. Coupons aged by supplier (7 days at 120° F)
Military Seatbelt Webbing	Industrial Webbing Corporation of Boynton Beach, FL	MIL-W-17337 Webbing, lengths cut with heated knife to prevent fraying
Non-Skid Surface	Cardinal Scientific, Inc. Waldorf, MD	Non-skid coating applied to one side of the cold rolled steel coupons
Stainless Steel	Strategic Materials of Western New York, Inc.	304/304L SS sheared & edge conditioned 2B mill finish strip per ASTM A240 and A480 specifications

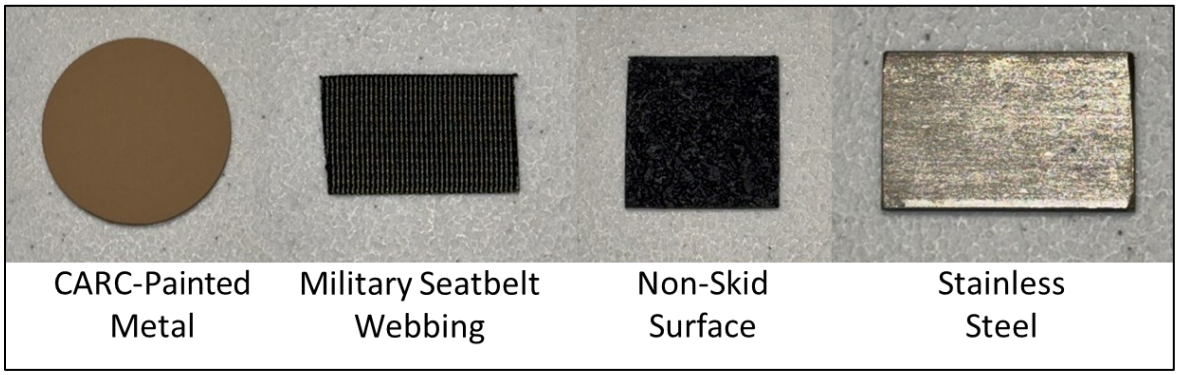


Figure 2: Material Coupons

2.6 Solvents

The solvents used on this project included:

- Ethyl Acetate: Fisher Chemical, Optima® Grade, E196-4, Lot 220718
- Methylene Chloride: Fisher Chemical, Optima® Grade, D151-4, Lot 206348
- Methyl tert-Butyl Ether: Fisher Chemical, HPLC Grade, E127-4, Lot 171805

2.7 Contamination Tool

Test samples were contaminated using a 50-µL Hamilton gas-tight syringe equipped with a 50-step PB-600 repeating dispenser. Pressing the PB-600 dispense button once delivers 1.0 µL of contaminant.

2.8 Temperature and Humidity Measurements

Laboratory temperature and relative humidity measurements were made during the testing using a Lascar Data Logger (P/N EL-21CFR-2-LCD+) with a NIST-traceable calibration. There were no environmental condition requirements, and the experiments were conducted at ambient laboratory conditions, which were approximately 21° C and 25% RH.

2.9 Gas Chromatograph – Mass Spectrometer (GC-MS)

Liquid extracts from the testing were analyzed and quantified for residual HD using GC-MS electron impact (EI) ionization. The GC-MS was operated in selected ion mode (SIM). Quantification was performed with Agilent MassHunter software with HD identified by comparison of the retention time and mass spectra against those of calibration standards and verified with NIST/EPA/NIH Mass Spectral Library Database (2010). The concentration of the agent was calculated by external standardization using reference calibration standards which were analyzed with each set of data. Calibration curves were generated in MassHunter using a linear or second order polynomial fit and weighted as appropriate (1/x). Correlation coefficients ($R^2 > 0.990$) were calculated from the regression fit of the calibration data.

Continuous calibration verification (CCV) standards were inserted into the run every 10 samples to identify any calibration drift. The acceptance criteria for the CCV are ±25% of the initial calibrated response or amount.

3.0 TEST PROCEDURES

This project was structured to include significant pre-test activity to ensure high quality and defendable data sets would be generated. As such, Avarint performed material compatibility and extraction efficiency studies to select solvents. Frequent technical discussions between DryDecon and Avarint technical teams occurred to determine final test matrices, control samples, data collection objectives, and the decontamination periods representative of the posture in which the D50 may be employed.

3.1 Test Matrix

The tables below present the contamination information for each material, the types and quantities (replicates) of samples, and the decontamination exposure periods. The following is a description of the sample types tested within this study:

- Test Samples: contaminated with HD and subjected to decontamination.
- Positive Control Samples: contaminated with HD and not subjected to decontamination.
- Negative Control Samples: not contaminated with HD and subjected to decontamination.
- Dose Confirmation Samples (DCS): HD placed directly into solvent to verify mass of agent applied to each coupon.

