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# Remediation Options for Porous Materials Contaminated with Persistent Chemical Warfare Agents VX and HD

Office of Research and Development
Homeland Security Research Program

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U.S. Environmental Protection Agency
Office of Research and Development
National Homeland Security Research Center
Research Triangle Park, North Carolina 27711

## DISCLAIMER

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# EXECUTIVE SUMMARY

Under the National Response Framework, the U.S. Environmental Protection Agency (EPA) is designated as the coordinating agency to prepare for, respond to, and recover from a threat to public health, welfare, or the environment caused by hazardous materials incidents including chemical, biological, and radiological substances. The imminent threat of a chemical warfare agent release on infrastructural materials as part of a building or a transportation hub is driving U.S. EPA's Homeland Security Research Program (HSRP) to develop a research program that systematically evaluates potential decontamination technologies for chemical (warfare) agents. The U.S. EPA is tasked to remediate infrastructure or equipment contaminated with these agents after they are released. It is unknown how effective many of the available technologies are, especially for decontamination of porous or permeable materials. Previous Department of Defense and EPA's National Homeland Security Research Center (NHSRC) studies have focused on nonporous materials, included sealed surfaces. In this study, U.S. EPA addressed a high priority gap as identified by the HSRP's EPA Program Office partners by evaluating the effectiveness of several decontaminant solutions on porous or permeable materials. In addition, the effect of the decontaminant on the building material was also assessed (qualitatively).

Four commercially available decontaminant solutions were quantitatively evaluated for their ability to decontaminate two persistent chemical warfare agents (VX and HD) on permeable surfaces associated with subway-related materials of construction. Decontamination efficacies, defined as the percentage of agent removed from the material surface by decontamination efforts, were determined through testing to evaluate performance of each decontaminant for each surface type.

Coupons (approximately 4-inch × 4-inch) from each of the surface types (glazed ceramic tile, rubber molding, and concrete sealant, Sure Klean® Siloxane PD, applied to sandstone) were prepared and were spiked with neat chemical agent and allowed to be in contact with the surface (4 hours [h] for HD and 24 h for VX) prior to surface treatment by the decontaminant. Either Clorox® Bleach, hydrogen peroxide solution (3.1%), or EasyDecon® DF-200 was applied to the contaminated coupons. The decontaminant remained in contact with the coupons for 1 h with the exception of the DeconGel® 1108, which required a three-day drying time as the gel was still tacky after 25 to 48 h. The drying time for the DeconGel® 1108 depends on a combination of temperature, relative humidity, film thickness, air flow, and material. It is unclear what caused the curing time to exceed the normal drying time of approximately 16-24 h. After treatment and removal of excess residual decontaminant from the surface, a wipe sample of the coupon surface was collected, and the whole coupon was subsequently extracted. Extracts were assayed by gas chromatography/mass spectrometry (GC/MS) for HD and liquid chromatography triple quad mass spectrometry (LC-MS/MS) for VX to determine residual agent left on the surface. Decontamination efficacy results are shown in Table ES-1.

| *Table ES-1: Summary of Decontamination Efficacy Results* | | | | | |
|---|---|---|---|---|---|
| **Agent** | **Decontaminant** | **Glass (%)** | **Ceramic (%)** | **Sealant (%)** | **Rubber (%)** |
| VX | Bleach | 99.996 | 99 | 88 | 15 |
| | Peroxide | 96 | 96 | 50 | 13 |
| | EasyDecon® | 99.995 | 99.992 | 71 | 8 |
| | DeconGel® | 99.9 | 99.7 | 32 | 74 |
| HD | Bleach | 99.992 | 99.97 | 98 | 65 |
| | Peroxide | 43 | 76 | 39 | 35 |
| | EasyDecon® | 99 | 97 | 64 | 52 |
| | DeconGel® | ND | ND | 99.98[1] | 75 |
| Percent of agent decontaminated was calculated considering agent recovered from both wipe and coupon extracts. Significant digits are based on calculated standard deviation which is in the order of the last digit. ND: Not determined; positive control recoveries were too low to calculate meaningful decontamination efficacy. [1] Based on 2% recovery of HD from positive control | | | | | |

Decontamination efficacy for DeconGel® 1108 could not be calculated for HD on the nonporous glass and ceramic materials because less than 0.3% of the HD spiked on the positive controls was recovered after three days due to the volatility of HD under these test conditions. Bleach performed the best across all of the materials, except rubber, and peroxide performed the worst among the selected materials. Even though the main active ingredient was peroxide, EasyDecon® DF-200 performed better than the peroxide. Application of DeconGel® 1108 resulted in similar efficacy values for VX on glass and ceramic, lower on the sealed surface and higher for the rubber surface when compared to the other three decontaminants.

Low collection efficiencies (positive control recoveries) were observed for the sealant, suggesting that the agent is sorbed into the material and is protected from collection processes, or the agent is attenuated from the surface. The low agent collection efficiencies bias these decontamination efficacy results high. Since floors in underground transportation systems mostly consist of concrete sealed with concrete sealant, further studies should address the fate of this material, i.e., whether agent sorbs through the sealant or the agent is neutralized by the Sure Klean® Siloxane PD sealant. Public health may be at subsequent risk if the sealant allows agent sorption and protects the agent from decontamination processes or extraction processes.

The results obtained from this study showed that VX and HD can be neutralized (greater than 97%) by full strength bleach, EasyDecon® DF-200, and DeconGel® when the decontaminants are used for remediation of nonporous materials. These commercial decontaminants are noticeably less effective for decontamination of permeable elastomers (sealant and rubber). Elastomers have low intermolecular forces and relatively unhindered single bonds that link the silicon and oxygen backbone chain atoms together. It results in a higher than normal amount of free volume and a high degree of chain mobility and make sealant and rubber permeable to these agents. Due to an impervious layer or coating of the vitreous substance, glazed ceramic tile behaved as a nonporous material. One should be careful to extrapolate the controlled-environment laboratory

testing data to field applications of these decontaminants. Interferences from debris, oil, grease, and other intrusive materials of imperfections such as cracks or aged material can impact the performance of the decontaminants. The study did not measure amount of agents present in the spent material (decontamination liquid or gel) that was removed from the coupon surface prior to the sampling. These spent materials may require specialized hazardous waste handling and additional treatment prior to proper disposal as waste.

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# ABBREVIATIONS/ACRONYMS

| | |
|---|---|
| °C | degree(s) Celsius |
| µg | microgram(s) |
| µL | microliter(s) |
| µm | micrometer(s) |
| avg. | average |
| CASARM | Chemical Agent Standard Analytical Reference Material |
| CCV | continuing calibration verification |
| DCM | dichloromethane |
| DIMP-$d_{14}$ | diisopropyl methylphosphonate deuterated |
| EI | electron ionization |
| EPA | U.S. Environmental Protection Agency |
| ESI | electrospray ionization |
| eV | electron volt(s) |
| g | gram(s) |
| GC | Gas chromatograph(y) |
| GC/MS | Gas chromatograph/mass spectrometer |
| GC x GC/TOFMS | Two Dimensional Gas Chromatography Time-of-Flight Mass Spectrometry |
| HD | sulfur mustard (bis(2-chloroethyl) sulfide) |
| h | hour(s) |
| HSRP | Homeland Security Research Program |
| i.d. | inner diameter |
| ICAL | initial calibration |
| ICV | initial calibration verification |
| IS | internal standard |
| ISO | International Organization for Standardization |
| LC-MS/MS | Liquid chromatography triple quadrupole mass spectrometry |
| LC/qTOF | Liquid chromatography quadrupole Time-of-Flight Mass Spectrometry |
| LCS | laboratory control spike |
| m/z | mass to charge ratio |
| min | minute(s) |
| mL | milliliter(s) |
| MRM | multiple reaction monitoring |
| MS | mass spectrometer |
| msec | millisecond(s) |
| ND | not determined |
| ng | nanogram(s) |
| NHSRC | National Homeland Security Research Center |
| NIST | National Institute of Standards and Technology |
| NMR | Nuclear magnetic resonance |
| ORD | Office of Research and Development |
| PB | procedural blank |
| PC | positive control |
| PN | part number |
| ppm | part(s) per million |
| QA | Quality Assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| $R^2$ | coefficient of determination |
| rec | recovery |

| | |
|---|---|
| RPD | relative percent difference |
| RS | recovery standard |
| RSD | relative standard deviation |
| SB | surface blank |
| sec | second(s) |
| SIM | selected ion monitoring |
| temp | temperature |
| TR | test replicate |
| VOA | volatile organic analysis |
| VX | O-ethyl S-[2-(diisopropylamino)ethyl] methylphosphonothioate |

# 1. INTRODUCTION

## 1.1 Background

Under the National Response Framework, the U.S. Environmental Protection Agency (EPA) is designated as the coordinating agency to prepare for, respond to, and recover from a threat to public health, welfare, or the environment caused by hazardous materials incidents to include chemical, biological, and radiological substances. The threat and potential consequences of a chemical agent release, such as a building or a transportation hub, is driving U.S. EPA's Homeland Security Research Program (HSRP) to develop a research program that systematically evaluates potential decontamination technologies for chemical agents. The U.S. EPA is tasked to remediate sites contaminated with these agents after they are released, and it is unknown how effective many of these available technologies are. In this study, a high priority research gap is addressed as identified by EPA program office partners through the evaluation of the effectiveness of decontamination solutions on porous or permeable materials.

## 1.2 Objectives

The main objectives for this study were to provide decontamination efficacies of four chemical agent decontaminants on porous or permeable materials. Secondary objectives were to develop a laboratory wipe method for determining residual agent on surface materials and to demonstrate that this method neutralizes the decontaminant to avoid bias in efficacy results.

Four decontamination products were evaluated for their ability to decontaminate porous surfaces that have been contaminated by chemical warfare agents, O-ethyl S-[2-(diisopropylamino)ethyl] methylphosphonothioate (VX) and bis(2-chloroethyl) sulfide (sulfur mustard, HD). The commercially available decontaminant solutions tested were household bleach (Clorox® Company, Oakland, California), household peroxide solution (HEB Grocery Company, San Antonio, Texas), EasyDecon® DF-200 (Intelagard, Inc., Lafayette, Colorado), and DeconGel® 1108 (CBI Polymers, Richardson, Texas). The surfaces tested were all associated with various materials of construction used in (underground) transportation systems. These materials included: standard window glass, glazed ceramic tile, rubber molding, and concrete sealant. To evaluate the concrete sealant, the sealant was applied to sandstone tile. These materials provided different surface porosities that could affect decontamination efficacies. Glass was included as a nonporous reference material.

The decontaminants were evaluated by determining the decontamination efficacy for each surface. Decontamination efficacy is derived from the amount of agent removed from the material surface by the decontaminant and normalized to the amount recovered if no decontamination had occurred, as shown in Equation 1. Using the agent amount recovered without decontamination normalizes the results to focus on agent losses from the decontamination process and ignores agent losses associated with natural attenuation.

$$Decontamination\ Efficacy = \left[1 - \frac{Residual\ Agent_{After\ decontamination}}{Residual\ Agent_{No\ decontamination}}\right] \times 100\%$$

***Equation 1***

To determine collection efficiency, a wipe collection method was developed and used to measure residual agent on the material surface. Since the wipe would also collect residual decontaminant, the developed extraction method included a biphasic solution (dichloromethane and aqueous buffer) and additives to neutralize and remove residual decontaminant to accurately quantify agent mass in the extracts. Recognizing that an agent would penetrate porous material and would not be collected by the wipe sample, a coupon extraction method was also used. Decontamination efficacy was based on both the wipe results and the combined wipe and coupon results.

A demonstration of the wipe method was conducted to assess agent stability in wipe extracts, high extraction efficiency and precision, high collection efficiency and precision, and to verify the decontamination efficacy testing process.

## 1.3 Approach

The approach used to evaluate the four commercially available decontamination solutions on the four surface materials is identified in the scheme shown in Figure 1.

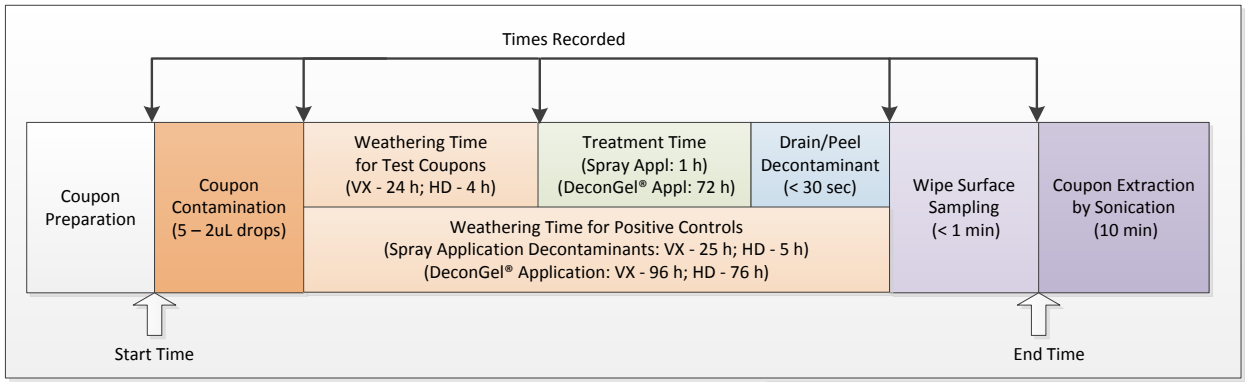


***Figure 1: Decontamination Efficacy Test Scheme***

Coupons for each surface material were prepared and visually inspected for defects. Agent was applied to the test coupons in five uniform droplets (oriented as five dots on a die). After agent application, the coupons were stored for 24 h for VX and 4 h for HD in closed plastic containers to prevent air flow from effecting sorption or attenuation on the surface. During this agent-material contact period, temperature and percent relative humidity were monitored. After the agent-material contact period expired, the decontaminant was applied to the test coupons. Positive control coupons were not treated with decontaminant. Bleach, peroxide, and EasyDecon® DF-200 solutions were sprayed onto the test coupons and were allowed to interact with the surface for 60 minutes. DeconGel® 1108, designed to form a removable dry film over the contaminated material, was applied to the surface and allowed to dry for 72 h before removing. After coupon treatment, wipe samples were taken from the coupon surface, and the coupon was then extracted.

Collected wipe samples were extracted using a method specifically developed to neutralize residual decontaminant collected during the wiping process. Wipe and coupon extracts were assayed to determine the amount of agent on the coupon after decontamination and to identify toxic agent decomposition products formed from decontamination.

## 1.4 Experimental Design

The decontamination efficacy test matrix is presented in Table 1.

***Table 1: Decontamination Efficacy Test Matrix***

| Agent | Decontaminant | Agent-Material Contact Time[1] | Treatment | # of Coupon[2] Replicates per Surface and Sample Type[3] | | | |
|---|---|---|---|---|---|---|---|
| | | | | Glass | Ceramic Tile | Concrete Sealant | Rubber Molding |
| VX | Spray Control | 25-h | -- | 1-SB\|3-PC | 1-SB\|3-PC | 1-SB\|3-PC | 1-SB\|3-PC |
| | Bleach | 24-h | 1 h | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR |
| | Peroxide | 24-h | 1 h | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR |
| | Easy Decon® | 24-h | 1 h | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR |
| | Gel Control | 96-h | -- | 3-PC | 3-PC | 3-PC | 3-PC |
| | DeconGel® | 24-h | 72-h | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR |
| HD | Spray Control | 5-h | -- | 1-SB\|3-PC | 1-SB\|3-PC | 1-SB\|3-PC | 1-SB\|3-PC |
| | Bleach | 4-h | 1 h | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR |
| | Peroxide | 4-h | 1 h | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR |
| | Easy Decon® | 4-h | 1 h | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR |
| | Gel Control | 76-h | -- | 3-PC | 3-PC | 3-PC | 3-PC |
| | DeconGel® | 4-h | 72-h | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR | 2-PB\|5-TR |

1. Agent-Material Contact Time is time from agent contamination to initial treatment.

2. Coupons (4-inch × 4-inch) represent materials found in underground transportation systems.

3. SB: Surface Blank not contaminated and not treated; PC: Positive Control contaminated but not treated; PB: Procedural Blank not contaminated but treated; TR: Test Replicate contaminated and treated.

For the spray decontamination solutions (bleach, peroxide, and EasyDecon® DF-200), decontamination efficacy testing was segregated by surface material type and agent type, i.e., all HD decontamination tests on glass coupons were conducted together. For DeconGel® 1108, testing was conducted on all surface materials at the same time.

For each agent and material type, there were one surface blank (SB), three positive controls (PC), two procedural blanks (PB) for each decontamination solution, and five test replicate (TR) coupons for each decontamination solution. The surface blank was not spiked with agent and not treated by any of the decontamination solutions (negative control). Positive controls were spiked with agent but not treated with any of the decontamination solutions. These control coupons remained in contact with agent for the total duration of both agent-material contact time and decontamination treatment time. The positive controls were used to calculate decontamination efficacy for given agent/surface contact time to allow for separation of decontaminant efficacy from other losses in the amount of agent recovered due to, e.g., evaporation losses from the surfaces. The procedural blanks were not spiked with agent but were treated by one of the decontamination solutions. The procedural blanks were used to verify that there were no contaminants observed from the decontamination solution or the interaction of the decontamination solution and the surface material that could interfere with agent detection. The procedural blanks were also used to verify that there was no cross-contamination from the handling and extraction process. The test replicates were spiked with agent and treated with one of the decontamination solutions.

# 2. PROCEDURES

## 2.1 Decontamination Solutions

This study evaluated four chemical agent decontamination solutions: household bleach solution, 3% peroxide solution, EasyDecon® DF-200, and DeconGel® 1108. The first two products are readily available in retail stores. The latter two products were developed for chemical and/or biological agent decontamination or encapsulation purposes. Decontamination solution information is presented in Table 2.

***Table 2: Decontamination Solution***

| Decontaminant | Lot# | Distributor | Active Ingredient |
|---|---|---|---|
| Clorox® Bleach | A515101TX-1 11:38R | Clorox® Company Oakland, California | 7.3% sodium hypochlorite[1] |
| Topical Solution USP | L0014877FA | HEB Grocery Company San Antonio, Texas | 3.1% hydrogen peroxide[2] |
| EasyDECON® DF200 | (Part 1) 1537 | Intelagard Lafayette, Colorado | *n*-Alkyl(C12-C16) N, N-dimethyl N-benzylammonium chloride |
| | (Part 2) 120314 | | 8.0% hydrogen peroxide |
| | (Part 3) 16119 | | Diacetin |
| DeconGel® 1108 | Not available | CBI Polymers, Metis Scientific Richardson, Texas | Polymer gel designed to encapsulate |

[1] Verified by Iodometric Method 4500-Cl B (American Public Health Association Method 4500-CL: Standard Methods for the Examination of Water and Wastewater, 21CFR 165.110(b)(4)).
[2] Verified by American Chemical Society Specification, Reagent Chemicals 8th ed. –Hydrogen Peroxide Assay.

The first three solutions are aqueous-based and were applied via spray bottle. The DeconGel® 1108 is a thick polymer and is typically applied to surfaces via paint brush, roller, or trowel. The DeconGel® 1108 was applied using a large syringe.

EasyDecon® DF-200 consists of three solutions. For each test, the three EasyDecon® DF-200 solutions were combined within six h of application.

## 2.2 Surface Materials

The four surface types selected to evaluate the decontamination solutions were glass, ceramic tile, rubber base molding, and concrete sealant applied to sand stone. Sure Klean® Weather Seal Siloxane PD concrete sealant was applied to sandstone to simulate application to concrete. While the texture of sandstone is similar to concrete, sandstone does not have the pits and cracks that concrete does. Each material was acquired or cut into approximately four-inch square coupons. Information for each material is provided in Table 3.

| Table 3: Coupon Materials to be Used for Decontamination Efficacy Testing | | | | |
|---|---|---|---|---|
| **Material** | **Retailer** | **Dimensions** | **Part Number** | **Description** |
| Glass | Thad Ziegler Glass, Ltd.<br>2202 Jackson Keller<br>San Antonio, Texas 78230 | Length 4 inch<br>Width 4 inch<br>Thickness 0.09 inch | NA | Window glass |
| Glazed Ceramic Tile | Floor Décor<br>5776 Stemmons<br>San Antonio, Texas 78238 | Length 4.25 inch<br>Width 4.25 inch<br>Thickness 0.25 inch | 914100885 | Bright White Ice |
| Rubber Base Molding | Professional Flooring Supply<br>12625 Wetmore Rd.<br>San Antonio, Texas 78247 | Length 4 inch<br>Width 4 inch<br>Thickness 0.125 inch | #60CR1P100 | Roppe “Pinnacle Rubber Black” Wall Cove Base (coupons cut) |
| SandStone Teak Honed (substrate for concrete sealant) | Floor Décor<br>5776 Stemmons<br>San Antonio, Texas 78238 | Length 3.75 inch<br>Width 3.75 inch<br>Thickness 0.44 inch | 933100122 | Sandstone Honed 4×4 Teak CASA ANTICA |
| Concrete Sealant | San Antonio Masonry and Tool Supply<br>7480 FM 1560 N<br>San Antonio, Texas 78254 | NA; applied to backside of sandstone tile | SKWS1 | Sure Klean® Siloxane PD Lawrence, Kansas |

Photographs of the coupons are shown in Figure 2. The glass was ordered from a local glass company already cut to specifications. The glazed ceramic bathroom tile was purchased and used as is. The rubber base molding was purchased as a roll (6-inch × 120-foot). Coupons (4-inch × 4-inch) were cut from the roll by removing an inch from both top and bottom of the roll and cutting 4 inch sections.

