TEST REPORT

Aerosolized Decontamination of Fentanyl Surface Contamination Using Dahlgren Decon® / PeroxySolid™ Dispensed by the AeroClave RDS 3110

Confined-Space (ISO Shipping Container) Efficacy Screening — Aluminum Coupon Challenge

Report Element	Detail
Report Number	FLT-TR-2026-001
Test Date	3 March 2026
Test Location	First Line Technology, LLC — Training Annex, Fredericksburg, VA
Test Article(s)	Dahlgren Decon® / PeroxySolid™ (22 oz kit configuration); AeroClave RDS 3110 Room Decontamination System
Challenge Agent	Fentanyl (Cerilliant certified reference standard, 1 mg/mL in methanol)
Test Type	Screening-level efficacy evaluation (non-GLP, non-validated)
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Revision	Rev. 0 — Initial issue

1. Executive Summary

On 3 March 2026, First Line Technology, LLC conducted a screening-level efficacy test to determine whether Dahlgren Decon® / PeroxySolid™, dispensed as an aerosol by the AeroClave RDS 3110 Room Decontamination System, could neutralize fentanyl surface contamination within a confined space. The test was conducted inside a 20 ft × 8 ft × 8 ft steel intermodal (conex) container using four aluminum coupons, each loaded with approximately 250 µg of fentanyl reference standard and positioned 59 to 100 inches from the dispensing unit.

Three 22 oz Dahlgren Decon kits were mixed per manufacturer instructions, charged to the RDS 3110 holding tank, and dispensed over a single 30-minute run cycle. One coupon (D3) was recovered immediately following the run; the remaining three coupons and the source reagent vial were recovered after an additional dwell period of approximately two hours.

All samples were screened using a BTNX lateral flow immunoassay in an on-site opioid detection kit (ODK) configuration with a stated detection limit of 20 ng/mL. Every sample, including coupons recovered immediately after the run and those held for extended dwell, returned a negative result for fentanyl within three minutes.

Bottom line: A single 30-minute RDS 3110 run using 3 × 22 oz of Dahlgren Decon® / PeroxySolid™ reduced fentanyl on all four coupons below the detection threshold of the field screening method, corresponding to a

nominal reduction of at least 99.96 percent (≥3.4 log) from the applied challenge. This result was obtained at 39 °F and 42 percent relative humidity in an unsealed container, conditions expected to be less favorable to peroxygen chemistry than typical indoor remediation environments. Because no untreated positive-control coupon was carried through the sampling and analysis chain, this test establishes a promising screening result rather than a validated efficacy claim.

2. Purpose and Objectives

The purpose of this test was to generate initial performance data on the combined use of Dahlgren Decon® / PeroxySolid™ and the AeroClave RDS 3110 for remediation of fentanyl-contaminated confined spaces — an operational problem set encountered in clandestine laboratory response, contaminated vehicle and container remediation, evidence-processing spaces, and law enforcement facility decontamination.

2.1 Specific Objectives

1. Determine whether a single 30-minute RDS 3110 dispensing cycle using Dahlgren Decon® / PeroxySolid™ reduces deposited fentanyl on hard, non-porous surfaces below the detection limit of a field-deployable lateral flow screening method.
2. Assess whether efficacy varies with distance from the dispensing unit across a range of approximately 59 to 100 inches.
3. Evaluate the practicality of the process under cold-weather conditions in a non-sealed enclosure.
4. Identify variables, controls, and instrumentation required for a subsequent quantitative, controlled test series.

2.2 Success Criterion

A coupon was considered to have passed if the recovered sample produced a negative result on the lateral flow assay, indicating fentanyl below the 20 ng/mL assay detection limit in the prepared sample volume.