Table 2 – Coupon Contamination Profiles

Material	Size	Surface Area (cm^2)	HD Droplets	Contamination Density (g/m^2)
CARC-Painted Coupons	2” diameter x 0.125” (circular)	20.3	2	1.25
Non-Skid Surface	1.5” x 1.5” x 0.60” (square)	14.5	2	1.75
Military Seatbelt Webbing	2.5 cm x 4 cm (rectangular)	10.0	1	1.27
Stainless Steel	2.5 cm x 4 cm x 0.125” (rectangular)	10.0	1	1.27

Table 3 – Sample Types, Replicates and Decontamination Profile

Material	D50 Exposure (hours)	Test Samples	Pos. Ctrl Samples	Neg. Ctrl Samples	No. of Analyses
Dose Confirmation Samples (DCS)	-	3	-	-	3
CARC-Painted Coupons	4	5	3	1	9
Non-Skid Surface	4	5	3	1	9
Military Seatbelt Webbing	1 3 4	3 3 5	3 3 3	 1	6 6 9

Material	D50 Exposure (hours)	Test Samples	Pos. Ctrl Samples	Neg. Ctrl Samples	No. of Analyses
Stainless Steel	1	3	3		6
	3	3	3		6
	4	4	3	1	8

3.2 Extraction Efficiency Studies

Prior to beginning the test, a study using the solvents identified in Section 2.6 was conducted to determine whether a 0.01 g/m^2 residual HD concentration of the extracted coupons would be able to be detected and quantified accurately and reproducibly. This mass value represents approximately 0.5 to 1% of the initial HD challenge, correlating to at least a 99% decontamination efficacy. The general procedure for this study is detailed below.

1. A 10,000 ng/µL (0.01 g/mL) HD standard was created by adding 39.4 µL of neat HD to a final volume of 5 mL hexane. A 1-mL aliquot of this standard was removed and set aside in the fume hood for use.
2. Twenty-three (23) 6-oz glass jars (with lids) were filled with 20 mL of extraction solvent.
3. Test coupons were laid out on the floor of the fume hood.
4. Test coupons were dosed with a volume of 0.01 g/mL HD standard equal to the volume of contamination during the actual test (i.e., 1.0 µL for stainless steel and military webbing; 2.0 µL for CARC and non-skid).
5. One jar was dosed with 1.0 µL of the 0.01 g/mL HD standard to be used as a Dose Confirmation Sample.
6. One minute after contamination, the coupons were placed into glass jars (one coupon per jar). The jars were sealed and sonicated for ten minutes in a water bath at ambient temperature.
7. After sonication, an aliquot of the extract solvent was removed from each jar and placed into a GC vial for analysis by GC-MS.

3.3 Material Compatibility Study

Test coupons were placed into jars containing each solvent and visually observed to determine whether physical changes or damage to the materials occurred. The solvents were analyzed to assess the potential for co-extractives and/or chromatographic interferences that would be a problem when being analyzed using GC-MS.

3.4 D50 Installation and Optimization of Test Conditions

DryDecon (Tyson Bernthal) delivered the D50 system to the Avarint laboratory and assisted in the set-up and integration of the device with the decontamination chamber (see Figure 3). DryDecon provided training on the operation of the D50 to the Avarint technical team.

Figure 3: D50 (left) and Effluent Tube Connection to Chamber (right)

Avarint and DryDecon conducted several experiments using tap water as a simulated decontaminant to monitor the resulting aerosol environmental conditions and perform visual observations of the wetting of the interior surfaces of the chamber. During these trials, the exhaust fan speed was regulated to optimize conditions and prevent wetting of the surfaces within the chamber. The target parameters were kept at a light aerosol "dry treatment profile" and a heavy aerosol "condensation treatment profile" as obtained from a Sensirion environmental sensor. Treatment profiles were correlated to the exhaust fan speed.

3.5 Decontamination Test

3.5.1 Sample Layout

Test sample coupons of each material type were laid out in a tray and included five CARC, five non-skid surface, ten stainless steel, and eleven military webbing coupons. Similarly, the positive control coupons were laid out in a separate tray and included three CARC, three non-skid surface, nine stainless steel, and nine military webbing coupons. In a third tray, one coupon of each material type was used as a negative control. The trays containing the test samples and the negative controls were placed into the test chamber (Figure 4) and the positive control tray remained outside of the decontamination chamber, but within the fume hood. Individual test coupon locations for data tracking purposes may be found in Appendix A.

Figure 4: Test Coupon Trays Inside Chamber

3.5.2 Detailed Procedures

A log of test activities (with time stamps) may be found in Appendix C.

1. The test and positive control samples were contaminated as described in Table 1. Two 1-µL droplets of HD onto the CARC and non-skid surface coupons and one 1-µL droplet of HD onto the military webbing and stainless steel coupons.
2. All samples were covered with aluminum foil (including the uncontaminated negative controls) and allowed to weather for 60 minutes.
3. 1 µL or 2 µL of HD was added to each of three 6-oz jars pre-filled with 20 mL of ethyl acetate to serve as the dose confirmation samples.
4. Approximately ten minutes before the end of the agent weathering period, the peracetic acid solution was prepared.
5. After the one-hour weathering period, the trays inside the decontamination chamber were uncovered. The positive controls located outside of the chamber remained covered to shield the HD droplets from evaporation caused by the fume hood air flow.
6. The D50 was initiated and allowed to flow at a dry treatment profile per the Sensirion environmental sensor. This dry treatment profile was maintained by setting the chamber exhaust fan to 100% of full speed. This time was designated t=0.
7. After one hour of decontamination (t=60 minutes), the flow from the D50 was stopped and the chamber was allowed to clear for two minutes with the exhaust fan running.
8. The chamber was opened, and three stainless steel and three webbing test coupons were removed, placed into individual 6-oz jars pre-filled with 20 mL of extraction solvent, and processed for GC-MS analysis.
9. At the same time, three stainless steel and three webbing positive control coupons were extracted and processed for extraction and GC-MS analysis.