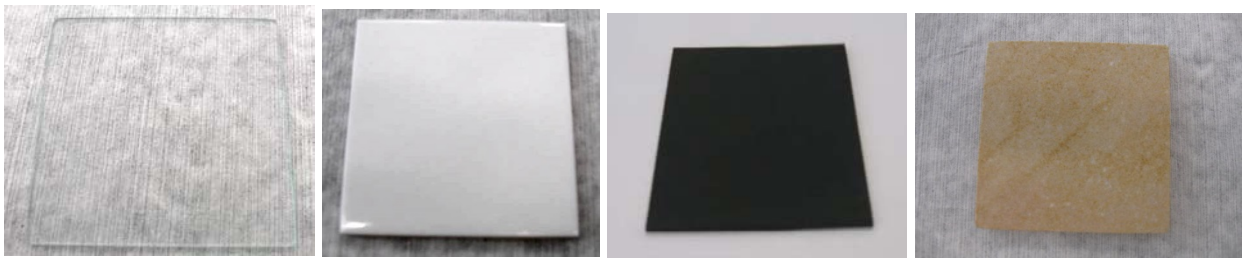

***Figure 2: Glass, Ceramic, Rubber, and Sealant/Sandstone Coupons***

Sure Klean® Siloxane PD is a water-based silane/siloxane water repellent sealant used on concrete and masonry surfaces. The sealant was applied to sandstone coupons for decontamination efficacy evaluation. Prior to application, the sandstone tiles were inspected for defects, cleaned, dried in an oven at 90 degrees Celsius (°C) for 24 h, and left under ambient conditions for one week. The cleaning process included washing the coupons with labware detergent (Contrex AP, Decon Labs, Inc., King of Prussia, Pennsylvania) and tap water, rinsing with warm tap water (49 °C) followed by two rinses with deionized water. The sealant was applied to the back side of the sandstone because the face appeared to have a finish. Two coats of Sure Klean® Weather Seal Siloxane PD Sealant were applied by paint brush to each sandstone coupon with 48 h drying time between coats. After four days of air drying, coupons were stored in a closed container until testing.

The other coupons were inspected for defects on the test surface, washed and rinsed thoroughly to remove any residues from the test surface. Coupons with divots, cracks, scratches, or any observable defects were excluded from testing. Coupons were washed with labware detergent and tap water, rinsed with warm tap water followed by two rinses with deionized water, and dried. Glass and ceramic coupons were placed in the oven at 90 °C for 20 minutes (min). The rubber was allowed to air dry under ambient conditions on a laboratory bench. Coupons were stored in sealed Ziploc® bags until needed for testing.

## 2.3 Chemical Warfare Agent Purity

Chemical Agent Standard Analytical Reference Material (CASARM) stocks were used to prepare analytical standards for instrument calibration. HD, lot# HD-U-5032-CTF-N, 98% purity used for decontamination testing was CASARM-certified material with a purity of 98%. VX, lot# VX-U-5251-CTF-N, 98.5% purity, was not CASARM-certified. VX purity was determined by $^{13}$C-Nuclear magnetic resonance (NMR) and $^{31}$P-NMR to be 98.5%.

## 2.4 Testing Timeline

Figure 1 illustrates the test process from agent spiking through coupon extraction. Timing for agent-material contact and decontaminant treatment was critical for reducing variation in the test results. A timeline was developed that specified actions on each coupon at a specific time to ensure that each coupon was kept under the same time constraints. The timeline was maintained by an individual who communicated instructions to the operators performing the work, documenting issues/observations as they occurred, and recording times. This process was essential to ensure all test sequences were performed in the same sequence and across identical time intervals.

## 2.5 Agent Spiking

To address safety concerns and mitigate agent loss from airflow across coupon surfaces, coupons were placed in plastic storage containers with removable lids prior to agent spiking and remained in the containers through the agent-material contact time and the decontamination treatment processes. The storage container is presented in Figure 3. The dimensions of the storage containers used were 10.5-inch × 14-inch × 4-inch, and the containers would hold up to six coupons.

***Figure 3: Storage Container for Agent Contaminated Coupons***

Liquid agents VX and HD were applied to the coupons using a Hamilton 1700 Series Gastight syringe (Fisher Scientific, Houston, Texas; model 80920-50µL) affixed to a Hamilton Repeating dispenser (Model 8370-PB600). In this configuration, the syringe is capable of delivering 2 microliter (µL) drops. Five droplets were spiked onto each coupon in the pattern of a square with a dot in the middle. The droplet pattern was centered on the coupon with all agent droplets at least 1 inch from the coupon edges. Initial extraction tests conducted for the wipe demonstration indicated poor agent collection efficiency from the sealant/sandstone. To ensure that sufficient agent is recovered to calculate decontamination efficacy, the amount of agent applied was increased. For the sealant/sandstone coupons, five 10 µL droplets were applied (total volume applied was 50 µL) using Eppendorf™ Repeater™ Stream (Fisher Scientific, Houston, Texas; catalog 022460803) with 0.1 mL Eppendorf™ Combitips™ (Fisher Scientific, Houston, Texas; catalog 0030089405). All other coupon types were spiked with five 2 µL droplets (total volume applied was 10 µL).

## 2.6 Agent-Material Contact Time

The agent-material contact period was the time between spiking the agent and the decontaminant application on the coupons. Agent spike, decontaminant application, and coupon extraction times were recorded to ensure accurate agent-material contact and decontamination treatment times. The agent-material contact time was four h for HD and 24 h for VX test replicate coupons. The extended contact times (typically 30 min to one h for nonporous material decontamination studies) were intended to allow for potential permeation of agent into the porous materials to occur. For positive control samples, the agent-material contact period was extended to include the decontaminant treatment time. For example, the HD positive control samples for the spray decontaminants were left for five hours and the positive control samples for DeconGel® 1108 were left for 76 h.

Coupons were stored in multiple plastic containers according to agent, decontaminant, and test/control type. For example, test coupons treated with bleach were not stored with control samples or test coupons for other decontaminants. After the coupons were spiked with agent, the containers were closed using the container lids to prevent air flow across the coupons and minimize attenuation during the agent-material contact period. Calibrated Omega temperature and humidity data loggers (Omega Engineering, Stamford, Connecticut; part number (PN) OM-EL-USB-2) were used to monitor environmental conditions in the plastic containers during agent-material contact time. The data loggers were programmed to collect temperature and humidity readings at one-minute intervals.

## 2.7 Decontamination

Once the agent-material contact time had elapsed, the test coupons were treated with decontaminant solutions (bleach, 3% peroxide, and EasyDecon® DF-200) using a glass oil mister (Prepara Kitchen Tools, New York). The decontamination treatment duration was one hour for bleach, peroxide, and EasyDecon® DF-200. Midway through the decontamination treatment duration, coupons were visually checked to verify that the surface still had decontaminant on the material surface. After application of the decontaminants, the containers were closed to prevent airflow across the coupon surface. Temperature and humidity were not monitored during decontamination treatment. One hour after application, test coupons were turned onto their side to drain residual decontaminant solution that was discarded to waste. Coupon wiping and extraction followed thereafter. Liquid waste potentially containing residual chemical agent was not analyzed in this study.

Preliminary application testing of DeconGel® 1108 indicated that the film was still tacky after 48 h. To ensure that the film was completely dry, the decontamination treatment duration for DeconGel® 1108 was 72 h. After application of the DeconGel® 1108, the containers were left open to allow air flow across the coupon surface to promote DeconGel® 1108 drying. The containers for the positive controls associated with the DeconGel® 1108 were kept closed for the entire duration.

### *2.7.1 Spray Application*

The decontamination solutions were applied using a glass oil mister (shown in Figure 4). This sprayer was small, easy to handle, and had a consistent misting spray result. The container was pressurized using the white top, and the liquid was atomized as the trigger was pressed. An application method was developed using water and verified using each of the decontaminant solutions.


***Figure 4: Glass Oil Mister***

The application method included the following steps. The mister bottle was filled with decontamination solution to the maximum fill line identified on the bottle. The green top was tightened snugly to prevent pressure loss. The white cap was placed over the green top and pumped four times. A four-sided acrylic box (application chamber shown in Figure 5) was placed around the coupon being treated to prevent overspray. The bottle was positioned horizontally and resting against the top of the application chamber. The trigger was pressed for seven seconds while moving the bottle side to side to get even coverage over the coupon. Before spraying the next coupon, the green cap was loosened to vent the pressure, tightened snugly, and the bottle was pumped four times.

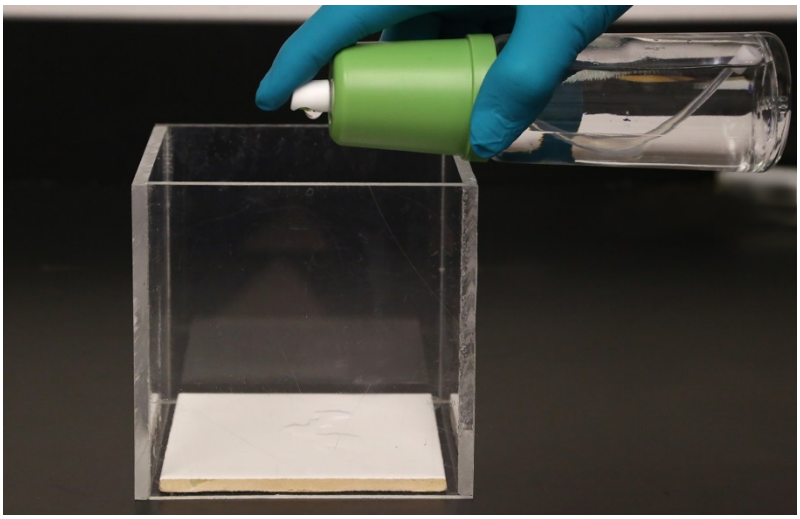

***Figure 5: Application Chamber for Spraying Decontaminant Solution***

Bottles were dedicated to a particular decontaminant solution. Each bottle was calibrated using the decontaminant solution before and after each test set. At the end of the test set, the decontamination solution was removed and the bottle/nozzle rinsed thoroughly with water. The calibration consisted of a total of 14 replicate sprays (seven before testing and seven after testing). Each spray was collected in a beaker, and the mass of the decontamination solution was measured using a balance. The average and standard deviation for the 14 data points was calculated. Calibration results are summarized in Table 4. There were observable losses during treatment due to some of the decontaminant coating the sides of the application chamber. The gravimetric loss was determined to be 21% (seven replicates, 11% RSD). The corrosive nature of the decontamination solutions did affect the sprayer and resulted in spray bottles being replaced frequently.

| Table 4: Spray Bottle Calibration Results | | | | |
|---|---|---|---|---|
| **Test Material** | **Agent** | **Mass of Bleach Solution Applied** | **Mass of Peroxide Solution Applied** | **Mass of EasyDecon® DF-200 Solution Applied** |
| Glass | HD | 4.7 g/11% RSD | 5.0 grams (g)/ 16% RSD | 4.0 g/9.3% RSD |
| | VX | 4.4 g/10% RSD | 4.9 g/5.7% RSD | 4.3 g/6.7% RSD |
| Ceramic | HD | 3.8 g/6.7% RSD | 5.1 g/6.6% RSD | 4.4 g/5.1% RSD |
| | VX | 4.6 g/6.6% RSD | 5.0 g/7.3% RSD | 4.5 g/6.6% RSD |
| Sealant | HD | 5.9 g/6.9% RSD | 5.5 g/6.2% RSD | 5.0 g/6.7% RSD |
| | VX | 5.8 g/9.0% RSD | 5.6 g/6.6% RSD | 5.0 g/5.2% RSD |
| Rubber | HD | 5.6 g/7.4% RSD | 6.2 g/4.8% RSD | 5.0 g/11% RSD |
| | VX | 5.6 g/12% RSD | 6.2 g/4.7% RSD | 4.3 g/7.6% RSD |

### *2.7.2 DeconGel® 1108 Application*

The DeconGel® 1108 solution was applied using a 60 mL plastic syringe (Becton, Dickinson and Company, Franklin Lakes, New Jersey) with a 1 cm diameter bored opening at the syringe tip, as shown in Figure 6. For each applicable coupon, 25 mL of the viscous solution was slowly poured onto the coupon in a circular motion to minimize bubble formation and generate an even surface. The decontamination contact time for the DeconGel® 1108 was set for 72 h. After application of the DeconGel® 1108, the containers were left open to allow air flow across the coupon surface. At the end of this period, the dried DeconGel® 1108 was peeled off the test coupons and disposed of via hazardous waste. The dried DeconGel® 1108 was not analyzed for presence of residual chemical agent. Coupon wiping and extraction followed.

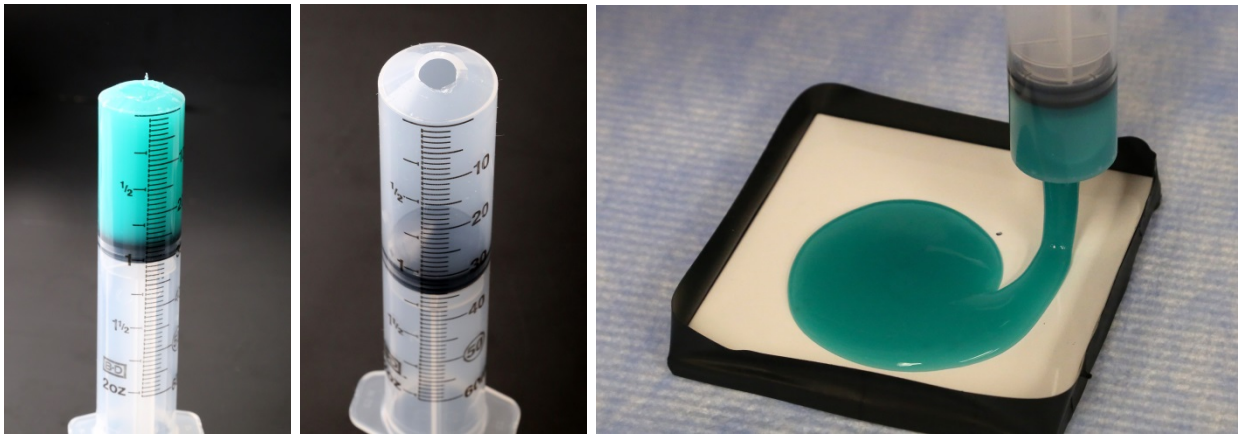

***Figure 6: DeconGel® 1108 Syringe Applicator and Application onto a Coupon***

## 2.8 Sample Collection

Residual agent remaining on the coupon was determined by collecting a wipe sample and by extracting the whole coupon. The surface wipe allowed for quantification of agent residue on the surface and represents a contact hazard. The coupon extraction can remove more of the agent residue on the surface and to some degree can extract agent that has penetrated into the material.

### *2.8.1 Wipe Collection Method*

A white microfiber cloth (Anypromo, Chino, California) (2-inch × 3-inch) was used for collecting wipe samples. This material was selected following wipe method development. The microfiber was cleaned by washing with dichloromethane (Fisher Scientific, Houston, Texas) wetting with solvent (isopropyl alcohol or acetone) and air drying at room temperature covered with foil rinsed with acetone (Fisher Scientific, Houston, Texas). Once the microfibers were dry, they were stored in a Ziploc® bag until testing. Control blank wipes were conducted by wetting the wipe material with solvent and wiping a clean glass plate. The microfiber cloth was placed in a 20 mL Volatile Organic Analyte (VOA) vial with cap (Thermo Scientific, Grand Island, New York) and wetted with 1 mL of isopropyl alcohol (Fisher Scientific, Houston, Texas) prior to starting the tests. When the coupon was placed on the tray ready for wiping, the damp microfiber cloth was removed from the capped vial with forceps. The wipe was folded in half and wiped back and forth (east/west) motion from top to bottom moving in an 'S' pattern. The wipe was folded in half so that the cloth surface used to wipe the surface was folded inward. The coupon was wiped a second time in an up and down (north/south) motion from top to bottom. The wipe was folded in half, dirty side inward. The coupon was wiped a third time starting from the outside corners and following a circular pattern inward. The coupon was folded, dirty side inward, and placed into the appropriately labeled vial already containing extraction solvent (5 mL dichloromethane and 5 mL of pH buffer with sodium thiosulfate).

The wipe controls (two wipe blanks and three laboratory control spike [LCS] wipes) were also prepared. For the wipe blank, the damp microfiber cloth was removed from the capped vial and placed into the appropriately labeled vial already containing extraction solvent. For the wipe LCS, the damp microfiber cloth stored in the capped vial was spiked with dilute agent (HD 2,500 nanograms (ng) or VX 1250 ng), removed from the vial, and placed into the appropriately labelled vial already containing extraction solvent. The agent spike amount was selected based on the detection limits of the analysis and the anticipated agent recovery of the test replicates.

Special care was taken to prevent contamination between coupons. Butyl gloves and forceps were rinsed with acetone and dried using Kimwipes™ (Fisher Scientific, Houston, Texas) prior to handling each coupon.

## 2.9 Extraction Methods

### *2.9.1 Laboratory Wipe Method Development*

The requirements for the laboratory wipe method development included a decontaminant quench and method demonstration. Since the microfiber wipe would sorb residual decontaminant on the coupon during collection, it was necessary for the extraction to neutralize the decontaminant to prevent further agent decomposition in the extract. Decomposition in the extract could significantly affect variability and overestimate decontaminant performance. A detailed description of the method development effort is provided in Appendix A.

The wipe method was developed in three steps: wipe comparison, solvent system, and decontaminant neutralization tests. The wipe comparison tests evaluated the collection efficiency of three types of wipes (microfiber cloth from Anypromo, Chino, California; cotton gauze from Dukal Corporation, Hauppauge, New York, Lot# A17610 27; and polyester cotton blend from Fruit of the Loom) using two types of wetting solvent (acetone and isopropyl alcohol). The microfiber cloth performed slightly better than the other materials on average but the performance was not statistically different. Wipes wetted with isopropyl alcohol performed better than wipes wetted with acetone. The solvent system tests evaluated the

wipe extraction efficiency of two volumes of the biphasic (dichloromethane and aqueous buffer) solvent system at three agent spike levels. There was not a significant performance difference between the two extraction volumes tested. Therefore, the extraction volume selected was 10 mL of the 1/1 dichloromethane/aqueous solvent system. The decontaminant neutralization tests were conducted to investigate additives for neutralizing residual decontaminant solution that may be collected during the wiping process. The three decontamination solutions tested were bleach, peroxide, and EasyDecon® DF-200. EasyDecon® DF-200 consists of peroxide and an amine surfactant. Agent recovery performance was compared from triplicate extract solutions with and without additives for each decontaminant solution. Test results indicated that sodium thiosulfate (Fisher Scientific, Houston, Texas) was effective for preserving agent in the presence of bleach and additives were not necessary for 3% peroxide. The amine surfactant in EasyDecon® DF-200 was basic (pH 10) and caused HD to decompose.

Aqueous buffers were incorporated into the extraction system because the decontaminants were all aqueous-based and the proposed additives were all miscible in aqueous solution. During wipe extraction, the decontaminant should partition into the aqueous phase, immediately diluting and neutralizing the decontaminant. Separate pH buffers were used for each agent. VX used a pH 10 buffer that consisted of 0.5 M Carbonate (Sigma Aldrich, St. Louis, Missouri) buffer and 1.25 M sodium thiosulfate, and HD used a pH 5 buffer that consisted of 1.0 M acetate (Fisher Scientific, Houston, Texas) buffer and 1.25 M sodium thiosulfate. For VX, the pH 10 buffer was needed to partition VX into the dichloromethane layer. The pH 5 buffer was used to prevent HD decomposition. The resulting method is described in Section 2.9.2.

### *2.9.2 Wipe Extraction Method*

In a 20 mL VOA vial with Teflon-lined cap, 5.0 mL of dichloromethane and 5.0 mL of buffer (pH 10 carbonate buffer with sodium thiosulfate for VX extracts and pH 5 acetate buffer with sodium thiosulfate for HD extracts) was added. After wiping each coupon with the 2-inch x 3-inch microfiber cloth, the folded wipe sample was placed into the 20 mL VOA vial containing the extraction solution. The vials were vortexed for 15 minutes. The wipe remained in the solvent system for a minimum of 30 min. The extract, including the microfiber wipe, was filtered through 0.45 micrometer (µm) Nylon syringe filter. Sufficient time was allowed for the solution to separate into two layers. In some cases, a centrifuge was used to expedite the separation. Approximately 4 mL of the dichloromethane layer (bottom) was removed and placed into a 1 dram vial containing sodium sulfate to dry the dichloromethane. Aliquots of the dried dichloromethane were prepared for analysis.