3. Scope

This report documents a single-trial, screening-level evaluation. It is not a validated efficacy study and was not conducted under Good Laboratory Practice, an EPA efficacy test protocol, or an accredited quality system. The following were expressly outside the scope of this test:

- Quantitative confirmatory analysis (LC-MS/MS or equivalent) of residual fentanyl.
- Determination of sampling and extraction recovery efficiency.
- Establishment of a minimum effective contact or dwell time.
- Evaluation of porous substrates, fabrics, or adulterated or bulk-powder fentanyl presentations.
- Characterization of reaction byproducts or degradation pathways.
- Determination of safe re-entry time following aerosol dispensing.
- Materials-compatibility assessment of the treated enclosure.

4. Materials and Equipment

4.1 Decontaminant

Parameter	Detail
Product	Dahlgren Decon® / PeroxySolid™
Configuration	22 oz kit — 3 kits used
Lot Numbers	51320 • 49420 • 52220
Preparation	Mixed per manufacturer instructions at 1205 EST, 3 March 2026
Nominal Volume Prepared	3 × 22 oz ≈ 1,952 mL
Delivery	Charged directly to the AeroClave RDS 3110 holding tank following mixing

Table 4-1. Decontaminant preparation record.

4.2 Dispensing System

Parameter	Detail
System	AeroClave RDS 3110 Room Decontamination System
Nominal Output	Approximately 28 mL per minute per dispensing head
Run Duration	30 minutes (set point)
Calculated Dispense	Approximately 1,680 mL over the 30-minute cycle (two-head basis)
Placement	Approximate geometric center of the container floor; final position constrained slightly by extension cord routing

Table 4-2. Dispensing system configuration. Dispense volume is calculated from nominal output rate, not metered.

4.3 Challenge Material and Substrate

Parameter	Detail
Challenge Agent	Fentanyl, Cerilliant certified reference standard, 1 mg/mL in methanol
Aliquot Volume	250 µL per coupon, delivered with a 0.01–1 mL adjustable pipette set to 250 µL
Mass Applied	Approximately 250 µg (0.25 mg) fentanyl per coupon
Coupon Substrate	6061-T6 aluminum, mill finish, 2 in diameter × 0.125 in thick
Coupon Quantity	Four (D1, D2, D3, D4)
Drying	Aliquots dried to completion under fume hood prior to transport
Transport	Pyrex container with lid; coupons individually labeled and photographed

Table 4-3. Challenge material and coupon preparation.

4.4 Analytical Materials

Parameter	Detail
Screening Kit	Opioid Detection Kit (ODK), Lot 082025
Assay	BTNX lateral flow immunoassay test strip, Lot DOAA2409002
Stated Detection Limit	20 ng/mL fentanyl in prepared sample
Sampling Media	Kit-supplied cotton collection swabs; deionized water; polymer weigh boats
Procedure	Performed in accordance with the instructions enclosed with the ODK

Table 4-4. Analytical screening materials.

4.5 Test Enclosure and Ambient Conditions

Parameter	Detail
Enclosure	Steel intermodal (conex) shipping container, 20 ft × 8 ft × 8 ft
Approximate Volume	1,280 ft^3 (≈36.2 m^3)
Sealing	Not a sealed environment — container has an unsealed door assembly and a window penetration
Temperature	39 °F at time of test
Relative Humidity	42 percent at time of test
Monitoring	Temperature and humidity sensor placed inside the container; conditions documented at test start

Table 4-5. Test enclosure and ambient conditions.

5. Test Configuration

The RDS 3110 was positioned at the approximate center of the container floor. The four loaded coupons and the source fentanyl vial were distributed around the interior at varying distances and elevations, including placements on work surfaces and on the container floor, to sample a range of aerosol exposure conditions. Distances below are measured from the nearest edge of each sample to the RDS 3110.

Sample	Distance from RDS 3110	Placement
D1	91 in	Container floor, left forward quadrant
D2	95 in	Elevated on work surface adjacent to window penetration, left side
D3	59 in	Elevated on work surface, rear centerline — nearest sample to the unit
D4	100 in	Container floor, right rear quadrant adjacent to door — farthest sample from the unit
Source Vial	40 in	Elevated on work surface, forward centerline; vial head broken during aliquot process

Table 5-1. Sample placement and standoff distance. Refer to Appendix A for plan-view layout.