10. The D50 system was resumed with the chamber exhaust fan set to 90% of full speed.
11. After two hours (t=120 minutes), a new batch of PAA solution was prepared and used to re-supply the D50. While the D50 was running, the reservoir containing the original PAA was disconnected, and the contents discarded. The new PAA solution was added to the reservoir and the reservoir reconnected to the D50. At this time the chamber exhaust fan was set to 80% of full speed.
12. After three hours (t=180 minutes), flow from the D50 was stopped and the decontamination chamber was allowed to clear for two minutes.
13. The chamber was opened, and three stainless steel and three webbing test coupons were removed, extracted, and processed for GC-MS analysis.
14. At the same time, three stainless steel and three webbing positive control coupons were extracted and processed for GC-MS analysis.
15. The D50 was then resumed with the chamber exhaust fan set to 50% of full speed as directed by DryDecon.
16. After approximately ten minutes, the decontamination chamber exhaust fan speed was adjusted to 30% at the direction of DryDecon based on measured environmental conditions and visual observation of the aerosol intensity.
17. After four hours (t=240 minutes) the D50 was stopped, and the interior of the decontamination chamber was allowed to clear for two minutes.
18. All remaining test samples, positive control samples and negative control samples were extracted and processed for GC-MS analysis.

4.0 CALCULATIONS

The concentration of residual HD in solvent extracts was determined through the analysis of samples using GC-MS. The results of the replicates were used in the following equation to calculate the total mass of residual HD:

$$RA_M = (RA_E \times V_E)/10^6$$

Where:

RA_M = residual HD mass within extraction solvent in mg
RA_E = HD concentration within solvent extract volume in ng/mL
V_E = volume of extraction solvent in mL

Decontamination efficacy was determined by comparing the test sample results to the dose confirmation samples (DCS) using the equation below:

$$D = 1 - \frac{RA_M}{\bar{M}_{PC}} \times 100$$

Where:

D = percent decontamination efficacy
RA_M = residual HD mass within extraction solvent in mg
M_{PC} = average mass recovered from DCS in mg

5.0 RESULTS AND DISCUSSION

5.1 Extraction Efficiency Results

The results of the extraction efficiency pre-study are presented in Table 4. Avarint has existing test data showing that EtAc is an acceptable solvent for both stainless steel and CARC. Based upon the results below for non-skid surface and military webbing, ethyl acetate (EtAc) was selected as the extraction solvent for all material types.

Table 4 – Extraction Efficiencies of Coupons in Solvents

Material	Recovery of Applied Agent (%)		
	MTBE	EtAc	$MeCl_2$
Non-Skid Surface	78.9	86.9	n/a
Military Webbing	88.9	101	79.4

5.2 Test Condition Optimization Results

Based on the dry runs performed as part of the test condition optimization, the test procedure was structured to achieve a light aerosol "dry treatment profile" from t=0 to t=180 minutes and a heavy aerosol "condensation treatment profile" from t=180 minutes to t=240 minutes. These targets were selected to prevent the formation of condensation on the materials inside the test chamber during the first three hours of decontamination followed by saturation of condensate during the final hour of testing.

5.3 Material Compatibility Study Results

The materials tested showed no issues with the selected solvent.

5.4 Decontamination Efficacy Results

Table 5 below presents the decontamination efficacy results by material type and D50 PAA decontamination exposure time. Data presented are averages of the replicate samples tested. The efficacy calculations are based upon the starting contamination challenge mass as determined through the GC-MS analysis of the dose confirmation samples. Full raw data may be found in Appendix B.

Table 5 – Decontamination Results (Total Residual Mass and Efficacy)

Material	D50 PAA Exposure (hrs)	Challenge Mass (mg)	+CTRL Mass Recovered (mg)	Total Residual Mass (mg)	Decontamination Efficacy (%)
CARC	4	2.17	0.37	0.00033	> 99.9%
Non-Skid Surface	4	2.17	1.09	0.325	85.0%
Stainless Steel	1	1.14	1.00	0.920	19.0%
	3	1.14	0.75	0.253	77.7%
	4	1.14	0.77	0.00026	> 99.9%
Military Webbing	1	1.14	0.71	0.52	54.2%
	3	1.14	0.49	0.14	87.7%
	4	1.14	0.35	0.040	96.5%

Figure 5 below presents the test results plotted as the total residual mass of HD in milligrams. The plot contains bars (in blue) for the starting challenge masses for both the CARC and non-skid surface (2.17 mg) and the stainless steel and military webbing (1.14 mg).

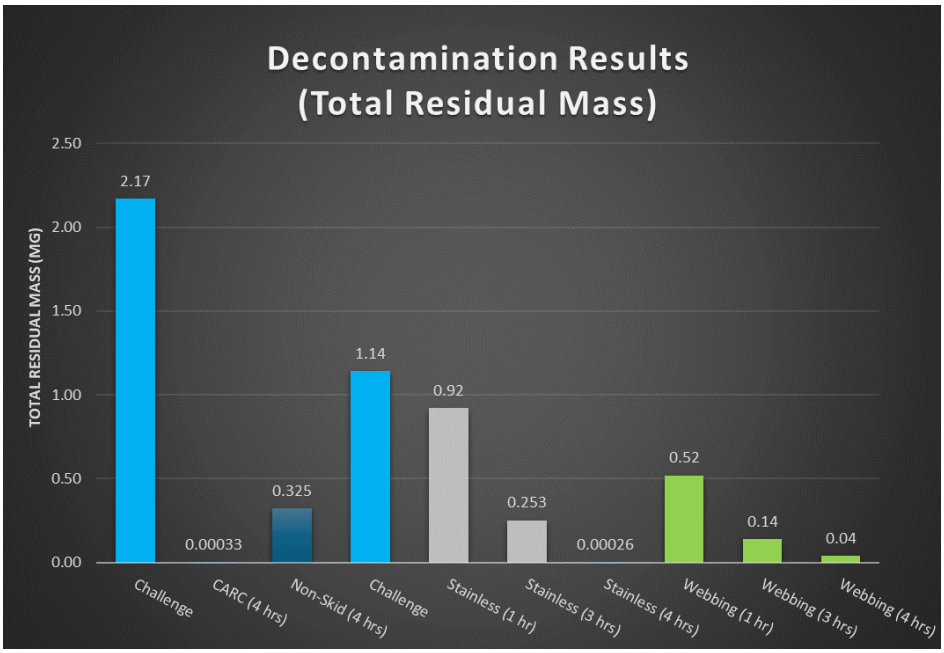


Figure 5: Decontamination Results (Total Residual Mass)

Figure 6 presents the results data as decontamination efficacy, i.e., the percent of the initial starting mass of HD that was remaining on/in each sample type.