### *2.9.3 Whole Coupon Extraction*

In addition to collecting a surface wipe, the coupon was extracted to provide information regarding collection efficiency and determine agent penetration into the material. After collecting the wipe sample, the coupon was carefully lowered into a stainless steel vessel as shown in Figure 7. The vessel contained seven modules, each filled with dichloromethane for extracting coupons. The amount of dichloromethane in each module was based on the coupon material type to ensure that the coupon was completely submerged in solvent throughout the extraction process (Glass 200 mL, Rubber 200 mL, Ceramic tile 150 mL, and Sealant 130 mL). Once all of the holders were filled, the stainless steel vessel was covered with foil and placed into a sonicator. The samples were sonicated for 10 minutes. Effective cooling (ice-cold water bath - no floating ice) was used to control temperature to minimize evaporation loss. The coupons remained submerged in the extraction solvent for a minimum of one hour prior to collecting 4 mL aliquot of the dichloromethane extract for analysis.

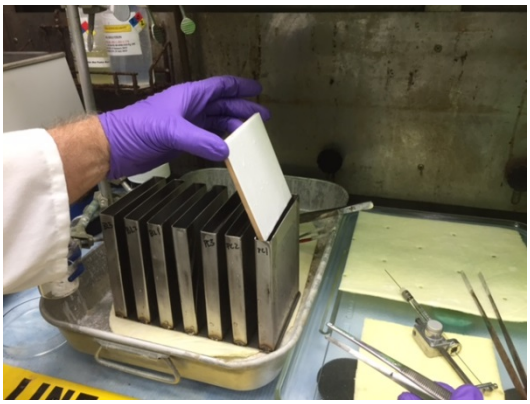

***Figure 7: Stainless Steel Coupon Extraction Vessel***

After testing and collecting the extract, the coupons and excess extract were discarded to waste. The vessel was cleaned between uses by thoroughly rinsing three times with acetone and drying.

## 2.10 Analytical Methods

The main focus of the analytical method was to quantify residual VX and HD to calculate the decontamination efficacy. However, it is important to determine whether other toxic materials are being formed from the decontamination process. Analysis was conducted using targeted methods and survey methods. Targeted methods focused specifically on quantification of VX and HD. This analysis included all of the calibration and QC analysis to support the calculated results. The survey methods were focused on identification of unknowns (qualitative analysis).

Compound calibration curves consisted of six calibration points. The initial calibrations (ICALs) were performed and met calibration criteria prior to assaying samples. The calibration curve was verified using an initial calibration verification (ICV) standard at the mid-level that was independently prepared. Samples were bracketed by passing continuing calibration verification (CCV) standards, assayed at a minimum frequency of one CCV for every ten samples. Calibration acceptance criteria are identified in Table 5. Failure to meet acceptance criteria requires instrument maintenance and performing another initial calibration curve.

***Table 5: Calibration Acceptance Criteria***

| Type | Acceptance criteria | Frequency |
|---|---|---|
| Calibration Curve (ICAL) | (coefficient of determination, $R^2 \geq 0.99$ or %RSD $\leq$20%) and 70-130% accuracy of the true concentration | Before sample analysis begins and after ICV or CCV failure |
| Initial Calibration Verification (ICV) | 75-125% accuracy | After Calibration but before sample analysis begins |
| Continuing Calibration Verification (CCV) | 75-125% accuracy | Between the sample series, every ten samples at a minimum |
| Instrument Solvent Blank | No hits in the agent retention time window | Bracketing CCV standards and after ICV |

Internal standards (ISs) were used for determining instrument drift or matrix interferences that affect response. Internal standards were spiked into all standards and samples at the same level and included in the calibration curve calculations. The internal standard acceptance criteria are identified in Table 6. All results met these criteria.

| Table 6: Internal Standard Acceptance Criteria | | |
|---|---|---|
| **Type** | **Acceptance Criteria** | **Frequency** |
| Calibration (ICAL) | %RSD ≤ 20% | All Standards |
| Continuing Calibration Verification (CCV) | 100 ± 25% of ICAL | All Standards |
| All Samples and QC | 100±50% of previous CCV | All Samples |

### 2.10.1 GC/MS (HD-Targeted Analysis)

The instrument used for HD analysis was an Agilent (Santa Clara, California) 6890 gas chromatograph and 5973 quadrupole mass spectrometer operated in electron ionization (EI)+ selected ion monitoring (SIM) mode. Acquisition parameters are provided in Table 7. The samples were analyzed using a six-point standard calibration curve ranging from 5 to 100 ng/mL calculated using relative response factors. The instrument detection limit was 1 ng/mL. The internal standard naphthalene-$d_8$ was spiked into all standards and samples at 100 ng/mL.

| Table 7: GC/MS Parameters for HD Analysis | |
|---|---|
| **Column Type** | RTX-VGC, 30 m x 0.32 mm inner diameter (i.d.) 1.8 µm film thickness (No. 19419, Restek Corporation, Bellefonte, Pennsylvania) |
| **Column Program** | 60 °C initial temperature (temp), hold 0 min, 14 °C/min to 200 °C, hold 0 min, 40 °C/min to 240 °C, hold 5 min |
| **Transfer line Temperature** | 240 ° C |
| **Injection Port Temperature** | 210 °C |
| **Carrier Flow Rate** | 1.5 mL/min constant flow |
| **Injection** | Pulsed Splitless (25 psi until 0.5 min., split 60 mL/min at 1 min.) |
| **Injection Volume** | 2 µL |
| **Acquisition Mode** | Selected ion monitoring (SIM)<br>HD ions: 158 (quant), 109, 111, and 160 *m/z**<br>napthalene-$D_8$: 136 (quant) and 108 *m/z*) |
| **Electron Impact** | 70 electron volts (eV) |
| **Ion Dwell Time/Scan Rate** | 100 milliseconds (msec) or approximately 2 scans per second (sec) |
| **MS Quad Temperature** | 150 °C |
| **MS Source Temperature** | 230 °C |

**m/z* = mass to charge ratio

### 2.10.2 LC-MS/MS (VX-Targeted Analysis)

The instrument used for VX analysis was an Agilent 6410 triple quadrupole mass spectrometer detector (Santa Clara, California), with Agilent 1200 series pump and autosampler, operated in Electrospray Ionization (ESI) positive ion multiple reaction monitoring (MRM) mode. The acquisition parameters are identified in Table 8. The samples were analyzed using a six-point standard calibration curve ranging from 2 to 60 ng/mL calculated using linear regression. The instrument detection limit was 0.5 ng/mL. The internal standard deuterated diisopropyl methyl phosphonate (DIMP-$d_{14}$) (Cerilliant, Austin, Texas, PN: ERD-086) was spiked into all standards and samples at 4.0 ng/mL. Samples were also screened for EA-2192, a toxic decomposition product of VX that could present a public health risks during VX cleanup operations. EA-2192 transition ions were monitored, and a standard was assayed to determine the retention time window, but the response was not calibrated.

<table>
<tr><th colspan="2">Table 8: LC-MS/MS Parameters for VX Analysis</th></tr>
<tr><td>Mass spectrometric source</td><td>Electrospray Ionization, positive ion mode</td></tr>
<tr><td>HPLC column</td><td>Allure PFP propyl, 2.1 mm x 150 mm, 5 µm or equivalent (Restek No. 9169562)</td></tr>
<tr><td>HPLC column temperature</td><td>Ambient</td></tr>
<tr><td>Mobile phase components</td><td>A = water containing 2 mM formic acid and 2 mM ammonium formate<br>B = acetonitrile containing 0.1% formic acid</td></tr>
<tr><td>Gradient profile – Group A</td><td>
<table>
<tr><th>Time (min)</th><th>% A</th><th>% B</th><th>Flow rate (mL/min)</th></tr>
<tr><td>0</td><td>20</td><td>80</td><td>0.4</td></tr>
<tr><td>3</td><td>20</td><td>80</td><td>0.4</td></tr>
<tr><td>10</td><td>0</td><td>100</td><td>0.4</td></tr>
<tr><td>12</td><td>0</td><td>100</td><td>0.4</td></tr>
<tr><td>12.5</td><td>20</td><td>80</td><td>0.4</td></tr>
<tr><td>15</td><td>20</td><td>80</td><td>0.4</td></tr>
</table>
</td></tr>
<tr><td>Injection volume</td><td>5 µL</td></tr>
<tr><td>Drying gas (Type, flow, Temp)</td><td>Nitrogen, 11 L/min, 300 °C</td></tr>
<tr><td>Nebulizer</td><td>30 psig</td></tr>
<tr><td>Capillary Voltage</td><td>3500 V</td></tr>
<tr><td>Fragmentor</td><td>130 V</td></tr>
<tr><td>Acquisition Mode</td><td>Multiple reaction monitoring (MRM)<br>VX transition ions: 268→128 (quant), 268→86, 268→167, and 268→139<br>DIMP-$d_{14}$ transition ions: 195→99 (quant) and 195 →80<br>EA-2192 transition ions: 240→128 and 240 →86</td></tr>
</table>

### *2.10.3 GC x GC/TOFMS (Survey Analysis)*

Survey analyses for VX and HD extracts were conducted to identify agent decomposition products formed from the decontamination process. The Pegasus® 4D GCxGC/TOFMS (Leco, St. Joseph, Michigan) is a Two-Dimensional Gas Chromatograph Time-of-Flight Mass Spectrometer. The acquisition parameters are identified in Table 9. Two orthogonal columns separated by a thermal modulator offer high resolution chromatography. The TOF mass spectrometer provided spectra for National Institute of Standards and Technology (NIST) library identification for eluting peaks. Spectral results were reviewed for detections related to HD and VX. Most reported detections had a match quality greater than 650 out of 1000 with the exception of HD- and VX-related unknowns. These detections had characteristic HD and VX ions but their spectra did not precisely match any of the library spectra. The samples were spiked with semivolatile internal standard mix (Restek PN. 31206) at 1.0 micrograms per milliliter (µg/mL). The responses and retention times for the internal standards were used to monitor instrument drift.

| *Table 9: GC x GC/TOFMS Parameters for Survey Analysis* | |
|---|---|
| **Column 1 Type** | RXI-1MS, 30 m x 0.25 mm i.d., 0.25 µm film thickness (Restek No. 13323) |
| **Column 2 Type** | RXI-17SilMS, 1.5 m x 0.18 mm i.d. 0.18 µm film thickness (Restek No. 14102) |
| **Column 1 Program** | 50 °C initial temp, hold 2 min, 10 °C/min to 260 °C, hold 0 min, 20 °C/min to 300 °C, hold 2 min |
| **Column 2 Program** | 55 °C initial temp, hold 2 min, 10 °C/min to 265 °C, hold 0 min, 20 °C/min to 305 °C, hold 2 min |
| **Modulation** | 3 sec (0.75 sec hot pulse and 0.75 sec cold pulse) 2 cycles |
| **Modulator Offset Temperature** | + 20 °C |
| **Injection Port Temperature** | 260 °C |
| **Transfer line Temperature** | 300 °C |
| **Carrier Flow Rate** | 1.0 mL/min constant flow |
| **Injection** | Splitless (split 30 mL/min. at 1 min) |
| **Injection Volume** | 1 µL |
| **Acquisition Mode** | EI, scan range 45-600 *m/z* |
| **Acquisition Rate** | 100 spectra/sec |
| **Electron Impact** | 70 eV |
| **MS Source Temperature** | 225 °C |

### *2.10.4 LC/qTOF (Survey Analysis)*

An Agilent 6540 UHD Accurate Mass Q-TOF LC/MS instrument used to survey VX sample extracts was operated in ESI+ scan mode. The acquisition parameters are identified in Table 10. Samples were processed using Agilent Mass Hunter software. An internal standard, diisopropyl methyl phosphonate-$d_{14}$, was spiked into all samples at 100 ng/mL and was used to verify instrument stability and estimate relative concentrations of peaks detected. Data results identified molecular formulas based on mass accuracy of less than 5 parts per million (ppm).

| *Table 10: LC-qTOF Parameters for Survey Analysis* | | | | | |
|---|---|---|---|---|---|
| **Mass spectrometric source** | Agilent Jet Stream Electrospray Ionization, positive ion mode | | | | |
| **HPLC column** | Allure PFP propyl, 2.1 mm × 150 mm, 5 µm or equivalent (Restek No. 9169562) | | | | |
| **HPLC column temperature** | Ambient | | | | |
| **Mobile phase components** | A = water containing 0.1% formic acid<br>B = methanol containing 0.1% formic acid | | | | |
| **Gradient profile – Group A** | | Time (min) | % A | % B | Flow rate (mL/min) |
| | | 0 | 98 | 2 | 0.4 |
| | | 2 | 98 | 2 | 0.4 |
| | | 17 | 25 | 75 | 0.4 |
| | | 20 | 0 | 100 | 0.4 |
| | | 23 | 0 | 100 | 0.4 |
| | | 23.01 | 98 | 2 | 0.4 |
| | | 25 | 98 | 2 | 0.4 |
| **Injection volume** | 5 µL | | | | |
| **Drying gas (type, flow, temp)** | Nitrogen, 8 L/min, 325 °C | | | | |
| **Nebulizer** | 35 psig | | | | |
| **Capillary Voltage** | 3500 V | | | | |
| **Fragmentor** | 175 V | | | | |
| **Skimmer** | 65 V | | | | |
| **Sheath gas temp. and flow** | 350 °C and 11 L/min | | | | |
| **Acquisition Mode** | Scan | | | | |

## 2.11 Calculations

The following calculations were used to evaluate the data and determine decontamination efficacy. These calculations are documented in Chemical Contaminant and Decontaminant Test Methodology Source Document [1]. All wipe and coupon extract results were converted to total mass (nanograms) using Equation 2. Average total mass was calculated for each set.

$$Total\ Mass_{(ng)} = Extract\ Concentration_{(\frac{ng}{mL})} \times Extract\ Volume_{(mL)} \times Dilution\ Factor$$

***Equation 2***

Recoveries were calculated for all spiked samples. Percent recovery was based on the theoretical spike amount using Equation 3. Average percent recovery and percent Relative Standard Deviation (RSD) were calculated for each set.

$$Recovery_{(\%)} = (Found\ Total\ Mass_{(ng)}\ x\ 100\ )/Spike\ Mass_{(ng)}$$

***Equation 3***

RSD was calculated for positive control and test replicates using Equation 4.

$$\%RSD = \frac{Standard\ Deviation\ of\ Replicates}{Average\ of\ Replicates}$$

***Equation 4***

The percent efficacy calculation is presented in Equation 5. This equation uses the positive control to normalize the data to exclude losses from attenuation, collection, and extraction efficiencies. For most materials, efficacies were calculated for wipe only and combined wipe and coupon. For the sealant/sandstone, efficacies were calculated from the coupon only.

$$Efficacy = \left[1 - \frac{Average\ Total\ Mass_{Test\ Replicates}}{Average\ Total\ Mass_{Positive\ Controls}}\right] \times 100\%$$

***Equation 5***

# 3. QUALITY ASSURANCE / QUALITY CONTROL

This work was conducted under a certified quality system that meets International Organization for Standardization (ISO) 9001:2008 Quality Management requirements.

## 3.1 Process and Data Quality Audit

Quality Assurance (QA) personnel reviewed the Quality Assurance Project Plan (QAPP), all procedures, and conducted surveillances on the method demonstration and efficacy testing processes to verify compliance. The method demonstration surveillance identified several recommendations that were incorporated into efficacy testing. The efficacy surveillance identified one unsatisfactory finding, DeconGel® 1108 was not sufficiently dry for collection at 24 h. EPA was notified and the finding was addressed by repeating the tests with a 72-hour drying time.

Analytical data packages were assembled according to contract requirements. The data were peer reviewed and validated by QA personnel. There were several findings, and corrective actions are identified as follows: 1) DeconGel® coupons were still wet after 24 h. Subsequent tests were performed using a 72 h drying time. 2) Initial tables were put together using data where the ending CCVs failed. Affected samples were reanalyzed with passing CCV values; tables were updated with these data meeting all criteria. 3) Injection log and extraction log pages were not approved within a timely manner. Logs were reviewed and approved. All of these findings were classified as minor, corrective actions were taken immediately and none of the findings affected the data quality.

## 3.2 Quality Performance Indicators for Wipe Method Demonstration

Performance indicators for wipe method demonstration testing are presented in Table 11. The percent difference between analytical results conducted on day 0 and day 3 after extraction was used to determine whether residual decontaminant collected during wipe collection was sufficiently neutralized and agent was preserved in the extract. The wipe LCS recovery and precision criteria were used to determine whether the extraction process of the wipe only was sufficient. The positive control wipe recovery and precision criteria were used to determine whether the collection efficiency of the wipe method was sufficient. Failing recovery criteria would be an indication that a coupon extraction method would be needed for efficacy testing. No recovery criterion was assigned for the decontaminant-treated coupons because the decontamination was expected to neutralize most of the agent spiked onto the coupon.

***Table 11: Agent Acceptance Criteria for Wipe Method Demonstration***

| Sample Types | Purpose | Criteria |
|---|---|---|
| Wipe Blank | Verify no method interferences | No detections for VX/HD |
| Wipe LCS | Determine wipe extraction efficiency and precision; verify extract stability | Rec: 100±25%, %RSD: < 25%<br>% Difference (Day 0 & 3) ≤20% |
| Positive Controls | Determine wipe collection efficiency and precision; verify extract stability | Rec: 100±50%, %RSD: < 25%<br>% Difference (Day 0 &3) ≤20% |
| Test Replicates | Verify extract stability | % Difference (Day 0 &3) ≤30% |

## 3.3 Wipe Demonstration Quality Control Samples

There were no agent detections for any of the control blanks (surface, procedural, and wipe method blanks). A total of 12 LCS samples were assayed for each agent. All LCS samples met recovery criteria (HD average (avg.) Recovery 96%, 9% RSD; VX avg. Recovery 95%, 13% RSD) demonstrating acceptable extraction efficiency. A summary of the wipe positive control results is presented in Table 12. Collection efficiency was demonstrated for glass and ceramic. However, the more porous materials did not meet requirements. Based on these results, a coupon extraction was included for efficacy testing.

| *Table 12: Summary of Wipe Positive Control Results* | | | | |
|---|---|---|---|---|
| **Test Set** | **HD** | | **VX** | |
| | **Average Recovery** | **%RSD** | **Average Recovery** | **%RSD** |
| Glass | 95% | 17 | 103% | 11 |
| Ceramic | 64% | 5.3 | 81% | 15 |
| Rubber | 36% | 15 | 40% | 82 |
| Sealant | <0.2% | 43 | <0.2% | 53 |

Stability was demonstrated by assaying the extracts twice. The intention was to assay extracts immediately after extraction (day 0) and on day 3. However, scheduling conflicts resulted in the second analysis being assayed on day 4 for VX and day 9 for HD. The average concentration for all HD extracts increased by 18%. VX samples were assayed on day 0 and day 4 after collection and extraction, showing an average concentration increase of 7%. Both results indicate that the method preserved the agent.

Several observations were made during the validation effort that allowed changes and adjustments to be made for decontamination efficacy testing. The wipe only recovered trace amounts of agent from the sealant/sandstone. The low overall recovery was assumed to be associated with the permeability of the sealant/material combination. Considering that the agent-material contact time would be extended from 1 h to 4 h for HD and 24 h for VX, the agent spike amount on the coupon was increased from 10 µL to 50 µL for sealant/sandstone. Collecting wipe samples from the sealant/sandstone was difficult due to surface roughness and yielded less than 0.2% recovery for both agents. Based on this information, wipe samples were not collected during decontamination efficacy testing. Interference problems for HD/rubber (coupon and wipe) extracts were observed through high background, failing CCVs, and poor chromatography, presumably due to high levels of phthalates (determined by GC x GC/TOFMS). This problem was resolved by diluting all of the extracts by at least 10x. The above-mentioned changes were incorporated prior to starting decontamination efficacy testing.

### 3.4 Quality Performance Indicators for Decontamination Efficacy

Performance indicators for efficacy testing are presented in Table 13.

| *Table 13: Decontamination Efficacy Performance Indicators* | | |
|---|---|---|
| **Control Type** | **Purpose** | **Criteria** |
| Surface Blank | Verify that the material has no interferences or cross-contamination (1 per surface and agent type) | VX /HD less than 0.2 total µg[1] |
| Positive Control | Determine collection efficiency (three per surface and agent type) | Rec: > 10%, %RSD: < 30% |
| Recovery Standards | Verify agent spike amount (three per deposition batch and agent type) | Rec: 100±15%, %RSD: < 15% |
| Procedural Blanks | Verify that there are no interferences from decontaminant material interaction (two per decontaminant, surface and agent type) | VX /HD less than 0.2 total µg |
| Wipe Blank | Verify that there are no interferences from extraction process (one per 20 wipe samples) | VX /HD less than 0.02 total µg |
| Wipe LCS | Determine extraction efficiency (one per 20 wipe samples) | Rec: 100±35% RPD[2]: < 30% |
| [1] Total µg is the amount found from both wipe and coupon extracts<br>[2] Relative percent difference | | |

## 3.5 Efficacy Quality Control Samples

There were no agent detections for any of the control blanks (surface, procedural, and wipe method blanks) with the exception of HD (0.35 µg) detected for the glass surface blank in the coupon extract. This detection was below the calibration range (3xMDL) and less than 0.01% of the positive control result. Based on the non-detection for the wipe extract, the detection resulted from cross contamination with the positive controls during coupon extraction.