Each coupon was photographed in position with a bagged identification label to establish an unambiguous chain of identity between placement, recovery, and analysis.

6. Test Procedure

5. Four 6061-T6 aluminum coupons were loaded with 250 µL of 1 mg/mL fentanyl reference standard and dried to completion under a fume hood.
6. Coupons were transferred to a sealed Pyrex transport container and moved to the conex.
7. Coupons D1 through D4 and the source vial were placed at the positions recorded in Table 5-1, then photographed with identification labels.
8. Temperature and humidity inside the container were recorded.
9. Three 22 oz Dahlgren Decon® / PeroxySolid™ kits were mixed per manufacturer instructions at 1205 EST and charged to the RDS 3110 holding tank.
10. The RDS 3110 was set to a 30-minute run cycle and started at 1205 EST. The cycle concluded at approximately 1235 EST.
11. Coupon D3 was recovered immediately following the cycle and transported to the Training Annex for screening analysis.
12. D3 was screened by two independent sampling approaches; results were recorded and photographed.
13. Because D3 screened negative, the remaining samples were allowed to dwell in the treated container and were recovered at approximately 1430 EST — an additional dwell of approximately two hours.
14. Coupons D1, D2, D4 and the source vial were transported to the Training Annex and screened. Results were recorded and photographed.

6.1 Sampling and Analysis Methods

Three sampling approaches were used across the sample set:

Method	Description
Rinse	Coupon surface rinsed with deionized water; approximately 1–2 mL of runoff collected in a clean polymer weigh boat and assayed.
Dry Swab	Kit-supplied cotton swab drawn across the coupon surface under gentle pressure with rotation of the swab head to maximize collection, then assayed per ODK instructions.
Hybrid	Coupon surface rinsed with approximately 2 mL deionized water into a clean weigh boat; swab briefly dipped in the runoff, then drawn across the coupon surface; swab assayed per ODK instructions. Each coupon was rinsed and sampled separately using fresh media.

Table 6-1. Sampling methods employed.

7. Results

All samples returned negative results for fentanyl. No sample produced a positive or faint-line indication. Negative results were observed within three minutes of assay initiation, consistent with the ODK instructions for use.

Sample	Standoff	Recovery Time	Sampling Method	Post-Run Dwell	Result
D3	59 in	≈1235 EST	Rinse, then dry swab (2 independent tests)	None	NEGATIVE
D2	95 in	≈1430 EST	Dry swab, direct from surface	≈2 hr	NEGATIVE
D1	91 in	≈1430 EST	Hybrid rinse and swab	≈2 hr	NEGATIVE
D4	100 in	≈1430 EST	Hybrid rinse and swab	≈2 hr	NEGATIVE
Source Vial	40 in	≈1430 EST	Dry swab of vial interior and broken vial head	≈2 hr	NEGATIVE

Table 7-1. Summary of screening results. All assays performed with ODK Lot 082025 and BTNX test strip Lot DOAA2409002, 20 ng/mL stated detection limit.

7.1 Detail — Sample D3 (Immediate Recovery)

Sample D3, the coupon nearest the dispensing unit, was recovered at the conclusion of the run cycle and screened twice using independent sampling approaches. The first test rinsed residue from the coupon with deionized water and assayed approximately 1 mL of the runoff. The second test used the kit-supplied swab drawn directly across the coupon surface. Both tests indicated no detectable fentanyl. Testing was performed in accordance with the ODK instructions, and results were photographed and recorded.

7.2 Detail — Samples D1, D2, D4 and Source Vial (Extended Dwell)

Sample D2 was prepared first and sampled by direct dry swab of the coupon surface using gentle pressure with rotation of the swab head to ensure complete collection across the coupon face. The swab was assayed per ODK instructions and a negative result was observed.

Samples D1 and D4 were sampled by the hybrid method: the coupon face was rinsed with approximately 2 mL of deionized water into a fresh polymer weigh boat, the swab was briefly dipped in the collected runoff, and the swab was then drawn across the coupon surface before being assayed. Each coupon was rinsed and sampled separately with fresh media. Both returned negative results.