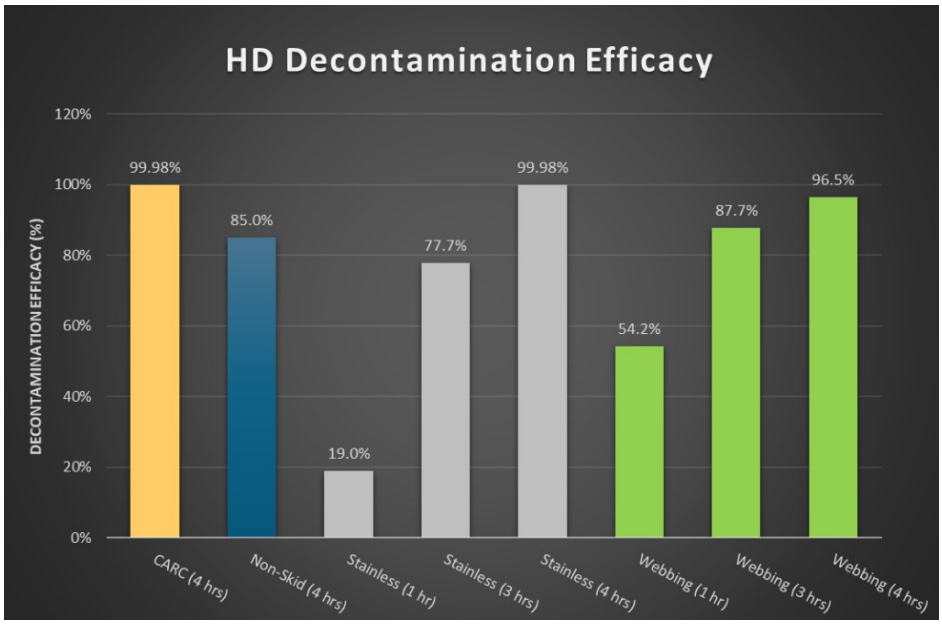


Figure 6: Decontamination Results (Efficacy)

The figures below show the D50 performance for each individual material type and include the starting challenge mass, the mass of HD recovered from the corresponding positive control

samples (+CTRL), and the subsequent mass recovered from the test samples as a function of decontamination time. Figure 7 presents the results as total residual mass for the CARC and non-skid surface, which were evaluated only at the four-hour decontamination time period. Figures 8 and 9 present the stainless steel and military webbing results as total residual mass, respectively, and provide the results for all three time points (1 hr, 3 hrs, and 4 hrs).