No significant interference issues were noted other than for dichloromethane extraction of the rubber material (wipe and coupon). This issue affected HD-targeted GC/MS analysis. To mitigate this issue, all rubber material HD extracts were assayed with a minimum dilution of 10x.

Two method blanks and three LCS samples were collected for every test set, resulting in eight method blanks and 12 LCS samples for each agent. Wipe method QC results are presented in Appendix A. These QC samples verified the performance of wipe extraction. All wipe QC samples met criteria. There were no detections in the method blanks. The average recovery for all of the HD and VX replicates were 100% and 92%, respectively, and the %RSD values were 6% and 4%, respectively.

A summary of the positive control results is presented in Table 16. The average recovery reported is based on theoretical yield to include density and purity of the agent. During the initial wipe demonstration, the positive control recoveries for the sealant and rubber materials were observed to be low (less than 20% recovered) and highly variable. As a result, the recovery acceptance limit was set to greater than 10% and %RSD set to less than 30%. The positive control failures were attributed to the porosity of the sealant/sandstone substrate and HD attenuation over the three-day period. The porosity of the sealant/sandstone also resulted in high variability between sample coupons. This variability is most likely related to extraction inefficiencies due to agent penetration and possible substrate-induced decontamination. The other failures were associated with the long HD material contact time. While HD is considered persistent, it attenuates from surfaces over time. Only a trace level of material was recovered from the two most nonporous materials, glass and ceramic, whereas the sealant and rubber showed recovery of substantially more material.

| Table 14: Summary of Positive Control Results | | | | | | |
|---|---|---|---|---|---|---|
| **Agent** | **Type** | **Parameter** | **Glass (Wipe Coupon)** | **Ceramic (Wipe Coupon)** | **Sealant (Coupon)** | **Rubber (Wipe Coupon)** |
| VX | Spray Control (24 h) | Average | 94% | 74% | 29% | 77% |
| | | %RSD | 20% | 11% | 10% | 18% |
| | | Pass /Fail | P | P | P | P |
| | Gel Control (96 h) | Average | 110% | 73% | 16% | 69% |
| | | %RSD | 7.1% | 20% | ***55%*** | 10% |
| | | Pass /Fail | P | P | ***F*** | P |
| HD | Spray Control (5 h) | Average | 61% | 120% | 27% | 130% |
| | | %RSD | 12% | 7.0% | ***84%*** | 19% |
| | | Pass /Fail | P | P | ***F*** | P |
| | Gel Control (76 h) | Average | ***<0.5%*** | ***<0.5%*** | ***2.2%*** | 130% |
| | | %RSD | 8% | 20% | 16% | 13% |
| | | Pass /Fail | ***F*** | ***F*** | ***F*** | P |

Three recovery standards (RSs) were prepared for each test set to determine the precision of the agent applied to surfaces. Recovery standards were prepared by spiking agent directly into a glass vial. The average recovery reported is based on theoretical yield to include density and purity of the agent. A summary of the recovery standard results is presented in Table 15, and individual results are presented in Appendix B. The recovery standard sets prepared for the HD Rubber tests and VX Sealant tests failed with high recovery, while all recovery standard sets met precision guidelines of percent relative standard deviation (%RSD) of less than 15%.

| Table 15: Summary of Recovery Standard Results | | | | |
|---|---|---|---|---|
| **Test Set** | **HD** | | **VX** | |
| | **Average Recovery** | **%RSD** | **Average Recovery** | **%RSD** |
| Glass | 94% | 5.1 | 99% | 1.7 |
| Ceramic | 98% | 12 | 96% | 5.3 |
| Rubber | 160% | 5.3 | 100% | 6.3 |
| Sealant | 85% | 15 | 140% | 6.0 |
| DeconGel® | 89% | 5.4 | 100% | 8.0 |

## 3.6 QAPP Deviations

QAPP deviations included the following: the spray application chamber was modified to remove the top plate, DeconGel® 1108 application process was modified, DeconGel® 1108 drying time extended from one day to three days, wipe samples were not collected for sealant/sandstone samples, and the agent spike amount on sealant/sandstone coupons was increased from 10 µL to 50 µL.

The spray application chamber identified in the QAPP assumed that the spray bottles would have a nozzle that would protrude through a hole in the top plate. However, the selected spray bottle did not have a protruding nozzle. The top plate would have interfered with the decontaminant application. As a result, the top plate was not incorporated with the spray application chamber.

The application process for DeconGel® 1108 included using a cover plate and weight to smooth out the DeconGel® 1108. Preliminary testing revealed that the DeconGel® 1108 could spread out evenly across the surface. The glass plate interfered with the drying process, and early removal of the plate disrupted the DeconGel® 1108 coverage. As a result, the cover plate was not used.

Based on manufacturer's recommendations, DeconGel® 1108 was expected to dry within 24 h; however, testing revealed that the DeconGel® 1108 was not completely dry within this time. Since DeconGel® 1108 was formulated to sorb agent into the gel, wet DeconGel® 1108 left behind after peeling would be collected by wipe sampling and coupon extraction, resulting in inaccurate measurement of decontamination efficacy. To insure adequate drying of DeconGel® 1108, the drying time was increased from one to three days.

The sealant/sandstone test process was modified following wipe demonstration testing. Based on low recoveries of the positive controls and the extended agent-material contact time for decontamination efficacy testing, sealant/sandstone recoveries for decontamination efficacy testing were expected to be lower with agent potentially not detected. As a result, the agent spike amount on the coupon was increased from 10 µL to 50 µL for sealant/sandstone. Also, wipe collection from sealant/sandstone yielded less than 0.2% recovery for both agents, and wipe samples were difficult to collect on the rough surface. Thus, wipe samples were not collected during decontamination efficacy testing.

# 4. RESULTS AND DISCUSSION

## 4.1 Test Conditions

### *4.1.1 Environmental Conditions during Agent-Material Contact*

Temperature and humidity were tightly controlled during the agent-material contact period. Typical tolerances for agent decontamination efficacy testing under controlled conditions were ±3 °C. Temperature and relative humidity were monitored inside the storage containers during agent-material contact time using data loggers recording at one-minute intervals. Temperatures and humidity ranges were combined from multiple containers according to coupon type and are presented in Table 16. All temperatures were 22 ± 2 °C. Percent relative humidity was within the range of 56 ± 5%, with the exception of the ceramic coupons. The high humidity observed for ceramic coupons was attributed to moisture sorbed during the cleaning process. There were no visible signs of moisture on the ceramic coupons during the spiking process. For HD ceramic containers, the humidity had not reached the equilibrium at the end of the four-h agent-material contact period for most containers. The sorbed water in the ceramic coupons could have affected agent penetration. Relative humidity readings for all other coupons were consistent with laboratory ambient conditions.

***Table 16: Temperature and Relative Humidity Range during Agent-Material Contact***

| Coupon Type | HD | | VX | |
|---|---|---|---|---|
| | Temperature (°C) | Relative Humidity (%) | Temperature (°C) | Relative Humidity (%) |
| Glass | 21.5 – 23.5 | 53 – 61 | 20.0 – 24.5 | 52 – 60 |
| Ceramic | 21.5 – 23.0 | 53 – 95 | 20.0 – 23.5 | 52 – 98 |
| Rubber | 21.0 – 23.0 | 53 – 58 | 20.0 – 24.0 | 52 – 61 |
| Sealant | 21.0 – 22.5 | 53 – 61 | 20.0 – 23.5 | 52 – 59 |

### *4.1.2 Agent-Material Contact Time*

The agent-material contact time is the duration between the agent spiking event and application of the decontamination solution. Since decontamination solution was not applied to the positive control samples, the agent-material contact time for these samples extended to the coupon wipe collection and extraction event. The agent-material contact time was controlled for each replicate to reduce the likelihood of this parameter affecting variability in the results. The typical criterion is ±10% of the target time. The test time schedule was set up for a maximum deviation of the target time to be less than five minutes. This schedule was followed for all coupons except DeconGel® 1108 positive controls. Unexpected delays for removal of DeconGel® 1108 test replicates affected the extraction time of DeconGel® 1108 positive controls. This delay affected four positive control data sets: VX/sealant (20 min), HD/sealant (45 min), VX/rubber (30 min), and HD/rubber (56 min). While the deviation exceeds the five-minute target, the deviation between the actual time and the targeted time was less than 2%. In each of these cases, the range between replicates in the set was within five minutes. For all tests, the maximum range between replicates within a test set was eight minutes. Considering the agent-material contact time was between four h and 96 h, these deviations were insignificant and do not affect decontamination efficacy results.

### *4.1.3 Decontaminant/ Material Treatment Time*

The decontamination/material interaction time is the duration between the application of decontaminant and the coupon wipe collection and extraction event. For the spray decontaminant solutions (bleach, peroxide, and EasyDecon® DF-200), the interaction time was 60 minutes. For DeconGel®, the interaction

time was three days (4320 min). The typical criterion is ±10% of the target time. The test time schedule was setup for a maximum deviation of the target time to be less than three minutes with a maximum range of three minutes between test replicates. For the spray decontaminants, only the HD/glass/peroxide and HD/glass/EasyDecon® DF-200 exceeded the three-minute deviation between the actual and targeted time duration (five min). These values were within the standard ±10% of the target time. Several of the DeconGel® 1108 tests exceeded the targeted duration up to 38 min; however, over the duration of three days, this amounts to less than a 1% difference. The deviations between the targeted time and actual duration and the duration range between test replicates were insignificant and do not affect decontamination efficacy results.

### 4.1.4 Spray Decontaminant Application

The requirements for decontaminant delivery include the use of a sprayer that would not spray the decontaminant on the surface material with a force that could dislodge agent droplets from the surface material, that would evenly coat the coupon surface, and the decontaminant would saturate the surface. A number of sprayers were tested for qualification, and only one type met these requirements. A standardized application method was developed to apply the decontaminants to the materials consistently.

A typical criterion for decontaminant delivery is ±10% of the target amount. Based on calibration results, this criterion was not met for a number of tests conducted. Calibration results are shown in Table 4. The calibration results do not take overspray into account but provide an optimistic amount of decontaminant applied to the coupon surface. While the deviation of the decontaminant amount applied to the different test replicates could affect the sample results, this is probably irrelevant considering that the entire surface was saturated with decontaminant during application, and visual observations were noted after application.

### 4.1.5 DeconGel® 1108 Application

The DeconGel® 1108 application process changed significantly from original intentions. The approach initially included the use of a glass plate and weight to distribute the DeconGel® 1108 uniformly. Initial testing indicated that the glass plate and weight were not needed and interfered with the drying process. Furthermore, sides of the coupons had to be elevated to contain the DeconGel® 1108 on the surface (see Figure 8).

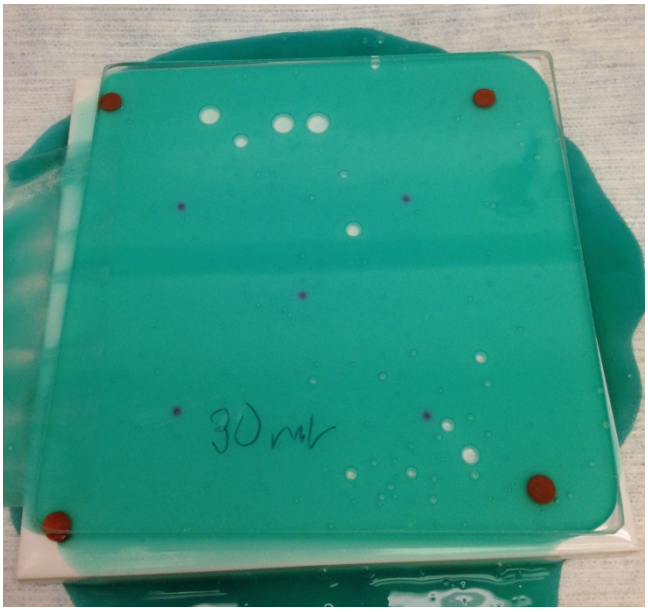


***Figure 8: DeconGel® 1108 applied to ceramic tile with glass plate covering***

Based on manufacturer's recommendations, the DeconGel® 1108 should be applied at 1/8-inch thickness (wet) and allowed to dry for approximately 24 h. Modifications to contain the DeconGel® 1108 on the

surface included adhesive tape on the side edges and underneath the coupon. Initial demonstrations indicated that these modifications would work, assuming adequate air flow across the coupon surface.

Decontamination efficacy testing was initially conducted with a 25-h drying/cure time. Most coupons recovered after 25 h after DeconGel® 1108 application were dry on the top surface but consistently tacky underneath. Coupons collected at 48 h were more cured and less tacky, while coupons collected at 72 h after application appeared to be completely cured/dry. DeconGel® 1108 efficacy was re-tested using a 72-hour cure time. For the DeconGel® 1108 efficacy testing (72-h), there were a few coupons that were still slightly tacky on the edges, but the film that contacted the surface directly over the agent deposition spot was dry. Photographs of DeconGel® 1108 with an initial application of 25 mL and after curing for 72 h are presented in Figure 9. The application of 25 mL yields a uniform thickness of 0.125 inch wet and less than 0.0625 inch dry.

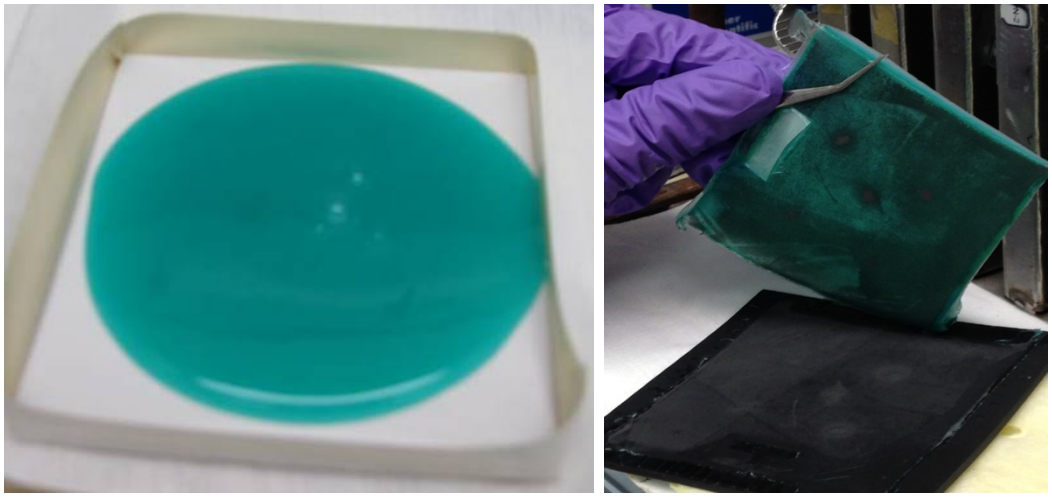

***Figure 9: DeconGel® 1108 initial application (left) and DeconGel® 1108 after 72-h cure (right)***

#### *4.1.6 Decontaminant Coverage*

Inconsistent decontaminant coverage over the coupon surface for bleach and peroxide after application was observed. Bleach, peroxide, and EasyDecon® DF-200 decontaminant solutions were all aqueous-based. During application of bleach and peroxide, the decontaminant coverage was relatively uniform and consistent. However, immediately after application, the decontamination solution migrates and collects in spots resulting in uneven and inconsistent coverage. Conversely, EasyDecon® DF-200 contains a surfactant that breaks the surface tension and keeps the decontaminant evenly spread across the surface. An example is shown in Figure 10, where bleach was applied to rubber coupons (left) and EasyDecon® DF-200 (right).

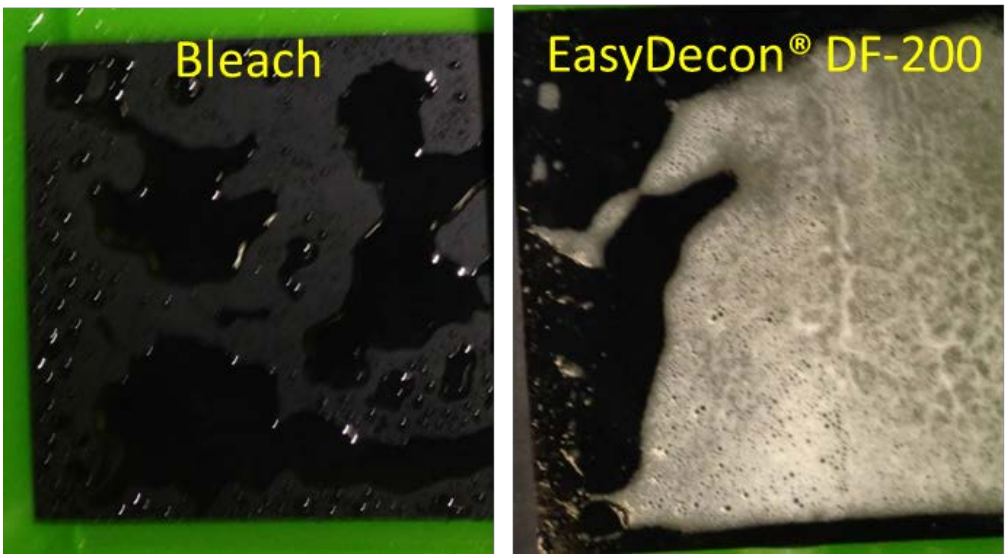


***Figure 10: Decontaminant applied to rubber coupon***

This phenomenon was observed for all coupons with bleach and peroxide applied. Significant differences can occur with replicate coupons depending on whether the decontaminant collects over the agent deposition spots on the surface. Since the active ingredient in EasyDecon® DF-200 is peroxide, it can be inferred that the differences in effectiveness between EasyDecon® DF-200 and peroxide solution are due to the uniformity of the application. The peroxide content in the EasyDecon® DF-200 applied formulation was 4%, and the peroxide content in the USP solution was 3%.

## 4.2 Test Results -- Decontamination Efficacy

Coupon recovery and decontamination efficacy results are presented in Appendices C and D. A summary of the efficacy results is presented in Table 17. Two efficacy calculations are presented for the evaluation of DeconGel® 1108: a) one calculation based on the spray positive control values, and b) one calculation based on the DeconGel® 1108 positive control values. The difference in the two types of positive controls is the agent-material contact time. The DeconGel® 1108 positive controls are more appropriate for mimicking sorption/penetration into the material surface. Assuming the low recovery for the HD positive controls was the result of evaporation, the spray positive controls may be more representative because the application of DeconGel® 1108 would prevent evaporation from the surface.

***Table 17: Decontamination Efficacy Results***

| Agent | Decontamination Type | Glass (%) | Ceramic (%) | Sealant (%) | Rubber (%) |
|---|---|---|---|---|---|
| VX | Spray Control (24 h) | | | | |
| | Bleach | 99.996 | 99 | 88 | 15 |
| | Peroxide | 96 | 96 | 50 | 13 |
| | Easy Decon® | 99.995 | 99.992 | 71 | 8 |
| | DeconGel® | 99.9 | 99.7 | 62 | 74 |
| | Gel Control (96 h) | | | | |
| | DeconGel® | 99.9 | 99.7 | 32 | 70 |
| HD | Spray Control (5 h) | | | | |
| | Bleach | 99.992 | 99.97 | 98 | 65 |
| | Peroxide | 43 | 76 | 39 | 35 |
| | Easy Decon® | 99 | 97 | 64 | 52 |
| | DeconGel® | 97 | 78 | 99.998 | 75 |
| | Gel Control (76 h) | | | | |
| | DeconGel® | ND | ND | 99.98 | 75 |

Percent of agent decontaminated was based on agent recovered from both wipe and coupon extracts. Significant digits are based on calculated standard deviation which is in the order of the last digit. Decontamination efficacy calculations for DeconGel® 1108 were presented using both control types. ND = not determined; positive control recoveries were too low to calculate a meaningful decontamination efficacy

The efficacy results are based on a scale from 0 to 100, where 100 is complete decontamination of the chemical agent, and 0 is no decontamination of the chemical agent. Overall, the bleach performed best, and 3% peroxide performed worst over the range of materials tested, with the exception of rubber. Note, the efficacy values are normalized to collection efficiency to allow a direct comparison of the decontaminants for each material. For example, the bleach/sealant HD efficacy results suggest that 98% of the HD was decontaminated. However, only 27% of the HD spiked onto the positive controls was recovered, leaving 73% unaccounted for and possibly still sorbed in the sealant/sandstone coupon.

Efficacy results varied among the materials. The glass material was used as a nonporous reference material for comparison purposes. Generally, the decontaminants performed best on glass. The glazed ceramic coupon also performed reasonably well; however, sorbed moisture may have affected efficacy results. For both glass and ceramic, efficacy results calculated using only wipe results and results using combined wipe and coupon extracts were approximately the same, indicating little penetration. Wipe sampling was not used for the sealant/sandstone coupons because of poor performance during method demonstration. Whether the low agent collection efficiency for the sealant/sandstone coupons (< 30%) was the result of sorbed agent that was not recovered or decontamination by the surface is unknown. This issue should be addressed in future studies. There were significant differences in the efficacy results for the wipe extracts and for the combined extracts. Wipe efficacy results for the rubber indicated greater than 90% destruction of agent, while the combined results indicated significantly less. Results clearly indicate that the agent was sorbed into the material and partially protected from surface decontamination.