Data-record note: *The contemporaneous field record identifies the hybrid-method coupons as "D2 and D4." Because D2 had already been sampled and reported by dry swab in the preceding paragraph of that record, the hybrid-method coupons are reported here as D1 and D4. This discrepancy should be reconciled against the photographic record before the data are used for any external purpose.*

The source fentanyl vial from which the coupon aliquots were drawn was sampled by drawing a kit-supplied cotton swab through the vial interior and across the broken vial head. The swab was assayed per ODK instructions and a negative result was observed.

7.3 Nominal Reduction Calculation

Each coupon received approximately 250 µg (250,000 ng) of fentanyl over a 2 in diameter face (approximately 20.3 cm^2). Under the planned sampling basis of extraction into 5 mL of water with a 20 ng/mL assay detection limit, the smallest quantity detectable across the full coupon face is approximately 100 ng. A negative result on that basis therefore corresponds to a nominal reduction of at least 99.96 percent, or approximately 3.4 log, relative to the applied challenge.

This calculation assumes complete recovery of any residual fentanyl by the sampling method. Recovery efficiency was not established in this test, so the stated reduction should be treated as a nominal upper-bound estimate rather than a measured value. See Section 9.

8. Discussion

A single 30-minute dispensing cycle using 3 × 22 oz of Dahlgren Decon® / PeroxySolid™ was sufficient to drive deposited fentanyl below field screening detection limits on all four coupons within a 1,280 ft^3 unsealed steel enclosure. The coupon recovered immediately at the end of the cycle (D3) screened negative on two independent sampling methods, indicating that the reduction occurred during or very shortly after the dispensing period rather than solely during the subsequent dwell.

No distance-dependent effect was observed. Efficacy at 100 inches of standoff (D4, adjacent to the container door) was indistinguishable from efficacy at 59 inches (D3). At the volumes dispensed relative to the enclosure size, aerosol distribution appears to have been effectively uniform across the container interior, including at floor level and on elevated surfaces, and was not defeated by the unsealed door or the window penetration.

The ambient conditions of 39 °F and 42 percent relative humidity are worth emphasizing. Peroxygen decontamination chemistry is temperature-dependent, and reaction kinetics at 39 °F would be expected to be slower than at typical indoor temperatures. The result obtained here is therefore likely conservative with respect to warmer operational environments — though this should be confirmed rather than assumed, since low temperature also affects aerosol droplet behavior, evaporation rate, and surface wetting in ways that are not necessarily unidirectional.

The negative result on the source vial is consistent with the coupon results but should not be read as an independent confirmation. The vial was inside the enclosure and exposed to the same aerosol, and it therefore functions as an additional treated sample, not as a positive control.

9. Limitations and Sources of Uncertainty

The following limitations constrain the conclusions that can be drawn from this test and should be addressed in any follow-on work intended to support a performance claim.

Limitation	Impact
No untreated positive control	No coupon was loaded, held outside the treated enclosure, and carried through the identical sampling and assay chain. Without this control, the negative results cannot be distinguished from a systematic failure of sampling recovery or assay performance. This is the most significant limitation of the test.
Recovery efficiency not established	The fraction of residual fentanyl actually transferred from coupon to assay by rinse or swab is unknown, so the reduction calculation in Section 7.3 is nominal rather than measured.
Screening assay only	Lateral flow immunoassay provides presence or absence at a stated threshold. No quantitative confirmatory analysis was performed.
Single trial, no replicates	Four coupons in one run cycle. No statistical treatment is possible and run-to-run variability is uncharacterized.
Reaction not quenched	Sampling occurred without a quench or kill step, so the reaction may have continued during recovery and handling. Minimum effective contact time cannot be inferred from these data.
Inconsistent sampling methods	Three different sampling approaches were used across five samples, introducing method variation between samples.
Non-sealed enclosure	Container leakage was not characterized or measured; actual delivered aerosol concentration and its persistence are unknown.
Dispensed volume not metered	Dispense volume was calculated from nominal output rate rather than measured. Actual delivered volume was not confirmed.
Single agent presentation	Only dried methanolic reference standard on non-porous aluminum was tested. Results do not extend to bulk powder, freebase, adulterated mixtures, or porous substrates.
Sample identification discrepancy	See data-record note in Section 7.2.