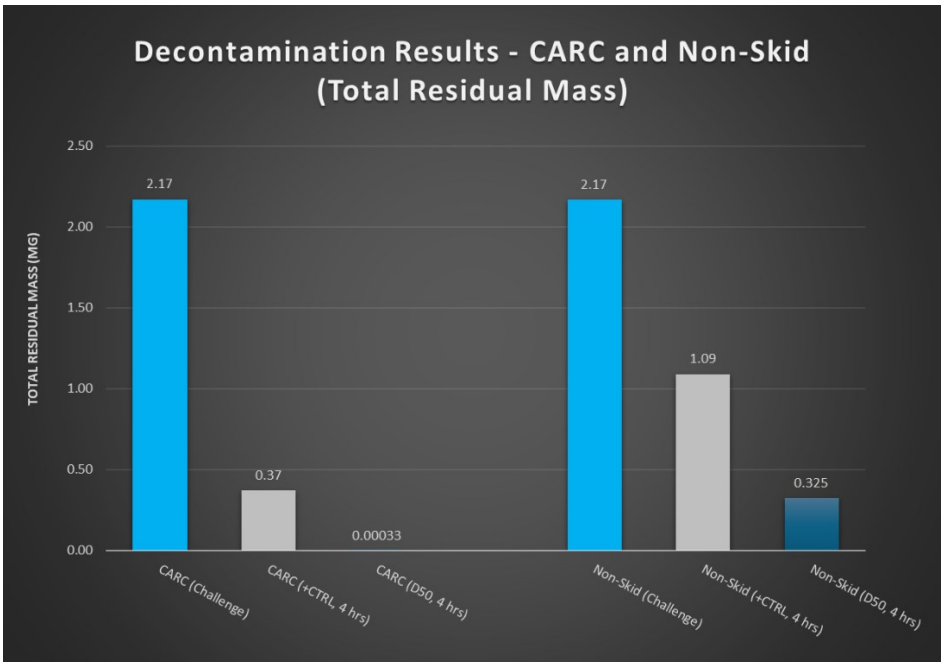


Figure 7: Total Residual Mass for CARC and Non-Skid Surface

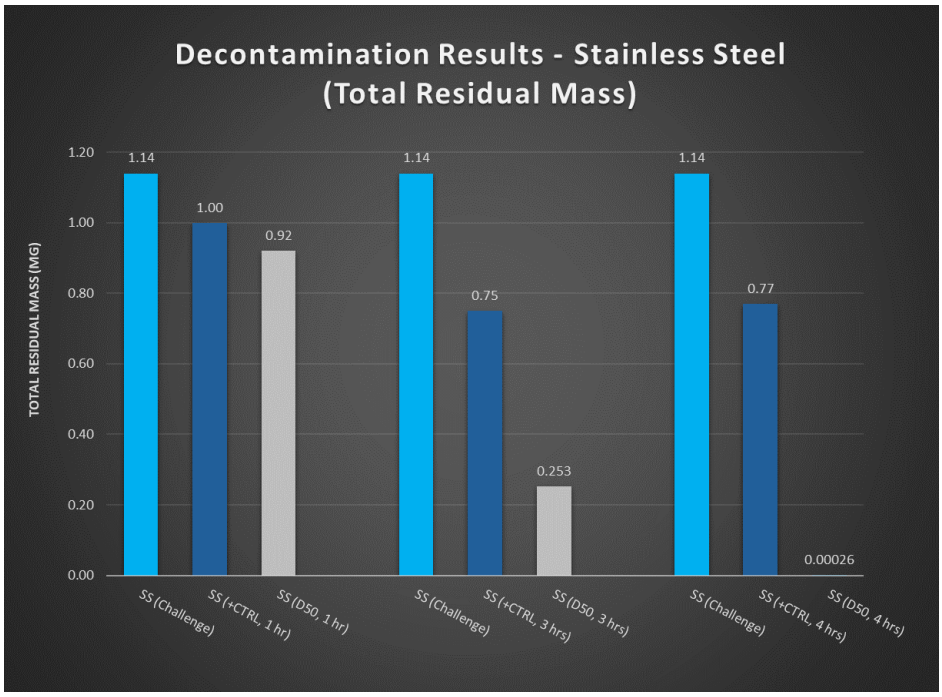


Figure 8: Total Residual Mass for Stainless Steel

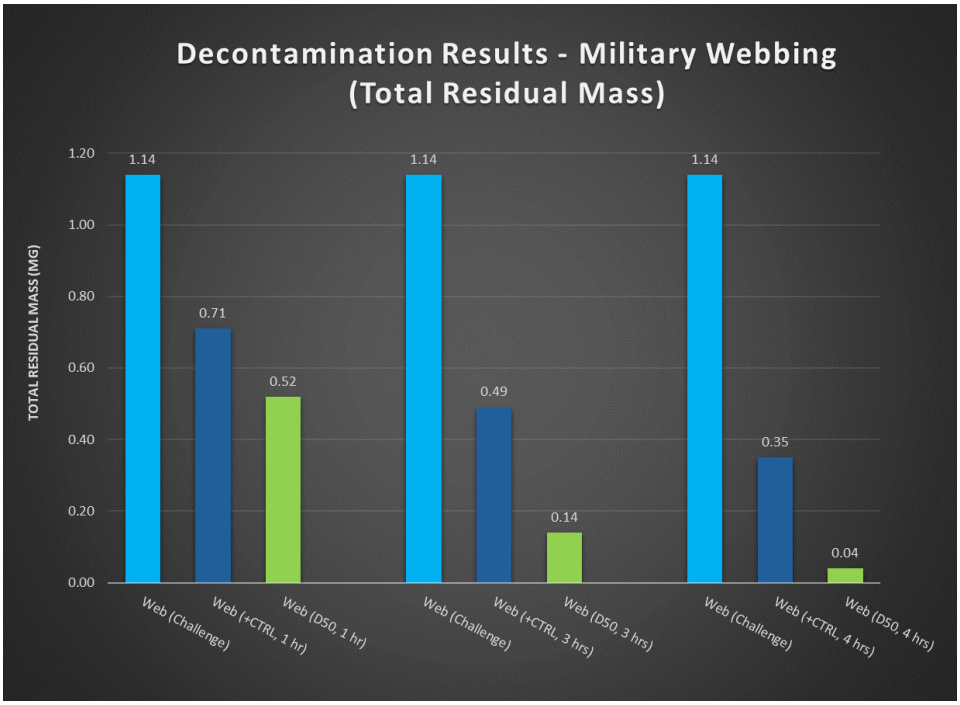


Figure 9: Total Residual Mass for Military Webbing

5.5 Discussion

The DryDecon™ D50 decontamination system was designed to work within a room or enclosed space with dimensions significantly larger than what can be achieved in a live-agent laboratory setting. During the test planning stages of this project, our focus was to employ the D50 system using the small test chamber and modify the test set-up to avoid particle condensation and wetting of the chamber or sample surfaces. This was achieved by integrating an exhaust fan with the exposure chamber to provide continuous removal of aerosolized PAA particles as new particles were introduced by the D50.