The decontaminant test replicates showed a number of anomalies. For example, the HD-contaminated ceramic coupons treated with bleach yielded nondetects for four of the five test replicates. For the one detection, HD was not detected in the wipe extract but 0.2% or 22 µg was detected from the coupon extract. Other examples show that the variations for the coupon replicates were high. The cause for the anomalies was not determined; however, the nonuniform treatment of the surface discussed in Section 4.6

and the imperfections of the surface could affect agent sorption and to some degree protect agent from the decontaminant solution.

## 4.3 Toxic Compounds Detected from the Treated Coupons

In addition to determining decontamination efficacy, extracts were assayed in the survey mode. The GC x GC/TOFMS and LC/qTOF qualitative survey results are summarized here. Reported detections focused on compounds related to HD and VX. Given the large number of signals detected, 20% of the sample set was screened to generate a list of target compounds. The entire sample set was re-processed from the target list using the retention time and mass spectrum of the identified compounds. The GC x GC/TOFMS detections were based on NIST library matches and reviewed manually. Ten unknown but HD-related peaks were found. Likewise, four unknown VX-related peaks were found. Concentrations of tentatively identified compounds were estimated using the internal standard naphthalene- $D_8$. Specific compounds of interest related to HD include: bis(2-chloroethyl) sulfone, bis(2-chloroethyl) sulfoxide, and divinyl sulfone. Note that HD is not a single pure component – some of these compounds could be decomposition products of HD, not compounds resulting from reaction with a decontaminant [2].

A compound of interest related to VX is the toxic O-Ethyl S-vinyl methyl phosphonothioate [2]; note two separate peaks were identified by library searching to match this compound. Presumably one of these compounds is the exact structure and the other is a similar compound (e.g., isomer yielding a similar mass spectral pattern). By LC/qTOF, several additional compounds were detected. Their exact masses suggest elemental compositions consistent with diisopropyl amine and O-ethyl O-[2-(diisopropylamino) ethyl] methyl phosphonate (retention times not verified). Another unknown compound was also detected with an elemental composition ($C_8H_{20}NO_2PS$) consistent with that of VX ($C_{11}H_{26}NO_2PS$) minus $C_2H_6$ (net).

EA-2192 was screened by LC/qTOF during VX-targeted analysis and was not detected. This toxic compound is formed from VX hydrolysis under neutral to basic conditions and was expected to be present. The EA-2192, a water-soluble compound, most likely partitioned to the aqueous portion of the biphasic extraction media, which were discarded/not analyzed.

# 5. CONCLUSIONS

The objectives for this study included developing a laboratory wipe method to determine residual agent on the surface, demonstrating method performance, and providing efficacies for four decontaminants on porous and nonporous surfaces.

A laboratory wipe method was developed using a microfiber cloth wetted with isopropyl alcohol to sample surfaces for residual VX and HD. The microfiber cloth was extracted with a biphasic (dichloromethane and pH buffer) solution to quench residual decontaminant and determine the mass of VX and HD collected. The method was evaluated to verify agent stability in the extracts and to demonstrate collection and extraction efficiency. Results indicated that the agent was stable in the extracts for over four days for VX and nine days for HD, the collection efficiency was over 50% for glass and ceramic, and average extraction efficiencies were greater than 95% and less than 15% RSD. Collection efficiencies were low for the more porous materials (rubber and sealant/sandstone). The sealant/sandstone surface was rough, making it difficult to collect wipe samples, and collection efficiency was less than 0.2%. Based on observations during wipe method demonstration testing, adjustments were made for decontamination efficacy testing to include: not collecting wipe samples for sealant/sandstone coupons and increasing the amount of agent added to the sealant/sandstone coupons.

Four commercially available chemical agent decontaminants (household bleach, household peroxide, EasyDecon® DF-200, and DeconGel® 1108) were evaluated for effectiveness on four test surfaces (glass, ceramic tile, concrete sealant, and rubber base molding) typically found in public areas. Generally, full strength bleach performed better than the other decontaminants; however, it is difficult to compare DeconGel® 1108 to the other decontaminants due to (over three days) natural attenuation of the associated positive controls. Household (3%) peroxide showed the lowest destruction efficiency. EasyDecon® DF-200, which consists of peroxide and a surfactant, performed better than household peroxide.

# 6. REFERENCES

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[2] Munro, N.B., Talmage, S.S., Griffin, G.D., Waters, L.C., Watson, A.P., King, J.F., and Hauschild, V. 1999. The Sources, Fate, and Toxicity of Chemical Warfare Agent Degradation Products. Environmental Health Perspectives 107, 12, 933-974

# 7. APPENDICES

Appendix A – Wipe Method Development and Demonstration

Appendix B – Summary of Wipe Method QC

Appendix C – Summary of QC Recovery Standards

Appendix D – Summary of Test Results

# Appendix A –Wipe Method Development and Demonstration

The wipe method was optimized in three steps: wipe comparison tests, solvent system tests, and decontaminant neutralization tests.

**Wipe Comparison**:

The wipe comparison tests were conducted to investigate performance of three wipe materials: microfiber cloth (Anypromo, Chino, California), cotton gauze (Dukal Corporation, sterile: Hauppauge, New York, Lot# A17610 27), and polyester cotton blend (Fruit of the Loom). The tests were conducted by spiking simulants chloroethyl ethyl sulfide (CEES) (Sigma Aldrich, St. Louis, Missouri, Lot # 02314JJ) for HD and diethyl ethylthiophosphonate (DEETP) (SwRI, San Antonio, Texas) for VX onto glass coupons and wiping the glass coupons using the wipe materials. In both cases, the surrogates were more volatile than the actual agents. The test was conducted by spiking 10 µL of CEES and DEETP onto a 4 inch x 4 inch glass coupon. The surface was then covered using a Petri dish for ten minutes. The wipe material was wetted with 0.5 mL of either acetone or isopropyl alcohol. The glass coupon was uncovered and wiped using the wetted wipe material. The wipe was placed into a 40 mL VOA vial and extracted with 20 mL of chloroform (Fisher Scientific, Houston, Texas). The sample was mixed for 15 minutes, and the solvent remained in contact for at least an hour prior to removing an aliquot for analysis by GC/MS.

Laboratory control spikes (LCSs) were prepared by spiking 10 µL of CEES and DEETP directly onto the wipe material. The wipe material was placed into the VOA vial prior to spiking CEES and DEETP and was not wetted with acetone or isopropyl alcohol. After spiking the wipe material, the VOA vials were covered for ten minutes to allow CEES and DEETP to soak into the wipe material before 20 mL of chloroform was added. Control blank wipes were prepared by wetting the wipe material with solvent (isopropyl alcohol or acetone) and wiping a clean (not spiked with CEES or DEETP) glass plate.

**Wipe Comparison Results**

The LCS results were used to determine the wipe extraction efficiency. Results are shown in Table A1. The expected recovery from 10 µL of CEES and DEETP spiked directly onto the wipe materials is 10.4 mg and 10.1 mg, based on density and purity. Recovery results were all within ± 5% of the target amount with the exception of CEES on the cotton/polyester material that yielded ~80% recovery. Based on calibration verification standards and recovery standards assayed, the 80% recovery was probably due to CEES calibration drift.

| *Table A1: Wipe Extraction Efficiency* | | | | | | |
|---|---|---|---|---|---|---|
| Sample Name | Microfiber Cloth | | Cotton Gauze | | Cotton/Polyester | |
| | CEES (mg) | DEETP (mg) | CEES (mg) | DEETP (mg) | CEES (mg) | DEETP (mg) |
| LCS-R1 | 9.85 | 10.36 | 9.32 | 9.53 | 9.00 | 10.17 |
| LCS-R2 | 9.94 | 10.17 | 10.00 | 10.11 | 8.15 | 10.53 |
| LCS-R3 | 9.51 | 10.25 | 9.86 | 10.04 | 7.69 | 10.37 |
| **Average** | 9.76 | 10.26 | 9.73 | 9.89 | 8.28 | 10.36 |
| | **Recovery (%)** | | | | | |
| | **94** | **102** | **94** | **98** | **80** | **103** |
| **%RSD** | **2%** | **1%** | **4%** | **3%** | **8%** | **2%** |

Wipe collection efficiency results are shown in Tables A2 and A3. Using isopropyl alcohol as the wetting solvent, CEES recovery ranged between 14 to 58% (calculations not shown in the tables) with high variability between replicates. The low recoveries and high variability are probably due to the volatility of CEES. DEETP recovery ranged between 41 and 101% with relatively low variability, with the exception of the first replicate for cotton gauze. Based on duplicate analytical injections for all three cotton gauze replicates, the variability was not associated with instrumental analysis. Using acetone as the wetting solvent, CEES recovery ranged between 21 to 43% with high variability between replicates. The low recoveries and high variability are probably due to the volatility of CEES. DEETP recovery ranged between 76 and 105% with relatively low variability.

| *Table A2: Wipe Collection Efficiency using 0.5 mL Isopropyl Alcohol* | | | | | | |
|---|---|---|---|---|---|---|
| Sample Name | Microfiber Cloth | | Cotton Gauze | | Cotton/Polyester | |
| | CEES (mg) | DEETP (mg) | CEES (mg) | DEETP (mg) | CEES (mg) | DEETP (mg) |
| Wipe Blank | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Wipe Replicate #1 | 6.17 | 10.01 | 1.47 | 4.21 | 3.29 | 9.38 |
| Wipe Replicate #2 | 4.88 | 9.64 | 2.44 | 8.12 | 3.64 | 10.21 |
| Wipe Replicate #3 | 4.15 | 9.06 | 2.22 | 7.55 | 3.17 | 9.35 |
| **Average** | **5.07** | **9.57** | **2.04** | **6.63** | **3.37** | **9.64** |
| **%RSD** | **20%** | **5%** | **25%** | **32%** | **7%** | **5%** |

| *Table A3: Wipe Collection Efficiency using 0.5 mL Acetone* | | | | | | |
|---|---|---|---|---|---|---|
| Sample Name | Microfiber Cloth | | Cotton Gauze | | Cotton/Polyester | |
| | CEES (mg) | DEETP (mg) | CEES (mg) | DEETP (mg) | CEES (mg) | DEETP (mg) |
| Wipe Blank | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Wipe Replicate #1 | 4.45 | 9.87 | 2.89 | 8.46 | 4.28 | 10.61 |
| Wipe Replicate #2 | 4.14 | 9.90 | 2.71 | 7.74 | 3.44 | 9.56 |
| Wipe Replicate #3 | 2.49 | 8.83 | 3.41 | 8.26 | 2.19 | 9.08 |
| **Average** | **3.69** | **9.53** | **3.00** | **8.15** | **3.30** | **9.75** |
| **%RSD** | **29%** | **6%** | **12%** | **5%** | **32%** | **8%** |

The wipe collection efficiency results showed high variability. The high variability is mostly associated with CEES, which is a volatile organic compound. DEETP, which is less volatile, had less than 10% RSD for most replicates. For the acetone-wetted wipes, there was not a significant difference in the CEES results for the three materials. The acetone-wetted microfiber cloth and cotton polyester materials were equivalent for DEETP, while the cotton gauze yielded lower recoveries. For the isopropyl alcohol-wetted wipes, the microfiber cloth showed higher recoveries for CEES than the other two materials. DEETP recovery from the isopropyl alcohol-wetted microfiber cloth was not significantly different from the cotton polyester material but was higher than the cotton gauze.

Based on the collection efficiency results, the microfiber cloth using isopropyl alcohol as the wetting solvent was carried forward for wipe method optimization and decontamination efficacy testing. The amount of isopropyl alcohol used was increased to 1.0 mL in effort to improve collection efficiency.

**Solvent System Tests**:

The purpose of this test was to determine an appropriate solvent extraction volume and verify that the solvent used to extract agent from the wipe yields acceptable results. This test compared extraction results of two solvent volumes and three spike amounts for both VX and HD spiked directly onto 2 inch x 3 inch white microfiber cloth wipes. The extraction solvent used was a biphasic solution containing 1:1 dichloromethane and deionized water. The two extraction volumes compared were 10 and 20 mL. The spike ranges tested were:

- HD (10 mL) – 0.050 to 2.5 µg
- HD (20 mL) – 0.10 to 5.0 µg
- VX (10 mL) – 0.025 to 1.25 µg
- VX (20 mL) - 0.050 to 2.5 µg

White microfiber cloth wipes were folded in half and placed into 20 mL VOA vials. Agent (HD or VX) diluted in isopropyl alcohol was spiked directly onto the wipe material. The sample was held for 10 min to allow the solvent to evaporate prior to extracting the samples. The sample was extracted with a 1:1 ratio of dichloromethane and deionized water. For HD extracts, the aqueous solution consisted of distilled water. For VX extracts, the aqueous solution consisted of pH 10

buffer (Fisher Scientific, Houston, Texas) to ensure that the VX partitioned into the organic phase. The samples were vortexed for 30 seconds and then allowed to sit for at least 30 minutes before removing the organic fraction and filtering through 0.45 µm nylon filter.

**Solvent System Test Results**:

HD test results are presented in Tables A4 thru A5.

| *Table A4: HD Results for 5 mL Dichloromethane (DCM) Extraction Volume* | | | |
|---|---|---|---|
| | Spike Amount (50 ng) | Spike Amount (500 ng) | Spike Amount (2500 ng) |
| Rep 1 | 53.6 | 485 | 2990 |
| Rep 2 | 61.6 | 491 | 2760 |
| Rep 3 | 60.8 | 515 | 2720 |
| Avg. (ng) | 58.7 | 497 | 2820 |
| **Avg (% Rec)** | **117%** | **99.4%** | **113%** |
| SD | 4.41 | 15.5 | 146 |
| %RSD | 7.5% | 3.2% | 5.1% |

| *Table A5: HD Results for 10 mL DCM Extraction Volume* | | | |
|---|---|---|---|
| | Spike Amount (100 ng) | Spike Amount (1,000 ng) | Spike Amount (5,000 ng) |
| Rep 1 | 103 | 830 | 5430 |
| Rep 2 | 129 | 942 | 5880 |
| Rep 3 | 128 | 913 | 5300 |
| Avg. (ng) | 120 | 895 | 5540 |
| **Avg (% Rec)** | **120%** | **89.5%** | **111%** |
| SD | 14.9 | 58.1 | 304 |
| %RSD | 12% | 6.5% | 5.5% |

VX results are presented in Tables A6 and A7.

| *Table A6: VX Results for 5 mL DCM Extraction Volume* | | | |
|---|---|---|---|
| | Spike Amount (25 ng) | Spike Amount (250 ng) | Spike Amount (1250 ng) |
| Rep 1 | 23.5 | 232 | 1620 |
| Rep 2 | 27.2 | 220 | 1620 |
| Rep 3 | 23.7 | 222 | 1650 |
| Avg. (ng) | 24.8 | 225 | 1630 |
| **Avg (% Rec)** | **99.3%** | **90.0%** | **130%** |
| SD | 2.08 | 6.42 | 17.3 |
| %RSD | 8.4% | 2.8% | 1.1% |

| *Table A7: VX Results for 10 mL DCM Extraction Volume* | | | |
|---|---|---|---|
| | Spike Amount (50 ng) | Spike Amount (500 ng) | Spike Amount (2500 ng) |
| Rep 1 | 42.8 | 478 | 2690 |
| Rep 2 | 47.6 | 508 | 3360 |
| Rep 3 | 45.8 | 451 | 5480* |
| Avg. (ng) | 45.4 | 479 | 3840 |
| **Avg (% Rec)** | **90.8%** | **95.8%** | **154%** |
| SD | 2.42 | 28.7 | 1460 |
| %RSD | 5.5% | 5.9% | 38% |
| *- Suspect that the sample was double spiked | | | |

Acceptance criteria for this testing sequence included average percent recovery of 100 ± 35% and percent relative standard deviation less than 25%. This criterion was met for all tests with the exception of the VX (2500 ng, 10 mL) replicates, which failed for both recovery and variability. In this set, one of the replicates appeared to be double spiked (> 200% recovery).

The preference was to use the smaller extraction volumes to lower detection limits, minimize generated waste, and minimize extract storage space. Since the criterion was met using 5 mL dichloromethane (10 mL or 1:1 dichloromethane:aqueous solution) extraction volume for both VX and HD extractions, the wipe extraction solvent parameters for decontaminant neutralization testing used 5 mL of dichloromethane. The solvent volume was sufficient to cover the wipe.

**Decontaminant Neutralization tests**

The decontaminant neutralization tests were conducted to investigate additives for neutralizing residual decontaminant solution that may have been collected during the wiping process. The three decontamination solutions tested were bleach (The Clorox® Company, Oakland, CA, Lot# A5:5101TX-1), 3% peroxide ((HEB-brand, obtained from HEB Grocery stores in San Antonio, Texas, Lot# 10014877BA), and EasyDecon® (EFT Holdings, Inc., Lafayette, Colorado). EasyDecon® consists of peroxide and an amine surfactant. Tests were conducted by spiking VX and HD into 10 mL of 1:1 dichloromethane:aqueous solvent system and 0.5 mL of decontaminant solution. VX and HD recovery performance was compared from triplicate extract solutions with and without neutralizing additives. Test results indicated that sodium thiosulfate (Sigma Aldrich, St. Louis, Missouri, Lot # MKBS3720V) was effective for preserving agent in the presence of bleach, and additives were not necessary for 3% peroxide. The amine surfactant in EasyDecon® was basic (pH 10) and negatively affected HD performance. Based on this information, the aqueous portion of the extraction solvent system was set as follows:

- VX: pH 10 buffer (0.5 molar (M) carbonate buffer and 1.25 M sodium thiosulfate)
- HD: pH 5 buffer (1.0 M acetate buffer and 1.25 M sodium thiosulfate)

All three decontamination solutions were tested in triplicate for each agent using the aqueous buffer. Results are presented in Table A8.

| *Table A8: Verification of Agent Preservation in the Wipe Extracts* | | | | |
|---|---|---|---|---|
| **Decontaminant** | **HD** | | **VX** | |
| | **Average Recovery** | **%RSD** | **Average Recovery** | **%RSD** |
| **Bleach** | 74% | 8.8% | 100% | 5.5% |
| **Peroxide** | 89% | 1.2% | 97% | 4.7% |
| **EasyDecon®** | 96% | 3.6% | 89% | 4.0% |

### Wipe Method Demonstration Test Results

The wipe method demonstration was performed to validate the optimized wipe method, determine analytical performance for each surface material and decontamination solution combination, and verify processes under tightly timed constraints as a prelude to decontamination efficacy testing. The wipe demonstration test matrix is presented in Table A9.

| *Table A9: Wipe Demonstration Test Matrix* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Agent** | **Decontaminant** | **Agent-Material Contact Time** | **Treatment Time** | **# of Coupon Replicates** | | | |
| | | | | **Glass** | **Ceramic** | **Sealant** | **Rubber** |
| VX | Control | 1 h | -- | 1-SB\|3-PC | 1-SB\|3-PC | 1-SB\|3-PC | 1-SB\|3-PC |
| | Bleach | 1 h | 15 min | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR |
| | Peroxide | 1 h | 15 min | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR |
| | Easy Decon | 1 h | 15 min | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR |
| HD | Control | 1 h | -- | 1-SB\|3-PC | 1-SB\|3-PC | 1-SB\|3-PC | 1-SB\|3-PC |
| | Bleach | 1 h | 15 min | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR |
| | Peroxide | 1 h | 15 min | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR |
| | Easy Decon | 1 h | 15 min | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR | 1-PB\|3-TR |
| SB and PB coupons were not spiked. All other coupons were spiked with 10 µL of agent (5 x 2 µL). For each agent/material set, four wipe control samples were prepared (1 wipe method blank and three LCSs). | | | | | | | |

Liquid agent (VX, lot# VX-U-5251-CTF-N, 98.5% purity; HD, lot# HD-U-5032-CTF-N, 98% purity) was applied to the coupons using a Hamilton 1700 Series Gastight Syringe (Model 80920-50 uL; Hamilton Robotics, Reno, Nevada) affixed to a Hamilton Repeating dispenser (Model 8370-PB600). The test process was started by spiking 10 µL of agent (five x 2 µL) using a 50 µL Hamilton 1700 Series Gastight syringe (Model 80920-50 µL) affixed to a Hamilton Repeating dispenser (Model 8370-PB600). After the coupons were spiked with agent, the container lid was closed for 60 min. Once the 60-min agent-material contact time had elapsed, the test coupons were treated with decontaminant solutions (bleach, 3% peroxide, and EasyDecon® DF-200). The positive control coupons were not treated, but wiped and extracted after the 60-min agent-material contact time had elapsed. The decontaminant solution was applied to the coupons using a glass oil mister (Prepara Kitchen Tools, New York, New York) and remained in contact for 15 min. At the end of the treatment period, test coupons were turned onto

their side to drain residual decontamination solution to waste. Coupons were wiped, extracted, and assayed.

Agent preservation was demonstrated by assaying the extracts twice. The intention was to assay extracts immediately after extraction (day 0) and on day 3; however, scheduling conflicts resulted in the second analysis being assayed on day 4 for VX and day 9 for HD. Wipe collection efficiency was determined from glass positive control results. Extraction efficiency was determined from LCS samples from each set.