Table 9-1. Limitations and sources of uncertainty.

10. Conclusions

1. A single 30-minute AeroClave RDS 3110 cycle dispensing 3 × 22 oz of Dahlgren Decon® / PeroxySolid™ reduced approximately 250 µg of dried fentanyl per coupon below the 20 ng/mL detection limit of the ODK lateral flow screening method on all four coupons.
2. Reduction was achieved by the conclusion of the dispensing cycle, as demonstrated by the immediately recovered coupon D3, and was not dependent on extended dwell.
3. Efficacy was uniform across standoff distances from 59 to 100 inches within a 20 ft × 8 ft × 8 ft enclosure, at both floor level and elevated surface positions.
4. The process performed effectively at 39 °F and 42 percent relative humidity in an unsealed enclosure, indicating tolerance to cold-weather and imperfectly sealed operational conditions.
5. Because no untreated positive control was carried through the sampling and analysis chain, these results constitute a favorable screening outcome that justifies a controlled follow-on study — not a validated efficacy claim. They should not be represented externally as a performance specification.

11. Recommendations for Follow-On Testing

11.1 Test Design and Controls

- Incorporate untreated positive-control coupons carried through the identical sampling and assay chain in every run, along with a method blank.
- Establish sampling recovery efficiency by extracting and assaying spiked coupons that receive no treatment.
- Standardize on a single sampling method across all coupons within a run to eliminate method variation.
- Run replicate coupons at each position to allow statistical treatment of results.
- Add quantitative confirmatory analysis by LC-MS/MS on a subset of samples to convert screening outcomes into measured log-reduction values.

11.2 Contact Time Determination

- Introduce a quench or kill reagent for the Dahlgren Decon® / PeroxySolid™ chemistry so that the reaction is arrested at the moment of sampling and true contact time can be resolved.
- Test shortened cycles — for example 15 and 20 minutes — followed by a defined 10-minute dwell, to identify the minimum effective exposure.
- Establish a time-course series with coupons recovered at successive intervals to construct a reduction-versus-time curve.

11.3 Agent Presentation and Substrate

- Test additional fentanyl presentations, including freebase, bulk powder, and adulterated or cut mixtures representative of seized material.
- Add porous substrates and fabrics impregnated with challenge material to represent upholstery, clothing, and soft furnishings.
- Consider fentanyl analogues and related synthetic opioids relevant to current operational encounters.

11.4 Enclosure Geometry and Aerosol Distribution

- Scale to larger room volumes to establish volume-to-decontaminant ratio limits.
- Introduce partial walls, partitions, and shadowed or line-of-sight-obstructed positions to determine whether aerosol distribution remains effective in realistic room configurations.
- Instrument the enclosure to characterize aerosol concentration and distribution rather than inferring it from coupon outcomes.
- Repeat at representative warm-weather and elevated-humidity conditions to bound the operational envelope.

11.5 Re-Entry and Operational Practicality

- Determine the time required for the aerosol to settle sufficiently to permit unimpeded, unprotected entry following a cycle — this is the primary operational gating factor for the process and is currently uncharacterized.
- Evaluate whether a neutralization agent can expedite clearance and shorten the re-entry interval.
- Assess materials compatibility and residue on treated surfaces, electronics, and evidence.

Appendix A — Test Layout Diagram

Plan view of the 20 ft × 8 ft steel conex showing the AeroClave RDS 3110 (AC) at the approximate geometric center, coupon positions D1 through D4, the source fentanyl vial, and standoff distances measured from the nearest sample edge to the unit. The door assembly is at right; a window penetration is at left. Shaded rectangles indicate work surfaces.