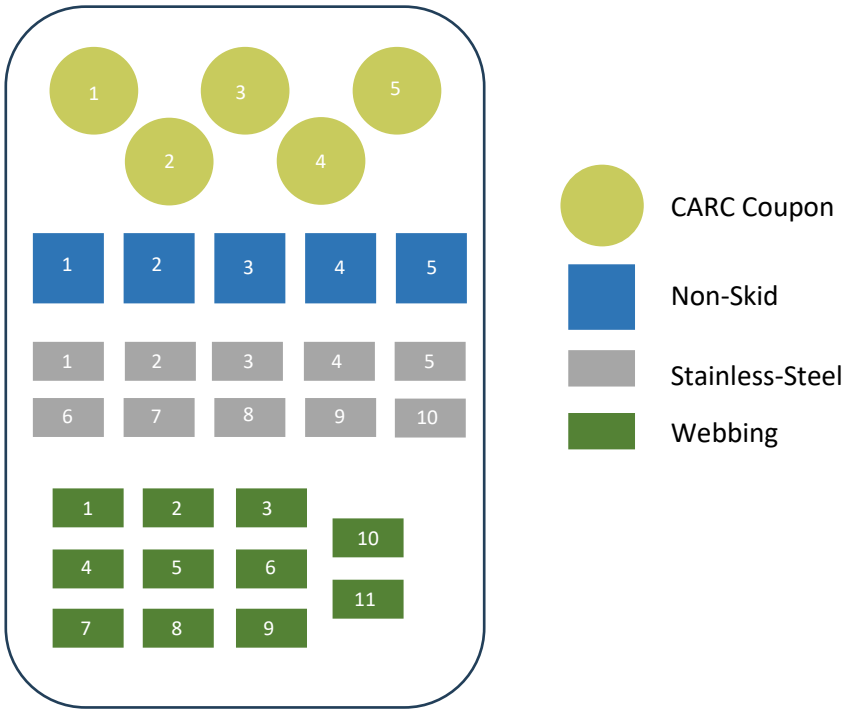
As stated in the project objectives, there was interest in assessing several different phases of D50 operation to include an initial light aerosol profile for the first hour of the test, followed by gradual increases in aerosol concentration at the one-, two-, and three-hour time points. During the first three hours of the decontamination cycle, a dry treatment profile was maintained (i.e., no wetting of surfaces or condensation was observed). As can be seen with the stainless steel and webbing results, the HD decontamination efficacy increases significantly from the one-hour to the three-hour time point: from 19.0% to 77.7% for the stainless and from 54.2% to 87.7% for the webbing. By the four-hour time point, the efficacy has increased to > 99.9% and 96.5% for the stainless steel and military webbing respectively. These four-hour efficacies correspond to total residual mass values of < 0.0003 mg for the stainless steel and 0.04 mg for the military webbing.

This increasing efficacy as a function of time, and the four-hour CARC result of < 0.0004 mg total residual hazard (> 99.9% efficacy), suggests that the dry treatment profile is an effective approach and further demonstrates the capability of the D50 system when used with PAA.

Using the available data from this project it is reasonable to infer that running a full test at a single setting that aligns with the dry profile setting used between the two-hour and the three-hour period, similar results would be observed, potentially achieving maximum efficacy within a period of less than four hours. Additional testing to optimize D50 decontamination profiles and investigate a broader range of test parameters is warranted given the encouraging results of this preliminary study.

APPENDIX A – TEST SAMPLE LOCATION MAP

The following is a diagram of the test sample locations within the decontamination tray. Individual coupon results (Appendix B) may be correlated to this record.



APPENDIX B – RAW TEST DATA

The tables below display the raw data for each individual coupon analyzed for residual HD during this test.

Table B.1 – CARC Sample Raw Data

							% Agent Recovered		% Agent Removed	
Material	Sample	Replicate	Time Point	Coupon Position	ng recovered	mg recovered	vs. original load	vs. Pos. Ctrl.	vs. original load	vs. Pos. Ctrl.
None	DCS	1	-	-	2186199.99	2.186				
	DCS	2	-	-	2108429.14	2.108				
	DCS	3	-	-	2205529.19	2.205				
				Average	**2166719.44**	**2.167**				
				Std. Dev.	51397.70	0.051				
CARC	Pos. Ctrl	1	4 hr	-	466392.02	0.466	21.53%	-	78.47%	-
	Pos. Ctrl	2	4 hr	-	361745.64	0.362	16.70%	-	83.30%	-
	Pos. Ctrl	3	4 hr	-	290555.90	0.291	13.41%	-	86.59%	-
				Average	**372897.85**	**0.373**	**17.22%**		**82.78%**	
				Std. Dev.	88446.96	0.088	4.08%		4.08%	
	Test	1	4 hr	1	306.24	0.0003	0.01%	0.08%	99.99%	99.92%
	Test	2	4 hr	2	352.19	0.0004	0.02%	0.09%	99.98%	99.91%
	Test	3	4 hr	3	334.68	0.0003	0.02%	0.09%	99.98%	99.91%
	Test	4	4 hr	4	349.27	0.0003	0.02%	0.09%	99.98%	99.91%
	Test	5	4 hr	5	286.62	0.0003	0.01%	0.08%	99.99%	99.92%
				Average	**325.80**	**0.0003**	**0.02%**	**0.09%**	**99.98%**	**99.91%**
				Std. Dev.	28.48	0.00003	0.00%	0.01%	0.00%	0.01%