**Wipe Method Demonstration Tests:**

Overall, the optimized wipe method performed well and met test objectives:

- Preservation of agent in the extracts;
- High extraction efficiency and precision;
- High collection efficiency and precision; and
- Verify decontamination efficacy testing process.

Agent preservation in the extract was demonstrated by assaying the extracts two times. The requirement to discern agent decomposition was an interval of three days. To ensure that the first analysis was assayed on day 0, the interval between the analyses was extended to four days for VX and nine days for HD. Even with the extended time, there was less than 30% difference between the two analyses for the treated replicates. Based on the data collected from the two analyses, the biggest concern is the observed increase in concentration for the second analysis. The average increase in concentration for HD was 18% and for VX was 7%. The increase in concentration demonstrates that the agent is adequately preserved in the extracts.

Extraction efficiency of the wipes was demonstrated via LCSs analyzed in triplicate each day. All replicates had recoveries between 75% and 125%, and precision was less than 20% RSD for all of the replicates.

Collection efficiency was demonstrated via agent-spiked coupons not decontaminated (positive control samples). Results varied based on coupon material. Window glass and ceramic tile met performance criteria, while the sealant and rubber failed to meet performance criteria. In many decontamination efficacy tests, glass and/or stainless steel are used as controls for determining process performance. Following the same standard, results from the glass material met collection efficiency and precision performance objectives. Average HD and VX recoveries were over 90% with %RSDs less than 20%. Although the agent recovery was lower than observed on glass, glazed ceramic material also met collection efficiency and precision performance objectives for both agents (HD 64%/5% RSD: VX 81%/15% RSD). Based on LCS information collected the same day, the lower recovery is directly related to the coupon material, not the wipe method.

The sealant, Sure Klean® Siloxane PD, applied to sandstone coupons in two separate coats failed agent recovery criteria. Less than 0.2% of the agent was recovered by the wipe method and less than 30% was recovered by coupon extraction. There was a deviation with the wipe collection method for this surface. Wiping the coupon was similar to wiping sandpaper. As a result, the operator had to abandon the back and forth motion and resorted to pulling the wipe across the coupon in each direction. Despite the difficulties with wiping the material, the poor recovery appears to be associated more with agent penetration into the porous material as evidenced by good recovery of wipe LCS samples and by 20-30% agent recovered from the coupon

extractions. Observations during agent spiking documented that the agent soaked into the material immediately. Pictures of the sandstone/sealant tile immediately after spiking agent and after the fifteen min decontamination application time are presented in Figure A1.

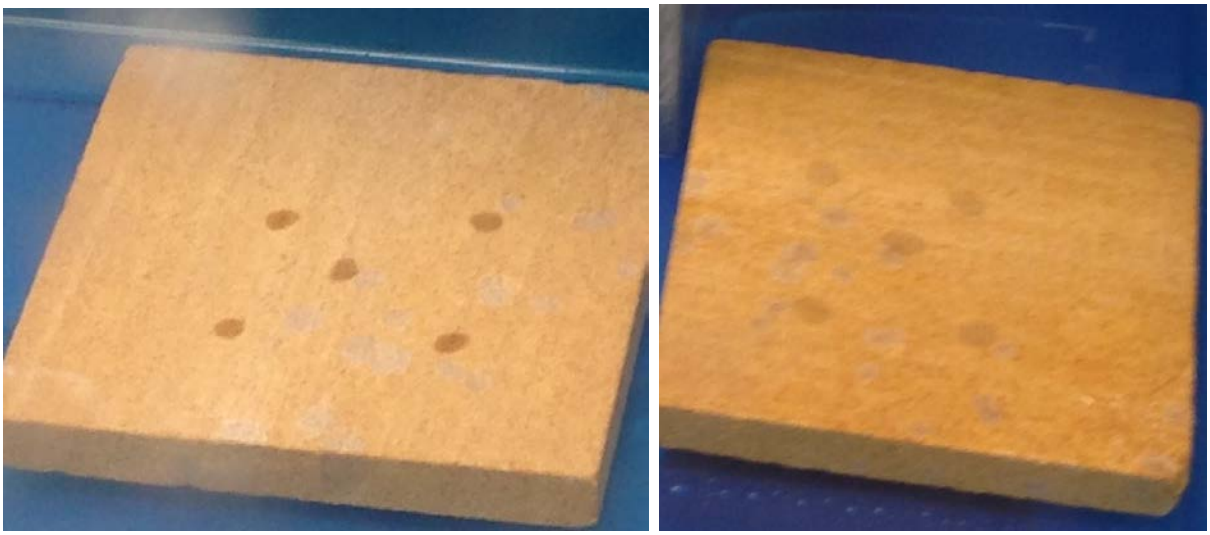

***Figure A1: Sealant coupon after agent spike (left), after decontaminant application (right)***

The rubber material failed agent recovery criteria. For HD, the average wipe recovery was 36% with a 15% RSD. Adding the results of the coupon extraction, the total HD recovery was 77% with a 7% RSD. For VX, the average wipe recovery was 40% with an 82% RSD. Adding the results of the coupon extraction, the total VX recovery was 59% with a 54% RSD. The low recovery and high variability are associated with the first wipe replicate. While this point does not pass an outlier test, it significantly affects the precision and is the difference for these data meeting criteria. Extraction notes indicated that there were phase separation issues associated with the rubber extracts, which offers one possible explanation. Pictures of the rubber filtered extracts are presented in Figure A2

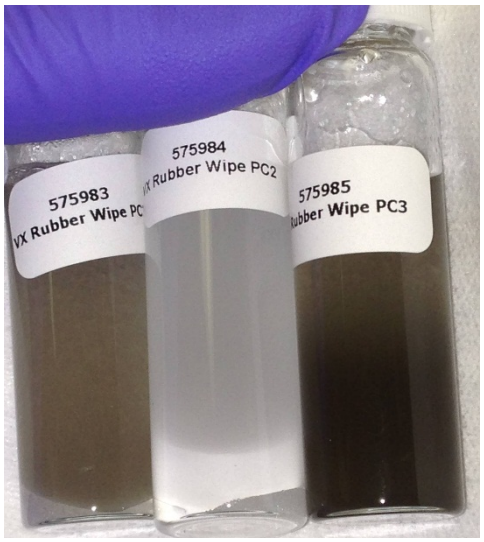

***Figure A2: Rubber filtered extracts***

The wipe and coupon extraction results for the rubber suggest that intermediate agent penetration occurs into the material. While the results do not meet test requirements, the deficiencies are related to the porosity of the material and not the method. This observation is supported by the wipe LCS samples collected that day indicating good extraction efficiency, and 20-40% of the agent was recovered from the coupon extractions.

In conclusion, performance issues were not associated with the wipe method but with the coupon material. The performance of all wipe LCSs demonstrated good extraction efficiency; the performance of the standardized material, glass, demonstrated good collection efficiency; and the consistency between the duplicate analyses demonstration good agent preservation. There were some issues associated with the rubber extracts. Examples included phase separation of the filtered extracts and chromatography issues associated with HD GC/MS analysis. The phase separation issues were addressed by additional filtration and using a centrifuge. The chromatographic issues included poor HD peak shape, noisy baseline, and poor response for calibration standards. Resolving these chromatographic issues resulted in delays for assaying the $2^{nd}$ analyses for the other materials. Also, only one set of data was collected for the HD rubber extracts and was analyzed almost two weeks after sample collection. These issues were resolved by diluting the extracts by a factor of 10, which affected the reporting limit.

# Appendix B – Summary of Wipe Method QC

| *Table B1: Summary of HD Wipe Method Blanks* | | | |
|---|---|---|---|
| **Wipe Controls** | **ID#** | **Spike Amount (ng)** | **Found (ng)** |
| Wipe Blk-1 (Glass) | 578545 | -- | <15 U |
| Wipe Blk-2 (Glass) | 578546 | -- | <15 U |
| Wipe Blk-1 (Ceramic) | 578706 | -- | <15 U |
| Wipe Blk-2 (Ceramic) | 578707 | -- | <15 U |
| Wipe Blk-1 (Rubber) | 578867 | -- | <150 U |
| Wipe Blk-2 (Rubber) | 578868 | -- | <150 U |
| Wipe Blk-1 (DeconGel®) | 584219 | -- | <15 U |
| Wipe Blk-2 (DeconGel®) | 584220 | -- | <15 U |
| U – HD not detected; value reported is the detection limit | | | |

| *Table B2: Summary of HD Laboratory Control Spikes* | | | | |
|---|---|---|---|---|
| **Wipe Controls** | **ID#** | **Spike Amount (ng)** | **Found (ng)** | **% Recovery** |
| LCS 1 (Glass) | 578542 | $2.5x10^3$ | $2.7x10^3$ | 110% |
| LCS 2 (Glass) | 578543 | $2.5x10^3$ | $2.5x10^3$ | 100% |
| LCS 3 (Glass) | 578544 | $2.5x10^3$ | $2.7x10^3$ | 110% |
| LCS 1 (Ceramic) | 578708 | $2.5x10^3$ | $2.5x10^3$ | 100% |
| LCS 2 (Ceramic) | 578709 | $2.5x10^3$ | $2.7x10^3$ | 110% |
| LCS 3 (Ceramic) | 578710 | $2.5x10^3$ | $2.6x10^3$ | 100% |
| LCS 1 (Rubber) | 578864 | $2.5x10^3$ | $2.3x10^3$ | 92% |
| LCS 2 (Rubber) | 578865 | $2.5x10^3$ | $2.2x10^3$ | 88% |
| LCS 3 (Rubber) | 578866 | $2.5x10^3$ | $2.5x10^3$ | 100% |
| LCS 1 (DeconGel®) | 584221 | $2.5x10^3$ | $2.6x10^3$ | 100% |
| LCS 2 (DeconGel®) | 584222 | $2.5x10^3$ | $2.7x10^3$ | 110% |
| LCS 3 (DeconGel®) | 584223 | $2.5x10^3$ | $2.5x10^3$ | 100% |
| AVG | -- | -- | $2.5x10^3$ | 100% |
| %RSD | -- | -- | 6.4% | -- |

| *Table B3: Summary of VX Wipe Method Blanks* | | | |
|---|---|---|---|
| **Wipe Controls** | **ID#** | **Spike Amount (ng)** | **Found (ng)** |
| Wipe Blk-1 (Glass) | 578620 | -- | <10 U |
| Wipe Blk-2 (Glass) | 578621 | -- | <10 U |
| Wipe Blk-1 (Ceramic) | 578786 | -- | <10 U |
| Wipe Blk-2 (Ceramic) | 578787 | -- | <10 U |
| Wipe Blk-1 (Rubber) | 578949 | -- | <10 U |
| Wipe Blk-2 (Rubber) | 578950 | -- | <10 U |
| Wipe Blk-1 (DeconGel®) | 584454 | -- | <10 U |
| Wipe Blk-2 (DeconGel®) | 584455 | -- | <10 U |
| U – VX not detected; value reported is the detection limit | | | |

| *Table B4: Summary of VX Laboratory Control Spikes* | | | | |
|---|---|---|---|---|
| **Wipe Controls** | **ID#** | **Spike Amount (ng)** | **Found (ng)** | **% Recovery** |
| LCS 1 (Glass) | 578622 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 2 (Glass) | 578623 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 3 (Glass) | 578624 | $1.3x10^3$ | $1.3x10^3$ | 100% |
| LCS 1 (Ceramic) | 578788 | $1.3x10^3$ | $1.1x10^3$ | 85% |
| LCS 2 (Ceramic) | 578789 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 3 (Ceramic) | 578790 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 1 (Rubber) | 578946 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 2 (Rubber) | 578947 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 3 (Rubber) | 578948 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 1 (DeconGel®) | 584456 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 2 (DeconGel®) | 584457 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| LCS 3 (DeconGel®) | 584458 | $1.3x10^3$ | $1.2x10^3$ | 92% |
| AVG | -- | -- | 1,200 | 92% |
| %RSD | -- | -- | 3.5% | -- |

# Appendix C – Summary of QC Recovery Standard

Table C1: Summary of HD Recovery Standard Information

Table C2: Summary of VX Recovery Standard Information

| *Table C1: Summary of HD Recovery Standard Information* | | | | |
|---|---|---|---|---|
| **Recovery Standards** | **ID#** | **Spike Amount (ng)** | **Found (ng)** | **% Recovery** |
| RS-1 (Glass) | 578497 | $1.2x10^7$ | $1.2x10^7$ | 100% |
| RS-2 (Glass) | 578498 | $1.2x10^7$ | $1.1x10^7$ | 92% |
| RS-3 (Glass) | 578499 | $1.2x10^7$ | $1.1x10^7$ | 92% |
| AVG | -- | -- | $1.1x10^7$ | 94% |
| %RSD | -- | -- | 5.1% | |
| RS-1 (Ceramic) | 578625 | $1.2x10^7$ | $1.3x10^7$ | 110% |
| RS-2 (Ceramic) | 578626 | $1.2x10^7$ | $1.1x10^7$ | 92% |
| RS-3 (Ceramic) | 578627 | $1.2x10^7$ | $1.1x10^7$ | 92% |
| AVG | -- | -- | $1.2x10^7$ | 98% |
| %RSD | -- | -- | 12% | |
| RS-1 (Rubber) | 578791 | $1.2x10^7$ | $2.0x10^7$ | 170% |
| RS-2 (Rubber) | 578792 | $1.2x10^7$ | $1.8x10^7$ | 150% |
| RS-3 (Rubber) | 578793 | $1.2x10^7$ | $1.9x10^7$ | 160% |
| AVG | -- | -- | $1.9x10^7$ | 160% |
| %RSD | -- | -- | 5.3% | |
| RS-1 (Sealant) | 578970 | $6.2x10^7$ | $6.2x10^7$ | 100% |
| RS-2 (Sealant) | 578971 | $6.2x10^7$ | $4.8x10^7$ | 77% |
| RS-3 (Sealant) | 578972 | $6.2x10^7$ | $4.9x10^7$ | 79% |
| AVG | -- | -- | $5.3x10^7$ | 85% |
| %RSD | -- | -- | 15% | |
| RS-1 (DeconGel®) | 584216 | $1.2x10^7$ | $1.0x10^7$ | 83% |
| RS-2 (DeconGel®) | 584217 | $1.2x10^7$ | $1.1x10^7$ | 92% |
| RS-3 (DeconGel®) | 584218 | $1.2x10^7$ | $1.1x10^7$ | 92% |
| AVG | -- | -- | $1.1x10^7$ | 89% |
| %RSD | -- | -- | 5.4% | |

| *Table C2: Summary of VX Recovery Standard Information* | | | | |
|---|---|---|---|---|
| **Recovery Standards** | **ID#** | **Spike Amount (ng)** | **Found (ng)** | **% Recovery** |
| RS-1 (Glass) | 578547 | $9.9x10^6$ | $1.0x10^7$ | 100% |
| RS-2 (Glass) | 578548 | $9.9x10^6$ | $9.7x10^6$ | 98% |
| RS-3 (Glass) | 578549 | $9.9x10^6$ | $1.0x10^7$ | 100% |
| AVG | -- | -- | $9.9x10^6$ | 99% |
| %RSD | -- | -- | 1.7% | |
| RS-1 (Ceramic) | 578711 | $9.9x10^6$ | $1.0x10^7$ | 100% |
| RS-2 (Ceramic) | 578712 | $9.9x10^6$ | $9.5x10^6$ | 96% |
| RS-3 (Ceramic) | 578713 | $9.9x10^6$ | $9.0x10^6$ | 91% |
| AVG | -- | -- | $9.5x10^6$ | 96% |
| %RSD | -- | -- | 5.3% | |
| RS-1 (Rubber) | 578901 | $9.9x10^6$ | $1.0x10^7$ | 100% |
| RS-2 (Rubber) | 578902 | $9.9x10^6$ | $9.8x10^6$ | 99% |
| RS-3 (Rubber) | 578903 | $9.9x10^6$ | $1.1x10^7$ | 110% |
| AVG | -- | -- | $1.0x10^7$ | 100% |
| %RSD | -- | -- | 6.3% | |
| RS-1 (Sealant) | 579008 | $5.0x10^7$ | $6.8x10^7$ | 140% |
| RS-2 (Sealant) | 579009 | $5.0x10^7$ | $6.6x10^7$ | 130% |
| RS-3 (Sealant) | 579010 | $5.0x10^7$ | $7.4x10^7$ | 150% |
| AVG | -- | -- | $6.9x10^7$ | 140% |
| %RSD | -- | -- | 6.0% | |
| RS-1 (DeconGel®) | 584451 | $9.9x10^6$ | $9.6x10^6$ | 97% |
| RS-2 (DeconGel®) | 584452 | $9.9x10^6$ | $9.6x10^6$ | 97% |
| RS-3 (DeconGel®) | 584453 | $9.9x10^6$ | $1.1x10^7$ | 110% |
| AVG | -- | -- | $1.0x10^7$ | 101% |
| %RSD | -- | -- | 8.0% | |

# Appendix D – Summary of Test Results

## *Table D1: Summary of HD Glass Results*

| Controls (5 h) | Spike Amount (ng) | Wipe (ng) | Coupon (ng) | Total (ng) | Wipe Recovery | Total Recovery |
|---|---|---|---|---|---|---|
| Surface Blank | -- | $<1.5x10^{1}$ U | $3.5x10^{2}$ | $3.5x10^{2}$ | -- | -- |
| PC 1 | $1.2x10^{7}$ | $8.0x10^{6}$ | $2.7x10^{5}$ | $8.3x10^{6}$ | 67% | 69% |
| PC 2 | $1.2x10^{7}$ | $6.5x10^{6}$ | $7.5x10^{3}$ | $6.5x10^{6}$ | 54% | 54% |
| PC 3 | $1.2x10^{7}$ | $7.2x10^{6}$ | $2.8x10^{4}$ | $7.2x10^{6}$ | 60% | 60% |
| AVG | -- | $7.2x10^{6}$ | $1.0x10^{5}$ | $7.3x10^{6}$ | 60% | 61% |
| %RSD | -- | 10% | 150% | 12% | -- | -- |
| **Bleach** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $5.4x10^{1}$ | $<6.0x10^{2}$ U | $5.4x10^{1}$ | 0.0000% | 0.0000% |
| TR 2 | $1.2x10^{7}$ | $4.6x10^{2}$ | $<6.0x10^{2}$ U | $4.6x10^{2}$ | 0.0038% | 0.0038% |
| TR 3 | $1.2x10^{7}$ | $5.3x10^{1}$ | $<6.0x10^{2}$ U | $5.3x10^{1}$ | 0.0000% | 0.0000% |
| TR 4 | $1.2x10^{7}$ | $9.0x10^{0}$ | $<6.0x10^{2}$ U | $9.0x10^{0}$ | 0.0001% | 0.0001% |
| TR 5 | $1.2x10^{7}$ | $9.9x10^{2}$ | $<6.0x10^{2}$ U | $9.9x10^{2}$ | 0.0083% | 0.0083% |
| AVG | -- | $3.0x10^{2}$ | NC | $3.0x10^{2}$ | 0.0026% | 0.0026% |
| %RSD | -- | 140% | NC | 140% | -- | -- |
| **3% Peroxide** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $4.1x10^{6}$ | $2.2x10^{3}$ | $4.1x10^{6}$ | 34% | 34% |
| TR 2 | $1.2x10^{7}$ | $3.9x10^{6}$ | $5.4x10^{3}$ | $3.9x10^{6}$ | 32% | 32% |
| TR 3 | $1.2x10^{7}$ | $3.6x10^{6}$ | $5.9x10^{3}$ | $3.6x10^{6}$ | 30% | 30% |
| TR 4 | $1.2x10^{7}$ | $5.3x10^{6}$ | $5.6x10^{3}$ | $5.3x10^{6}$ | 44% | 44% |
| TR 5 | $1.2x10^{7}$ | $3.8x10^{6}$ | $4.1x10^{4}$ | $3.8x10^{6}$ | 32% | 32% |
| AVG | -- | $4.1x10^{6}$ | $1.2x10^{4}$ | $4.1x10^{6}$ | 35% | 35% |
| %RSD | -- | 16% | 140% | 16% | -- | -- |
| **EasyDecon® DF-200** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $1.0x10^{3}$ | $<6.0x10^{2}$ U | $1.0x10^{3}$ | 0.0083% | 0.0083% |
| TR 2 | $1.2x10^{7}$ | $1.4x10^{4}$ | $2.9x10^{2}$ | $1.4x10^{4}$ | 0.12% | 0.12% |
| TR 3 | $1.2x10^{7}$ | $2.6x10^{4}$ | $3.3x10^{3}$ | $2.9x10^{4}$ | 0.22% | 0.24% |
| TR 4 | $1.2x10^{7}$ | $2.6x10^{5}$ | $6.7x10^{3}$ | $2.7x10^{5}$ | 2.2% | 2.3% |
| TR 5 | $1.2x10^{7}$ | $4.9x10^{4}$ | $4.4x10^{3}$ | $5.3x10^{4}$ | 0.41% | 0.44% |
| AVG | -- | $7.0x10^{4}$ | $3.7x10^{3}$ | $7.4x10^{4}$ | 0.58% | 0.61% |
| %RSD | -- | 150% | 72% | 150% | -- | -- |
| **Controls (76 h)** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| Surface Blank | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| PC 1 | $1.2x10^{7}$ | $7.9x10^{1}$ | $<6.0x10^{2}$ U | $7.9x10^{1}$ | 0.001% | 0.001% |
| PC 2 | $1.2x10^{7}$ | $8.3x10^{1}$ | $<6.0x10^{2}$ U | $8.3x10^{1}$ | 0.001% | 0.001% |
| PC 3 | $1.2x10^{7}$ | $7.0x10^{1}$ | $<6.0x10^{2}$ U | $7.0x10^{1}$ | 0.001% | 0.001% |
| AVG | -- | $7.7x10^{1}$ | NC | $7.7x10^{1}$ | 0.001% | 0.001% |
| %RSD | -- | 8.3% | NC | 8.3% | -- | -- |
| **DeconGel® 1108** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{1}$ U | $<6.0x10^{2}$ U | $<6.0x10^{2}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $3.9x10^{4}$ | $1.3x10^{3}$ | $4.0x10^{4}$ | 0.33% | 0.34% |
| TR 2 | $1.2x10^{7}$ | $6.4x10^{5}$ | $1.8x10^{4}$ | $6.6x10^{5}$ | 5.3% | 5.5% |
| TR 3 | $1.2x10^{7}$ | $<1.5x10^{3}$ U | $<6.0x10^{2}$ U | $<1.5x10^{3}$ U | NC | NC |
| TR 4 | $1.2x10^{7}$ | $<1.5x10^{3}$ U | $<6.0x10^{2}$ U | $<1.5x10^{3}$ U | NC | NC |
| TR 5 | $1.2x10^{7}$ | $2.5x10^{5}$ | $3.2x10^{2}$ | $2.5x10^{5}$ | 2.1% | 2.1% |
| AVG | -- | $1.9x10^{5}$ | $6.6x10^{2}$ | $1.9x10^{5}$ | 2.6% | 2.6% |
| %RSD | -- | 98% | 150% | 150% | -- | -- |

NC – Not calculated

U – Analyte not detected. The detection limit was adjusted with extraction factor to identify the level that could be observed. The '<' identifies that the result is less than the adjusted detection limit.