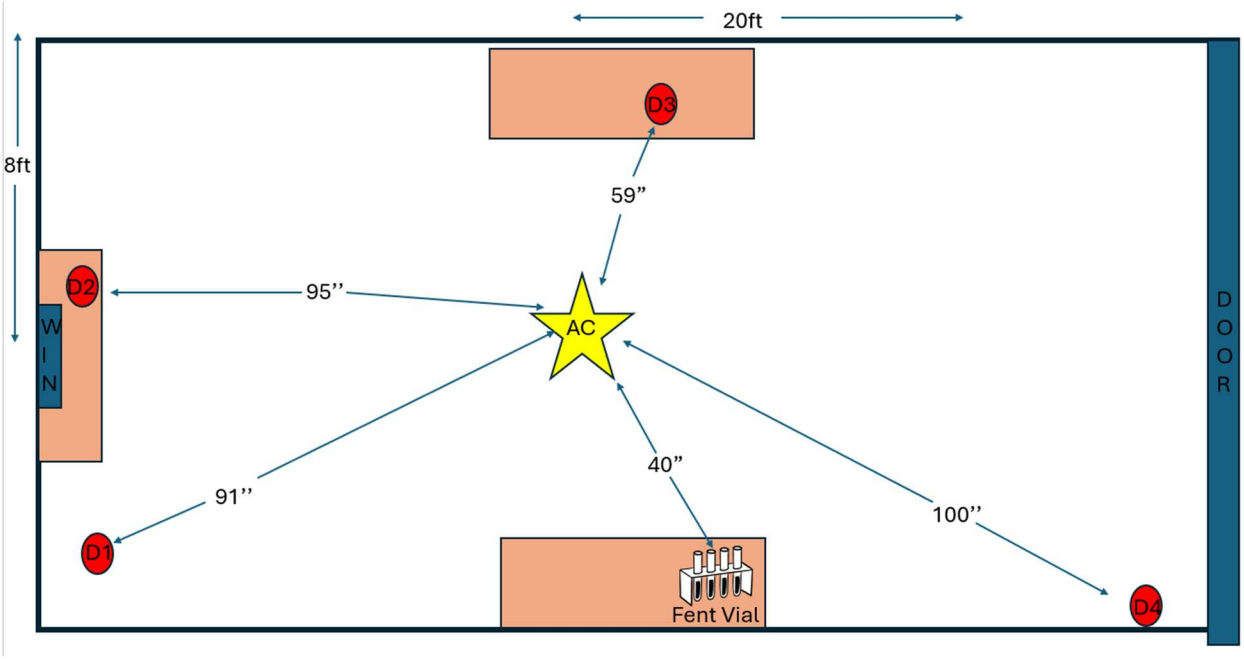


Figure A-1. Test layout, plan view. Not to scale.

Appendix B — Material and Lot Record

Item	Identifier	Notes
Dahlgren Decon® / PeroxySolid™	Lot 51320	22 oz kit
Dahlgren Decon® / PeroxySolid™	Lot 49420	22 oz kit
Dahlgren Decon® / PeroxySolid™	Lot 52220	22 oz kit
Opioid Detection Kit (ODK)	Lot 082025	Field screening kit
BTNX Lateral Flow Test Strips	Lot DOAA2409002	20 ng/mL stated detection limit
Fentanyl Reference Standard	Cerilliant, 1 mg/mL in methanol	Vial head broken during aliquot process
Coupons	6061-T6 aluminum, mill finish	2 in dia × 0.125 in, four each
Dispensing System	AeroClave RDS 3110	Nominal 28 mL/min/head

Table B-1. Materials and lot identification.

Appendix C — Photographic Record Index

The following photographs were taken during the test and are maintained with the test file. Images are not reproduced in this report.

- Coupons D1–D4 in position within the conex, each with bagged identification label.
- RDS 3110 placement within the conex.
- Temperature and humidity sensor reading at test start.
- Assay result for coupon D3, rinse method.
- Assay result for coupon D3, dry swab method.
- Assay results for coupons D1, D2, and D4.
- Assay result for source fentanyl vial.

End of Report