Table B.2 – Non-Skid Sample Raw Data

							% Agent Recovered		% Agent Removed	
Material	Sample	Replicate	Time Point	Coupon Position	ng recovered	mg recovered	vs. original load	vs. Pos. Ctrl.	vs. original load	vs. Pos. Ctrl.
None	DCS	1	-	-	2186199.99	2.186				
	DCS	2	-	-	2108429.14	2.108				
	DCS	3	-	-	2205529.19	2.205				
				Average	**2166719.44**	**2.167**				
				Std. Dev.	51397.70	0.051				
Non-Skid	Pos. Ctrl	1	4 hr	-	1057115.74	1.057	48.81%	-	51.19%	-
	Pos. Ctrl	2	4 hr	-	1068373.56	1.068	49.33%	-	50.67%	-
	Pos. Ctrl	3	4 hr	-	1141611.63	1.142	52.71%	-	47.29%	-
				Average	**1089033.64**	**1.089**	**50.28%**		**49.72%**	
				Std. Dev.	45880.47	0.0459	2.12%		2.12%	
	Test	1	4 hr	1	343894.88	0.344	15.88%	31.58%	84.12%	68.42%
	Test	2	4 hr	2	285789.41	0.286	13.20%	26.24%	86.80%	73.76%
	Test	3	4 hr	3	193621.98	0.194	8.94%	17.78%	91.06%	82.22%
	Test	4	4 hr	4	396517.83	0.397	18.31%	36.41%	81.69%	63.59%
	Test	5	4 hr	5	403232.10	0.403	18.62%	37.03%	81.38%	62.97%
				Average	**324611.24**	**0.325**	**14.99%**	**29.81%**	**85.01%**	**70.19%**
				Std. Dev.	87162.17	0.0871	4.02%	8.00%	4.02%	8.00%

Table B.3 – Stainless Steel Sample Raw Data

							% Agent Recovered		% Agent Removed	
Material	Sample	Replicate	Time Point	Coupon Position	ng recovered	mg recovered	vs. original load	vs. Pos. Ctrl.	vs. original load	vs. Pos. Ctrl.
None	DCS	1	-	-	1062823.38	1.063				
	DCS	2	-	-	1122718.95	1.123				
	DCS	3	-	-	1221328.44	1.221				
				Average	**1135623.59**	**1.136**				
				Std. Dev.	80036.62	0.080				
Stainless-Steel	Pos. Ctrl	1	1 hr	-	981623.11	0.982	86.44%	-	13.56%	-
	Pos. Ctrl	2	1 hr	-	1003661.84	1.004	88.38%	-	11.62%	-
	Pos. Ctrl	3	1 hr	-	1011288.31	1.011	89.05%	-	10.95%	-
				Average	**998857.75**	**0.999**	**87.96%**		**12.04%**	
				Std. Dev.	15405.05	0.015	1.36%		1.36%	
	Test	1	1 hr	6	904066.24	0.904	79.61%	90.51%	20.39%	9.49%
	Test	2	1 hr	8	913096.10	0.913	80.40%	91.41%	19.60%	8.59%
	Test	3	1 hr	10	941354.72	0.941	82.89%	94.24%	17.11%	5.76%
				Average	**919505.69**	**0.920**	**80.97%**	**92.06%**	**19.03%**	**7.94%**
				Std. Dev.	19453.01	0.019	1.71%	1.95%	1.71%	1.95%
Stainless-Steel	Pos. Ctrl	1	3 hr	-	774508.20	0.775	68.20%	-	31.80%	-
	Pos. Ctrl	2	3 hr	-	682561.95	0.683	60.10%	-	39.90%	-
	Pos. Ctrl	3	3 hr	-	794256.51	0.794	69.94%	-	30.06%	-
				Average	**750442.22**	**0.750**	**66.08%**		**33.92%**	
				Std. Dev.	59609.54	0.060	5.25%		5.25%	
	Test	1	3 hr	1	371167.31	0.371	32.68%	49.46%	67.32%	50.54%
	Test	2	3 hr	3	164992.31	0.165	14.53%	21.99%	85.47%	78.01%
	Test	3	3 hr	5	222526.53	0.223	19.60%	29.65%	80.40%	70.35%

							% Agent Recovered		% Agent Removed	
Material	Sample	Replicate	Time Point	Coupon Position	ng recovered	mg recovered	vs. original load	vs. Pos. Ctrl.	vs. original load	vs. Pos. Ctrl.
				Average	**252895.38**	**0.253**	**22.27%**	**33.70%**	**77.73%**	**66.30%**
				Std. Dev.	106389.54	0.106	9.37%	14.18%	9.37%	14.18%
Stainless-Steel	Pos. Ctrl	1	4 hr	-	771950.34	0.772	67.98%	-	32.02%	-
	Pos. Ctrl	2	4 hr	-	831420.34	0.831	73.21%	-	26.79%	-
	Pos. Ctrl	3	4 hr	-	710194.50	0.710	62.54%	-	37.46%	-
				Average	**771188.39**	**0.771**	**67.91%**		**32.09%**	
				Std. Dev.	60616.51	0.061	5.34%		5.34%	
	Test	1	4 hr	2	267.78	0.000	0.02%	0.03%	99.98%	99.97%
	Test	2	4 hr	4	303.61	0.000	0.03%	0.04%	99.97%	99.96%
	Test	3	4 hr	7	261.44	0.000	0.02%	0.03%	99.98%	99.97%
	Test	4	4 hr	9	214.43	0.000	0.02%	0.03%	99.98%	99.97%
				Average	**261.81**	**0.000**	**0.02%**	**0.03%**	**99.98%**	**99.97%**
				Std. Dev.	36.64	0.000	0.00%	0.00%	0.00%	0.00%