-- Not applicable

## *Table D2: Summary of HD Ceramic Results*

| Controls (5 h) | Spike Amount (ng) | Wipe (ng) | Coupon (ng) | Total (ng) | Wipe Recovery | Total Recovery |
|---|---|---|---|---|---|---|
| Surface Blank | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| PC 1 | $1.2x10^{7}$ | $1.4x10^{7}$ | $2.5x10^{5}$ | $1.4x10^{7}$ | 120% | 120% |
| PC 2 | $1.2x10^{7}$ | $1.5x10^{7}$ | $6.4x10^{2}$ | $1.5x10^{7}$ | 130% | 130% |
| PC 3 | $1.2x10^{7}$ | $1.3x10^{7}$ | $3.6x10^{5}$ | $1.3x10^{7}$ | 110% | 110% |
| AVG | -- | $1.4x10^{7}$ | 210,000 | $1.4x10^{7}$ | 120% | 120% |
| %RSD | -- | 7.0% | 86% | 7.0% | -- | -- |
| **Bleach** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $<1.5x10^{1}$ U | $2.2x10^{4}$ | $2.2x10^{4}$ | NC | 0.18% |
| TR 2 | $1.2x10^{7}$ | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | NC | NC |
| TR 3 | $1.2x10^{7}$ | $6.0x10^{0}$ | $<4.5x10^{2}$ U | $6.0x10^{0}$ | 0.0000% | 0.0000% |
| TR 4 | $1.2x10^{7}$ | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | NC | NC |
| TR 5 | $1.2x10^{7}$ | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | NC | NC |
| AVG | -- | NC | NC | NC | NC | NC |
| %RSD | -- | NC | NC | NC | -- | -- |
| **3% Peroxide** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $3.6x10^{6}$ | $8.6x10^{4}$ | $3.7x10^{6}$ | 30% | 31% |
| TR 2 | $1.2x10^{7}$ | $3.5x10^{6}$ | $7.2x10^{4}$ | $3.6x10^{6}$ | 29% | 30% |
| TR 3 | $1.2x10^{7}$ | $2.2x10^{6}$ | $1.2x10^{4}$ | $2.2x10^{6}$ | 18% | 18% |
| TR 4 | $1.2x10^{7}$ | $3.6x10^{6}$ | $2.7x10^{5}$ | $3.9x10^{6}$ | 30% | 32% |
| TR 5 | $1.2x10^{7}$ | $4.2x10^{6}$ | $1.5x10^{4}$ | $4.2x10^{6}$ | 35% | 35% |
| AVG | -- | $3.4x10^{6}$ | $9.1x10^{4}$ | $3.5x10^{6}$ | 29% | 29% |
| %RSD | -- | 22% | 120% | 22% | -- | -- |
| **EasyDecon® DF-200** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $1.2x10^{5}$ | $6.0x10^{4}$ | $1.8x10^{5}$ | 1.0% | 1. 5% |
| TR 2 | $1.2x10^{7}$ | $1.3x10^{5}$ | $8.9x10^{5}$ | $1.0x10^{6}$ | 1.1% | 8.3% |
| TR 3 | $1.2x10^{7}$ | $1.3x10^{5}$ | $1.5x10^{5}$ | $2.8x10^{5}$ | 1.1% | 2.3% |
| TR 4 | $1.2x10^{7}$ | $1.4x10^{4}$ | $6.0x10^{5}$ | $6.1x10^{5}$ | 0.12% | 5.1% |
| TR 5 | $1.2x10^{7}$ | $9.2x10^{3}$ | $2.4x10^{4}$ | $3.3x10^{4}$ | 0.077% | 0.28% |
| AVG | -- | $8.1x10^{4}$ | $3.4x10^{5}$ | $4.2x10^{5}$ | 0.67% | 3.5% |
| %RSD | -- | 78% | 110% | 92% | -- | -- |
| **Controls (76 h)** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| Surface Blank | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| PC 1 | $1.2x10^{7}$ | $2.5x10^{2}$ | $2.4x10^{4}$ | $2.4x10^{4}$ | 0.0021% | 0.20% |
| PC 2 | $1.2x10^{7}$ | $3.0x10^{2}$ | $3.2x10^{4}$ | $3.2x10^{4}$ | 0.0025% | 0.27% |
| PC 3 | $1.2x10^{7}$ | $2.4x10^{2}$ | $3.6x10^{4}$ | $3.6x10^{4}$ | 0.0020% | 0.30% |
| AVG | -- | $2.6x10^{2}$ | $3.1x10^{4}$ | $3.1x10^{4}$ | 0.0022% | 0.26% |
| %RSD | -- | 12% | 20% | 20% | -- | -- |
| **DeconGel® 1108** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{1}$ U | $<4.5x10^{2}$ U | $<4.5x10^{2}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $1.4x10^{4}$ | $5.3x10^{6}$ | $5.3x10^{6}$ | 0.12% | 44% |
| TR 2 | $1.2x10^{7}$ | $5.2x10^{4}$ | $1.1x10^{6}$ | $1.2x10^{6}$ | 0.43% | 10% |
| TR 3 | $1.2x10^{7}$ | $1.1x10^{3}$ | $2.6x10^{6}$ | $2.6x10^{6}$ | 0.009% | 22% |
| TR 4 | $1.2x10^{7}$ | $3.5x10^{4}$ | $4.9x10^{6}$ | $4.9x10^{6}$ | 0.29% | 40% |
| TR 5 | $1.2x10^{7}$ | $2.2x10^{2}$ | $2.3x10^{6}$ | $2.3x10^{6}$ | 0.002% | 19% |
| AVG | -- | 20,000 | $3.2x10^{6}$ | $3.2x10^{6}$ | 0.17% | 27% |
| %RSD | -- | 110% | 56% | 53% | -- | -- |

NC – Not calculated
U – Analyte not detected
-- Not applicable

## *Table D3: Summary of HD Rubber Results*

| Controls (5 h) | Spike Amount (ng) | Wipe (ng) | Coupon (ng) | Total (ng) | Wipe Recovery | Total Recovery |
|---|---|---|---|---|---|---|
| Surface Blank | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| PC 1 | $1.2x10^{7}$ | $2.6x10^{6}$ | $1.6x10^{7}$ | $1.9x10^{7}$ | 22% | 160% |
| PC 2 | $1.2x10^{7}$ | $1.6x10^{6}$ | $1.3x10^{7}$ | $1.5x10^{7}$ | 13% | 130% |
| PC 3 | $1.2x10^{7}$ | $1.3x10^{6}$ | $1.2x10^{7}$ | $1.3x10^{7}$ | 11% | 110% |
| AVG | -- | $1.8x10^{6}$ | $1.4x10^{7}$ | $1.6x10^{7}$ | 15% | 130% |
| %RSD | -- | 38% | 15% | 19% | -- | -- |
| **Bleach** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $1.3x10^{2}$ | $4.7x10^{6}$ | $4.7x10^{6}$ | 0.0011% | 39% |
| TR 2 | $1.2x10^{7}$ | $2.1x10^{2}$ | $5.1x10^{6}$ | $5.1x10^{6}$ | 0.0018% | 43% |
| TR 3 | $1.2x10^{7}$ | $3.1x10^{2}$ | $5.0x10^{6}$ | $5.0x10^{6}$ | 0.0026% | 41% |
| TR 4 | $1.2x10^{7}$ | $2.7x10^{2}$ | $5.8x10^{6}$ | $5.8x10^{6}$ | 0.0023% | 48% |
| TR 5 | $1.2x10^{7}$ | $2.5x10^{2}$ | $6.6x10^{6}$ | $6.6x10^{6}$ | 0.0021% | 55% |
| AVG | -- | $2.3x10^{2}$ | $5.4x10^{6}$ | $5.4x10^{6}$ | 0.0020% | 45% |
| %RSD | -- | 30% | 14% | 14% | -- | -- |
| **3% Peroxide** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $1.2x10^{5}$ | $1.1x10^{7}$ | $1.1x10^{7}$ | 1.0% | 92% |
| TR 2 | $1.2x10^{7}$ | $1.5x10^{5}$ | $1.0x10^{7}$ | $1.0x10^{7}$ | 1.3% | 83% |
| TR 3 | $1.2x10^{7}$ | $1.4x10^{5}$ | $1.0x10^{7}$ | $1.0x10^{7}$ | 1.2% | 83% |
| TR 4 | $1.2x10^{7}$ | $1.3x10^{5}$ | $9.5x10^{6}$ | $9.6x10^{6}$ | 1.1% | 80% |
| TR 5 | $1.2x10^{7}$ | $1.1x10^{5}$ | $9.5x10^{6}$ | $9.6x10^{6}$ | 0.92% | 80% |
| AVG | -- | $1.3x10^{5}$ | $1.0x10^{7}$ | $1.0x10^{7}$ | 1.0% | 81% |
| %RSD | -- | 12% | 6.1% | 5.7% | -- | -- |
| **EasyDecon® DF-200** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $1.6x10^{5}$ | $8.6x10^{6}$ | $8.8x10^{6}$ | 1.3% | 73% |
| TR 2 | $1.2x10^{7}$ | $2.8x10^{5}$ | $7.2x10^{6}$ | $7.5x10^{6}$ | 2.3% | 63% |
| TR 3 | $1.2x10^{7}$ | $1.6x10^{5}0$ | $7.0x10^{6}$ | $7.2x10^{6}$ | 1.3% | 60% |
| TR 4 | $1.2x10^{7}$ | $1.2x10^{5}$ | $7.5x10^{6}$ | $7.6x10^{6}$ | 1.0% | 63% |
| TR 5 | $1.2x10^{7}$ | $1.8x10^{5}$ | $6.4x10^{6}$ | $6.6x10^{6}$ | 1. 5% | 55% |
| AVG | -- | $1.8x10^{5}$ | $7.3x10^{6}$ | $7.6x10^{6}$ | 1.5% | 63% |
| %RSD | -- | 33% | 11% | 11% | -- | -- |
| **Controls (76 h)** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| Surface Blank | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| PC 1 | $1.2x10^{7}$ | $5.0x10^{4}$ | $1.5x10^{7}$ | $1.5x10^{7}$ | 0.42% | 130% |
| PC 2 | $1.2x10^{7}$ | $5.3x10^{4}$ | $1.8x10^{7}$ | $1.8x10^{7}$ | 0.44% | 150% |
| PC 3 | $1.2x10^{7}$ | $4.7x10^{4}$ | $1.4x10^{7}$ | $1.4x10^{7}$ | 0.40% | 120% |
| AVG | -- | $5.0x10^{4}$ | $1.6x10^{7}$ | $1.6x10^{7}$ | 0.42% | 130% |
| %RSD | -- | 6.0% | 13% | 13% | -- | -- |
| **DeconGel® 1108** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| PB 2 | -- | $<1.5x10^{2}$ U | $<6.0x10^{3}$ U | $<6.0x10^{3}$ U | -- | -- |
| TR 1 | $1.2x10^{7}$ | $1.4x10^{4}$ | $4.2x10^{6}$ | $4.2x10^{6}$ | 0.11% | 35% |
| TR 2 | $1.2x10^{7}$ | $1.7x10^{4}$ | $4.4x10^{6}$ | $4.4x10^{6}$ | 0.14% | 37% |
| TR 3 | $1.2x10^{7}$ | $1.1x10^{4}$ | $3.9x10^{6}$ | $3.9x10^{6}$ | 0.092% | 33% |
| TR 4 | $1.2x10^{7}$ | $1.2x10^{4}$ | $3.4x10^{6}$ | $3.4x10^{6}$ | 0.10% | 28% |
| TR 5 | $1.2x10^{7}$ | $2.0x10^{4}$ | $3.7x10^{6}$ | $3.7x10^{6}$ | 0.17% | 31% |
| AVG | -- | $1.5x10^{4}$ | $3.9x10^{6}$ | $3.9x10^{6}$ | 0.12% | 33% |
| %RSD | -- | 25% | 10% | 10% | -- | -- |

NC – Not calculated
U – Analyte not detected
-- Not applicable

## *Table D4: Summary of HD Sealant/Sandstone Results*

| Controls (5 h ) | Spike Amount (ng) | Wipe (ng) | Coupon (ng) | Total (ng) | Wipe Recovery | Total Recovery |
|---|---|---|---|---|---|---|
| Surface Blank | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| PC 1 | $6.2x10^{7}$ | -- | $1.4x10^{7}$ | $1.4x10^{7}$ | -- | 23% |
| PC 2 | $6.2x10^{7}$ | -- | $4.1x10^{6}$ | $4.1x10^{6}$ | -- | 6.6% |
| PC 3 | $6.2x10^{7}$ | -- | $3.2x10^{7}$ | $3.2x10^{7}$ | -- | 52% |
| AVG | -- | -- | $1.7x10^{7}$ | $1.7x10^{7}$ | -- | 27% |
| %RSD | | | 83% | 83% | -- | -- |
| **Bleach** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| PB 2 | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| TR 1 | $6.2x10^{7}$ | -- | $4.0x10^{5}$ | $4.0x10^{5}$ | -- | 0.65% |
| TR 2 | $6.2x10^{7}$ | -- | $1.2x10^{4}$ | $1.2x10^{4}$ | -- | 0.019% |
| TR 3 | $6.2x10^{7}$ | -- | $2.1x10^{3}$ | $2.1x10^{3}$ | -- | 0.0034% |
| TR 4 | $6.2x10^{7}$ | -- | $1.0x10^{6}$ | $1.0x10^{6}$ | -- | 1.6% |
| TR 5 | $6.2x10^{7}$ | -- | $1.3x10^{5}$ | $1.3x10^{5}$ | -- | 0.21% |
| AVG | -- | -- | $3.1x10^{5}$ | $3.1x10^{5}$ | -- | 0.50% |
| %RSD | -- | -- | 140% | 140% | -- | -- |
| **3% Peroxide** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| PB 2 | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| TR 1 | $6.2x10^{7}$ | -- | $1.1x10^{7}$ | $1.1x10^{7}$ | -- | 18% |
| TR 2 | $6.2x10^{7}$ | -- | $1.2x10^{7}$ | $1.2x10^{7}$ | -- | 19% |
| TR 3 | $6.2x10^{7}$ | -- | $1.2x10^{7}$ | $1.2x10^{7}$ | -- | 19% |
| TR 4 | $6.2x10^{7}$ | -- | $8.4x10^{6}$ | $8.4x10^{6}$ | -- | 14% |
| TR 5 | $6.2x10^{7}$ | -- | $7.2x10^{6}$ | $7.2x10^{6}$ | -- | 12% |
| AVG | -- | -- | $1.0x10^{7}$ | $1.0x10^{7}$ | -- | 16% |
| %RSD | -- | -- | 22% | 22% | -- | -- |
| **EasyDecon® DF-200** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| PB 2 | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| TR 1 | $6.2x10^{7}$ | -- | $6.5x10^{6}$ | $6.5x10^{6}$ | -- | 10% |
| TR 2 | $6.2x10^{7}$ | -- | $5.3x10^{6}$ | $5.3x10^{6}$ | -- | 8.5% |
| TR 3 | $6.2x10^{7}$ | -- | $5.9x10^{6}$ | $5.9x10^{6}$ | -- | 9.5% |
| TR 4 | $6.2x10^{7}$ | -- | $6.2x10^{6}$ | $6.2x10^{6}$ | -- | 10% |
| TR 5 | $6.2x10^{7}$ | -- | $6.4x10^{6}$ | $6.4x10^{6}$ | -- | 10% |
| AVG | -- | -- | $6.1x10^{6}$ | $6.1x10^{6}$ | -- | 9.8% |
| %RSD | -- | -- | 8.0% | 8.0% | -- | -- |
| **Controls (76 h)** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| Surface Blank | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| PC 1 | $6.2x10^{7}$ | -- | $1.4x10^{6}$ | $1.4x10^{6}$ | -- | 2.3% |
| PC 2 | $6.2x10^{7}$ | -- | $1.5x10^{6}$ | $1.5x10^{6}$ | -- | 2.4% |
| PC 3 | $6.2x10^{7}$ | -- | $1.1x10^{6}$ | $1.1x10^{6}$ | -- | 1.8% |
| AVG | -- | -- | $1.3x10^{6}$ | $1.3x10^{6}$ | -- | 2.2% |
| %RSD | -- | -- | 16% | 16% | -- | -- |
| **DeconGel® 1108** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| PB 2 | -- | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | -- |
| TR 1 | $6.2x10^{7}$ | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | NC |
| TR 2 | $6.2x10^{7}$ | -- | $3.7x10^{2}$ | $3.7x10^{2}$ | -- | 0.0006% |
| TR 3 | $6.2x10^{7}$ | -- | < $3.9x10^{2}$ U | < $3.9x10^{2}$ U | -- | NC |
| TR 4 | $6.2x10^{7}$ | -- | $2.7x10^{2}$ | $2.7x10^{2}$ | -- | 0.0004% |
| TR 5 | $6.2x10^{7}$ | -- | $1.3x10^{2}$ | $1.3x10^{2}$ | -- | 0.0002% |
| AVG | -- | -- | $2.5x10^{2}$ | $2.5x10^{2}$ | -- | 0.0004% |
| %RSD | -- | -- | 48% | 48% | -- | -- |