Table B.4 – Webbing Sample Raw Data

							% Agent Recovered		% Agent Removed	
Material	Sample	Replicate	Time Point	Coupon Position	ng recovered	mg recovered	vs. original load	vs. Pos. Ctrl.	vs. original load	vs. Pos. Ctrl.
None	DCS	1	-	-	1062823.38	1.063				
	DCS	2	-	-	1122718.95	1.123				
	DCS	3	-	-	1221328.44	1.221				
				Average	**1135623.59**	**1.136**				
				Std. Dev.	80036.62	0.080				
Webbing	Pos. Ctrl	1	1 hr	-	778506.28	0.779	68.55%	-	31.45%	-
	Pos. Ctrl	2	1 hr	-	652199.77	0.652	57.43%	-	42.57%	-
	Pos. Ctrl	3	1 hr	-	696178.15	0.696	61.30%	-	38.70%	-
				Average	**708961.40**	**0.709**	**62.43%**		**37.57%**	
				Std. Dev.	64116.24	0.064	5.65%		5.65%	
	Test	1	1 hr	7	536327.49	0.536	47.23%	75.65%	52.77%	24.35%
	Test	2	1 hr	8	501880.95	0.502	44.19%	70.79%	55.81%	29.21%
	Test	3	1 hr	9	516160.40	0.516	45.45%	72.81%	54.55%	27.19%
				Average	**518122.95**	**0.518**	**45.62%**	**73.08%**	**54.38%**	**26.92%**
				Std. Dev.	17306.93	0.017	1.52%	2.44%	1.52%	2.44%
Webbing	Pos. Ctrl	1	3 hr	-	485804.37	0.486	42.78%	-	57.22%	-
	Pos. Ctrl	2	3 hr	-	489825.88	0.490	43.13%	-	56.87%	-
	Pos. Ctrl	3	3 hr	-	488672.04	0.489	43.03%	-	56.97%	-
				Average	**488100.76**	**0.488**	**42.98%**		**57.02%**	
				Std. Dev.	2070.73	0.002	0.18%		0.18%	
	Test	1	3 hr	1	126774.10	0.127	11.16%	25.97%	88.84%	74.03%
	Test	2	3 hr	2	130502.24	0.131	11.49%	26.74%	88.51%	73.26%
	Test	3	3 hr	3	172973.61	0.173	15.23%	35.44%	84.77%	64.56%
				Average	**143416.65**	**0.143**	**12.63%**	**29.38%**	**87.37%**	70.62%
				Std. Dev.	25664.86	0.026	2.26%	5.26%	2.26%	5.26%
Webbing	Pos. Ctrl	1	4 hr	-	374012.065	0.374	32.93%	-	67.07%	-

							% Agent Recovered		% Agent Removed	
Material	Sample	Replicate	Time Point	Coupon Position	ng recovered	mg recovered	vs. original load	vs. Pos. Ctrl.	vs. original load	vs. Pos. Ctrl.
	Pos. Ctrl	2	4 hr	-	379473.76	0.379	33.42%	-	66.58%	-
	Pos. Ctrl	3	4 hr	-	304814.907	0.305	26.84%	-	73.16%	-
				Average	**352766.91**	**0.353**	**31.06%**		**68.94%**	
				Std. Dev.	41617.35	0.042	3.66%		3.66%	
	Test	1	4 hr	4	18416.67	0.018	1.62%	5.22%	98.38%	94.78%
	Test	2	4 hr	5	35957.51	0.036	3.17%	10.19%	96.83%	89.81%
	Test	3	4 hr	6	36378.80	0.036	3.20%	10.31%	96.80%	89.69%
	Test	4	4 hr	10	61068.46	0.061	5.38%	17.31%	94.62%	82.69%
	Test	5	4 hr	11	49463.22	0.049	4.36%	14.02%	95.64%	85.98%
				Average	**40256.93**	**0.040**	**3.54%**	**11.41%**	**96.46%**	**88.59%**
				Std. Dev.	16034.32	0.016	1.41%	4.55%	1.41%	4.55%

APPENDIX C – TEST ACTIVITY LOG

The following table records the test activity as a function of test time:

Test Date: 3/29/2024
Activity Log
Ashford Chemical Test Facility
DryDecon Decontamination Test (A0297.01)

Time Stamp	Test Time (h:mm:ss)	Decontamination time (h:mm:ss)	Activity
10:54:47	0:00		Dose Test Coupons and Positive Controls
11:44:00	0:49:13		Make up Peracetic Acid solution; add to D50 reservoir
11:54:17	0:59:30		Uncover the test coupons and negative controls
11:54:47	1:00:00	0:00:00	Start aerosol on D50
11:55:58	1:01:11	0:01:11	Aerosol noticeable in chamber
12:54:47	2:00:00	1:00:00	Turn aerosol off; let chamber clear
12:56:47	2:02:00	1:02:00	Open Chamber; remove stainless test coupons 6, 8, 10 and webbing test coupons 7, 8, 9
13:02:16	2:07:29	1:07:29	Turn aerosol back on; set fan for 90% full speed
13:49:47	2:55:00	1:55:00	Make up fresh batch of Peracetic Acid
13:54:47	3:00:00	2:00:00	Disconnect PAA reservoir from D50, discard solution, add fresh PAA solution
13:56:49	3:02:02	2:02:02	Reconnect PAA reservoir
13:58:47	3:04:00	2:04:00	Decrease fan speed to 80% full speed
14:54:47	4:00:00	3:00:00	Stop aerosol
14:56:47	4:02:00	3:02:00	Open chamber, remove stainless test coupons 1, 3, 5 and webbing coupons 1, 2, 3
15:00:58	4:06:11	3:06:11	Restart aerosol; set fan to 50% full speed
15:04:47	4:10:00	3:10:00	Decrease fan speed to 40%
15:06:47	4:12:00	3:12:00	Decrease fan speed to 30%
15:08:47	4:14:00	3:14:00	Increase fan speed to 35%
15:10:47	4:16:00	3:16:00	Decrease fan speed to 30%
15:54:47	5:00:00	4:00:00	Aerosol powered off
15:56:47	5:02:00	4:02:00	Open Chamber; remove remaining samples for analysis