NC – Not calculated
U – Analyte not detected
-- Not applicable

## *Table D5: Summary of VX Glass Results*

| Controls (5 h) | Spike Amount (ng) | Wipe (ng) | Coupon (ng) | Total (ng) | Wipe Recovery | Total Recovery |
|---|---|---|---|---|---|---|
| Surface Blank | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| PC 1 | $9.9x10^{6}$ | $1.1x10^{7}$ | $2.3x10^{5}$ | $1.1x10^{7}$ | 110% | 110% |
| PC 2 | $9.9x10^{6}$ | $7.7x10^{6}$ | $6.3x10^{5}$ | $8.3x10^{6}$ | 78% | 84% |
| PC 3 | $9.9x10^{6}$ | $8.1x10^{6}$ | $6.4x10^{5}$ | $8.7x10^{6}$ | 82% | 88% |
| AVG | -- | $8.9x10^{6}$ | $5.0x10^{5}$ | $9.3x10^{6}$ | 90% | 94% |
| %RSD | -- | 20% | 47% | 16% | -- | -- |
| **Bleach** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $9.7x10^{2}$ | < $4.0x10^{2}$ U | $9.7x10^{2}$ | 0.0098% | 0.0098% |
| TR 2 | $9.9x10^{6}$ | $3.7x10^{1}$ | < $4.0x10^{2}$ U | $3.7x10^{1}$ | 0.0004% | 0.0004% |
| TR 3 | $9.9x10^{6}$ | $1.7x10^{1}$ | < $4.0x10^{2}$ U | $1.7x10^{1}$ | 0.0002% | 0.0002% |
| TR 4 | $9.9x10^{6}$ | $1.9x10^{1}$ | < $4.0x10^{2}$ U | $1.9x10^{1}$ | 0.0002% | 0.0002% |
| TR 5 | $9.9x10^{6}$ | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | NC | NC |
| AVG | -- | 261 | NC | -- | 0.0026% | 0.0026% |
| %RSD | -- | 180% | NC | -- | -- | -- |
| **3% Peroxide** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $3.4x10^{5}$ | $2.4x10^{4}$ | $3.6x10^{5}$ | 3.4% | 3.6% |
| TR 2 | $9.9x10^{6}$ | $2.7x10^{5}$ | $2.3x10^{4}$ | $2.9x10^{5}$ | 2.7% | 2.9% |
| TR 3 | $9.9x10^{6}$ | $3.5x10^{5}$ | $2.6x10^{4}$ | $3.8x10^{5}$ | 3.5% | 3.8% |
| TR 4 | $9.9x10^{6}$ | $4.0x10^{5}$ | $3.0x10^{4}$ | $4.3x10^{5}$ | 4.0% | 4.3% |
| TR 5 | $9.9x10^{6}$ | $4.8x10^{5}$ | $5.3x10^{4}$ | $5.3x10^{5}$ | 4.8% | 5.3% |
| AVG | -- | $3.7x10^{5}$ | $3.1x10^{4}$ | $4.0x10^{5}$ | 3.7% | 4.0% |
| %RSD | -- | 21% | 40% | 22% | -- | -- |
| **EasyDecon® DF-200** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $7.5x10^{2}$ | $1.4x10^{2}$ | $8.9x10^{2}$ | 0.0076% | 0.0090% |
| TR 2 | $9.9x10^{6}$ | $3.0x10^{2}$ | $1.1x10^{2}$ | $4.1x10^{2}$ | 0.0030% | 0.0041% |
| TR 3 | $9.9x10^{6}$ | $2.7x10^{2}$ | < $4.0x10^{2}$ U | $2.7x10^{2}$ | 0.0027% | 0.0027% |
| TR 4 | $9.9x10^{6}$ | $1.3x10^{2}$ | < $4.0x10^{2}$ U | $1.3x10^{2}$ | 0.0013% | 0.0013% |
| TR 5 | $9.9x10^{6}$ | $1.2x10^{2}$ | < $4.0x10^{2}$ U | $1.2x10^{2}$ | 0.0012% | 0.0012% |
| AVG | -- | $3.1x10^{2}$ | NC | $3.6x10^{2}$ | 0.0032% | 0.0037% |
| %RSD | -- | 83% | NC | 88% | -- | -- |
| **Controls (76 h)** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| Surface Blank | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| PC 1 | $9.9x10^{6}$ | $8.8x10^{6}$ | $9.1x10^{5}$ | $9.7x10^{6}$ | 89% | 98% |
| PC 2 | $9.9x10^{6}$ | $1.0x10^{7}$ | $7.5x10^{5}$ | $1.1x10^{7}$ | 100% | 110% |
| PC 3 | $9.9x10^{6}$ | $9.8x10^{6}$ | $8.3x10^{5}$ | $1.1x10^{7}$ | 99% | 110% |
| AVG | -- | $9.5x10^{6}$ | $8.3x10^{5}$ | $1.1x10^{7}$ | 96% | 110% |
| %RSD | -- | 6.7% | 10% | 7.1% | -- | -- |
| **DeconGel® 1108** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | < $1.0x10^{1}$ U | < $4.0x10^{2}$ U | < $4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $1.3x10^{3}$ | $4.4x10^{3}$ | $5.7x10^{3}$ | 0.013% | 0.057% |
| TR 2 | $9.9x10^{6}$ | $1.9x10^{3}$ | $2.4x10^{4}$ | $2.6x10^{4}$ | 0.019% | 0.26% |
| TR 3 | $9.9x10^{6}$ | $2.6x10^{3}$ | $2.0x10^{3}$ | $4.6x10^{3}$ | 0.026% | 0.047% |
| TR 4 | $9.9x10^{6}$ | $6.3x10^{2}$ | $2.1x10^{3}$ | $2.7x10^{3}$ | 0.0064% | 0.028% |
| TR 5 | $9.9x10^{6}$ | $1.1x10^{3}$ | $1.4x10^{3}$ | $2.5x10^{3}$ | 0.011% | 0.025% |
| AVG | -- | $1.5x10^{3}$ | $6.8x10^{3}$ | $8.3x10^{3}$ | 0.015% | 0.084% |
| %RSD | -- | 51% | 140% | 120% | -- | -- |

NC – Not calculated
U – Analyte not detected
-- Not applicable

## *Table D6: Summary of VX Ceramic Results*

| Controls (5 h) | Spike Amount (ng) | Wipe (ng) | Coupon (ng) | Total (ng) | Wipe Recovery | Total Recovery |
|---|---|---|---|---|---|---|
| Surface Blank | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PC 1 | $9.9x10^{6}$ | $7.6x10^{6}$ | $6.4x10^{5}$ | $8.2x10^{6}$ | 77% | 83% |
| PC 2 | $9.9x10^{6}$ | $6.7x10^{6}$ | $1.7x10^{5}$ | $6.9x10^{6}$ | 68% | 70% |
| PC 3 | $9.9x10^{6}$ | $5.7x10^{6}$ | $1.1x10^{6}$ | $6.8x10^{6}$ | 58% | 69% |
| AVG | -- | $6.7x10^{6}$ | $6.4x10^{5}$ | $7.3x10^{6}$ | 67% | 74% |
| %RSD | -- | 14% | 73% | 11% | -- | -- |
| **Bleach** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | 1.1 | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $1.4x10^{5}$ | $< 4.0x10^{2}$ U | $1.4x10^{5}$ | 1.4% | 1.4% |
| TR 2 | $9.9x10^{6}$ | $2.9x10^{1}$ | $< 4.0x10^{2}$ U | $2.9x10^{1}$ | 0.0003% | 0.0003% |
| TR 3 | $9.9x10^{6}$ | $2.9x10^{5}$ | $1.5x10^{2}$ | $2.9x10^{5}$ | 2.9% | 2.9% |
| TR 4 | $9.9x10^{6}$ | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | NC | NC |
| TR 5 | $9.9x10^{6}$ | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | NC | NC |
| AVG | -- | $1.4x10^{5}$ | NC | $1.4x10^{5}$ | 1.4% | 1.4% |
| %RSD | -- | 100% | NC | 100% | -- | -- |
| **3% Peroxide** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $3.2x10^{5}$ | $9.2x10^{4}$ | $4.0x10^{5}$ | 3.2% | 4.0% |
| TR 2 | $9.9x10^{6}$ | $1.5x10^{5}$ | $4.6x10^{4}$ | $2.0x10^{5}$ | 1.5% | 2.0% |
| TR 3 | $9.9x10^{6}$ | $2.1x10^{5}$ | $5.6x10^{4}$ | $2.7x10^{5}$ | 2.1% | 2.7% |
| TR 4 | $9.9x10^{6}$ | $2.7x10^{5}$ | $8.0x10^{4}$ | $3.5x10^{5}$ | 2.7% | 3.5% |
| TR 5 | $9.9x10^{6}$ | $2.4x10^{5}$ | $8.3x10^{4}$ | $3.2x10^{5}$ | 2.4% | 3.2% |
| AVG | -- | $2.4x10^{5}$ | $7.1x10^{4}$ | $3.1x10^{5}$ | 2.4% | 3.1% |
| %RSD | -- | 27% | 27% | 25% | -- | -- |
| **EasyDecon® DF-200** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $2.5x10^{2}$ | $1.1x10^{3}$ | $1.4x10^{3}$ | 0.0025% | 0.014% |
| TR 2 | $9.9x10^{6}$ | $1.2x10^{2}$ | $1.2x10^{2}$ | $2.4x10^{2}$ | 0.0012% | 0.0024% |
| TR 3 | $9.9x10^{6}$ | $9.0x10^{1}$ | $9.6x10^{2}$ | $1.1x10^{3}$ | 0.0009% | 0.011% |
| TR 4 | $9.9x10^{6}$ | $6.0x10^{1}$ | $1.0x10^{2}$ | $1.6x10^{2}$ | 0.0006% | 0.0016% |
| TR 5 | $9.9x10^{6}$ | $4.0x10^{1}$ | $1.9x10^{2}$ | $2.3x10^{2}$ | 0.0004% | 0.0023% |
| AVG | -- | 110 | $4.9x10^{2}$ | $6.3x10^{2}$ | 0.0011% | 0.0063% |
| %RSD | -- | 74% | 100% | 92% | -- | -- |
| **Controls (76 h)** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| Surface Blank | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PC 1 | $9.9x10^{6}$ | $7.8x10^{6}$ | $3.5x10^{5}$ | $8.2x10^{6}$ | 79% | 83% |
| PC 2 | $9.9x10^{6}$ | $7.5x10^{6}$ | $3.9x10^{5}$ | $7.9x10^{6}$ | 76% | 80% |
| PC 3 | $9.9x10^{6}$ | $5.2x10^{6}$ | $3.8x10^{5}$ | $5.6x10^{6}$ | 53% | 57% |
| AVG | -- | $6.8x10^{6}$ | $3.7x10^{5}$ | $7.2x10^{6}$ | 69% | 73% |
| %RSD | -- | 21% | 5.5% | 20% | -- | -- |
| **DeconGel® 1108** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $1.3x10^{4}$ | $1.4x10^{3}$ | $1.4x10^{4}$ | 0.13% | 0.14% |
| TR 2 | $9.9x10^{6}$ | $6.0x10^{3}$ | $6.8x10^{4}$ | $7.4x10^{4}$ | 0.061% | 0.75% |
| TR 3 | $9.9x10^{6}$ | $4.1x10^{3}$ | $2.7x10^{3}$ | $6.8x10^{3}$ | 0.041% | 0.069% |
| TR 4 | $9.9x10^{6}$ | $4.5x10^{3}$ | $1.3x10^{3}$ | $5.8x10^{3}$ | 0.046% | 0.059% |
| TR 5 | $9.9x10^{6}$ | $3.3x10^{3}$ | $1.2x10^{3}$ | $4.5x10^{3}$ | 0.033% | 0.046% |
| AVG | -- | $6.2x10^{3}$ | $1.5x10^{4}$ | $2.1x10^{4}$ | 0.062% | 0.21% |
| %RSD | -- | 63% | 200% | 140% | -- | -- |

NC – Not calculated
U – Analyte not detected
-- Not applicable

## *Table D7: Summary of VX Rubber Results*

| Controls (5 h) | Spike Amount (ng) | Wipe (ng) | Coupon (ng) | Total (ng) | Wipe Recovery | Total Recovery |
|---|---|---|---|---|---|---|
| Surface Blank | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PC 1 | $9.9x10^{6}$ | $1.2x10^{6}$ | $6.6x10^{6}$ | $7.8x10^{6}$ | 12% | 79% |
| PC 2 | $9.9x10^{6}$ | $1.5x10^{6}$ | $7.5x10^{6}$ | $9.0x10^{6}$ | 15% | 91% |
| PC 3 | $9.9x10^{6}$ | $9.5x10^{5}$ | $5.2x10^{6}$ | $6.2x10^{6}$ | 10% | 62% |
| AVG | -- | $1.2x10^{6}$ | $6.4x10^{6}$ | $7.7x10^{6}$ | 12% | 77% |
| %RSD | -- | 23% | 18% | 18% | -- | -- |
| **Bleach** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $5.7x10^{4}$ | $7.6x10^{6}$ | $7.7x10^{6}$ | 0.58% | 78% |
| TR 2 | $9.9x10^{6}$ | $6.8x10^{4}$ | $7.2x10^{6}$ | $7.3x10^{6}$ | 0.69% | 74% |
| TR 3 | $9.9x10^{6}$ | $3.6x10^{4}$ | $6.0x10^{6}$ | $6.0x10^{6}$ | 0.36% | 61% |
| TR 4 | $9.9x10^{6}$ | $5.1x10^{4}$ | $6.1x10^{6}$ | $6.2x10^{6}$ | 0.52% | 63% |
| TR 5 | $9.9x10^{6}$ | $6.0x10^{4}$ | $6.5x10^{6}$ | $6.6x10^{6}$ | 0.61% | 67% |
| AVG | -- | $5.4x10^{4}$ | $6.7x10^{6}$ | $6.8x10^{6}$ | 0.55% | 68% |
| %RSD | -- | 22% | 10% | 11% | -- | -- |
| **3% Peroxide** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $1.0x10^{6}$ | $6.7x10^{6}$ | $7.7x10^{6}$ | 10% | 78% |
| TR 2 | $9.9x10^{6}$ | $1.0x10^{6}$ | $7.1x10^{6}$ | $8.1x10^{6}$ | 10% | 82% |
| TR 3 | $9.9x10^{6}$ | $9.9x10^{5}$ | $5.8x10^{6}$ | $6.8x10^{6}$ | 10% | 69% |
| TR 4 | $9.9x10^{6}$ | $1.2x10^{6}$ | $6.8x10^{6}$ | $8.0x10^{6}$ | 12% | 81% |
| TR 5 | $9.9x10^{6}$ | $1.0x10^{6}$ | $6.3x10^{6}$ | $7.3x10^{6}$ | 10% | 74% |
| AVG | -- | $1.0x10^{6}$ | $6.5x10^{6}$ | $6.5x10^{6}$ | 10% | 77% |
| %RSD | -- | 8.7% | 7.7% | 7.1% | -- | -- |
| **EasyDecon® DF-200** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $8.4x10^{4}$ | $7.5x10^{6}$ | $7.6x10^{6}$ | 0.85% | 77% |
| TR 2 | $9.9x10^{6}$ | $1.0x10^{5}$ | $7.2x10^{6}$ | $7.3x10^{6}$ | 1.0% | 74% |
| TR 3 | $9.9x10^{6}$ | $5.8x10^{4}$ | $6.1x10^{6}$ | $6.2x10^{6}$ | 0.59% | 63% |
| TR 4 | $9.9x10^{6}$ | $1.3x10^{5}$ | $6.4x10^{6}$ | $6.5x10^{6}$ | 1.3% | 66% |
| TR 5 | $9.9x10^{6}$ | $5.0x10^{4}$ | $7.5x10^{6}$ | $7.6x10^{6}$ | 0.51% | 77% |
| AVG | -- | 84,000 | $6.9x10^{6}$ | $7.0x10^{6}$ | 0.85% | 71% |
| %RSD | -- | 39% | 9.4% | 9.2% | -- | -- |
| **Controls (76 h)** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| Surface Blank | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PC 1 | $9.9x10^{6}$ | $4.7x10^{5}$ | $7.2x10^{6}$ | $7.7x10^{6}$ | 4.7% | 78% |
| PC 2 | $9.9x10^{6}$ | $5.6x10^{5}$ | $5.8x10^{6}$ | $6.4x10^{6}$ | 6.5% | 64% |
| PC 3 | $9.9x10^{6}$ | $4.5x10^{5}$ | $6.0x10^{6}$ | $6.5x10^{6}$ | 4.5% | 65% |
| AVG | -- | $4.9x10^{5}$ | $6.3x10^{6}$ | $6.9x10^{6}$ | 5.0% | 69% |
| %RSD | -- | 12% | 12% | 10% | -- | -- |
| **DeconGel® 1108** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| PB 2 | -- | $< 1.0x10^{1}$ U | $< 4.0x10^{2}$ U | $< 4.0x10^{2}$ U | -- | -- |
| TR 1 | $9.9x10^{6}$ | $1.4x10^{4}$ | $1.4x10^{6}$ | $1.4x10^{6}$ | 0.14% | 14% |
| TR 2 | $9.9x10^{6}$ | $3.2x10^{4}$ | $2.1x10^{6}$ | $2.1x10^{6}$ | 0.32% | 21% |
| TR 3 | $9.9x10^{6}$ | $2.4x10^{4}$ | $1.9x10^{6}$ | $1.9x10^{6}$ | 0.24% | 19% |
| TR 4 | $9.9x10^{6}$ | $2.6x10^{4}$ | $2.1x10^{6}$ | $2.1x10^{6}$ | 0.26% | 21% |
| TR 5 | $9.9x10^{6}$ | $1.8x10^{4}$ | $2.5x10^{6}$ | $2.5x10^{6}$ | 0.18% | 25% |
| AVG | -- | $2.2x10^{4}$ | $2.0x10^{6}$ | $2.0x10^{6}$ | 0.23% | 20% |
| %RSD | -- | 30% | 20% | 20% | -- | -- |

NC – Not calculated
U – Analyte not detected
-- Not applicable

## *Table D8: Summary of VX Sealant/Sandstone Results*

| Controls (5 h) | Spike Amount (ng) | Wipe (ng) | Coupon (ng) | Total (ng) | Wipe Recovery | Total Recovery |
|---|---|---|---|---|---|---|
| Surface Blank | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| PC 1 | $5.0x10^7$ | -- | $1.5x10^7$ | $1.5x10^7$ | -- | 30% |
| PC 2 | $5.0x10^7$ | -- | $1.3x10^7$ | $1.3x10^7$ | -- | 26% |
| PC 3 | $5.0x10^7$ | -- | $1.6x10^7$ | $1.6x10^7$ | -- | 32% |
| AVG | -- | -- | $1.5x10^7$ | $1.5x10^7$ | -- | 29% |
| %RSD | -- | -- | 10% | 10% | -- | |
| **Bleach** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| PB 2 | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| TR 1 | $5.0x10^7$ | -- | $6.3x10^4$ | $6.3x10^4$ | -- | 0.13% |
| TR 2 | $5.0x10^7$ | -- | $8.6x10^5$ | $8.6x10^5$ | -- | 1.7% |
| TR 3 | $5.0x10^7$ | -- | $4.8x10^4$ | $4.8x10^4$ | -- | 0.096% |
| TR 4 | $5.0x10^7$ | -- | $2.6x10^6$ | $2.6x10^6$ | -- | 5.2% |
| TR 5 | $5.0x10^7$ | -- | $4.8x10^6$ | $4.8x10^6$ | -- | 9.6% |
| AVG | -- | -- | $1.7x10^6$ | $1.7x10^6$ | -- | 3.4% |
| %RSD | -- | -- | 120% | 120% | -- | -- |
| **3% Peroxide** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| PB 2 | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| TR 1 | $5.0x10^7$ | -- | $6.4x10^6$ | $6.4x10^6$ | -- | 13% |
| TR 2 | $5.0x10^7$ | -- | $3.3x10^6$ | $3.3x10^6$ | -- | 6.6% |
| TR 3 | $5.0x10^7$ | -- | $1.0x10^7$ | $1.0x10^7$ | -- | 20% |
| TR 4 | $5.0x10^7$ | -- | $8.4x10^6$ | $8.4x10^6$ | -- | 17% |
| TR 5 | $5.0x10^7$ | -- | $7.2x10^6$ | $7.2x10^6$ | -- | 14% |
| AVG | -- | -- | $7.1x10^6$ | $7.1x10^6$ | -- | 14% |
| %RSD | -- | -- | 35% | 35% | -- | -- |
| **EasyDecon® DF-200** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| PB 2 | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| TR 1 | $5.0x10^7$ | -- | $5.1x10^6$ | $5.1x10^6$ | -- | 10% |
| TR 2 | $5.0x10^7$ | -- | $1.7x10^6$ | $1.7x10^6$ | -- | 3.4% |
| TR 3 | $5.0x10^7$ | -- | $3.4x10^6$ | $3.4x10^6$ | -- | 6.8% |
| TR 4 | $5.0x10^7$ | -- | $6.3x10^6$ | $6.3x10^6$ | -- | 13% |
| TR 5 | $5.0x10^7$ | -- | $4.7x10^6$ | $4.7x10^6$ | -- | 9.4% |
| AVG | -- | -- | $4.2x10^6$ | $4.2x10^6$ | -- | 8.5% |
| %RSD | -- | -- | 42% | 42% | -- | -- |
| **Controls (76 h)** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| Surface Blank | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| PC 1 | $5.0x10^7$ | -- | $8.5x10^6$ | $8.5x10^6$ | -- | 17% |
| PC 2 | $5.0x10^7$ | -- | $1.2x10^7$ | $1.2x10^7$ | -- | 24% |
| PC 3 | $5.0x10^7$ | -- | $3.3x10^6$ | $3.3x10^6$ | -- | 6.6% |
| AVG | -- | -- | $7.9x10^6$ | $7.9x10^6$ | -- | 16% |
| %RSD | -- | -- | 55% | 55% | -- | |
| **DeconGel® 1108** | **Spike Amount (ng)** | **Wipe (ng)** | **Coupon (ng)** | **Total (ng)** | **Wipe Recovery** | **Total Recovery** |
| PB 1 | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| PB 2 | -- | -- | < $2.6x10^2$ U | < $2.6x10^2$ U | -- | -- |
| TR 1 | $5.0x10^7$ | -- | $4.3x10^6$ | $4.3x10^6$ | -- | 8.6% |
| TR 2 | $5.0x10^7$ | -- | $3.7x10^6$ | $3.7x10^6$ | -- | 7.4% |
| TR 3 | $5.0x10^7$ | -- | $7.4x10^6$ | $7.4x10^6$ | -- | 15% |
| TR 4 | $5.0x10^7$ | -- | $4.8x10^6$ | $4.8x10^6$ | -- | 9.6% |
| TR 5 | $5.0x10^7$ | -- | $6.8x10^6$ | $6.8x10^6$ | -- | 14% |
| AVG | -- | -- | $5.4x10^6$ | $5.4x10^6$ | -- | 11% |
| %RSD | -- | -- | 30% | 30% | -- | -- |

NC – Not calculated; U – Analyte not detected; -- Not applicable

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