# EVALUATION OF COMMERCIALLY AVAILABLE DECONTAMINATION CHEMICALS

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## ABSTRACT

The effectiveness of commercially available decontamination solutions was compared with the effectiveness of 10% oxalic acid in controlled laboratory tests. Type 304L stainless steel and Inconel* 625 specimens were used. Contamination was sludge from Savannah River Plant (SRP) high level waste tanks. Measured amounts of contamination were placed on each specimen. They were then heated to bond the contamination to the surface and cleaned according to the manufacturer's directions. The effectiveness of the product was determined by monitoring specimens before and after cleaning. Four of the 16 solutions evaluated removed all the contamination from Type 304L stainless steel. Inconel 625 was more difficult to decontaminate. Further tests are planned with the chemicals that were most effective in this test.

## INTRODUCTION AND SUMMARY

Decontamination technology is being investigated in order to reduce personnel exposure, minimize the potential for release and uptake of radioactive material, and increase safety during decontamination operations. Currently, Type 304L stainless steel process equipment at SRP is decontaminated using 10 wt % oxalic acid solution, which is compatible with existing waste streams. Cleaning solutions (decontamination chemicals and detergents) are marketed that manufacturers claim will decontaminate better and faster than oxalic acid. Also, additives (surfactants) are sold that increase the efficiency of cleaning solutions. The companies listed in the 1987 Nuclear News Buyers' Guide (1) as vendors of decontamination materials were asked to send information about their products and samples for evaluation.

A series of laboratory tests was completed to determine the relative effectiveness of 16 chemicals and additives. Raw sludge from SRP waste tanks was used as the contamination. These tests therefore determine the relative effectiveness of the materials evaluated to remove this one type of contamination only. This contamination is typical of the type of contamination found at this site. It has been used successfully in previous decontamination tests (2-4). Ten weight percent oxalic acid solution was included as a control. Type 304L stainless steel and Inconel 625 coupons were contaminated with equal amounts of a water suspension of raw sludge. The coupons were heated to fix the contamination in the surface oxide film formed during heating. They were then cooled, monitored, and soaked in the various chemicals at concentration and temperature conditions recommended by the manufacturers. The coupons were then rinsed, dried, and monitored again.

Of 16 chemicals being evaluated, four removed all of the contamination from the Type 304L stainless steel specimens (Decon 4521, Decon 4518, Decon 4306D, and Radiacwash). Oxalic acid, the control, also removed all of the contamination. Five chemicals that removed from 38 to 98.6% of the contamination were Nutek 75C/2X, Nutek 750C, Lift-Away, Chem-Crest #17, Nutek 600 EL, Decomtam-Q, and Isoclean. Five chemicals that removed less than 24% of the contamination were Chem-Crest #200, Contrad 70, Rad-Con, Count-Off, and Neutrad CRC.

As expected, the Inconel 625 was more difficult to decontaminate than the Type 304L stainless steel. Out of the 16 chemicals being evaluated, only one removed 100% of the contamination from the Type 304L stainless steel specimens (Decon 4521). Oxalic acid, the control in these tests, removed 100% of the contamination. The order of ranking for the other chemicals was not the same for Type 304L stainless steel and Inconel 625.

To test the effectiveness of additives and surfactants, plans are to increase the bonding between the contamination and the specimen by increasing the temperature to which the specimens are heated. This is expected to make contamination more difficult, and will be continued until specimens are produced that can be only partially decontaminated with the most effective decontamination chemical being evaluated.

* Registered Trademark, Huntington Alloys.

## CHEMICALS EVALUATED

News Buyer's Guide (1) published a list of companies that produce decontamination materials. Seventy-two companies were contacted and 26 responded. Thirty-four materials recommended for decontamination of metal surfaces were selected for this experiment. These materials were divided into three subgroups: decontamination chemicals (15), surfactants (9), detergents (7).

The chemical compositions of the commercially available decontamination chemicals are proprietary and are not divulged in the technical literature. However, the components most commercially available chemicals contain to remove fixed contamination, include oxide removers, chelating agents, sequestrants, and emulsifiers. Other compounds can include ion-exchangers, peptizers, carriers, solvents, solubilizers, wetting agents, etc. Some chemical compounds cannot be used at SRP because they are incompatible with the waste stream. For example, all phosphates interfere with the waste glass process and are harmful to the environment.

The decontamination chemicals tested are listed in Table I. The concentration and temperature conditions recommended by the manufacturers are listed in Table II. Details concerning the products are discussed below:

a. Atomic Products produces a decontaminant called Radiacwash. It is aliquid that contains no phosphates, chromates, silicates, enzymes,borates aluminates, carbonates, halides, or inert fillers. It is nonalkaline, noncorrosive, biodegradable, and germicidal. It removes radioactive particles in two ways: It sequesters the metallic ions and then lifts and suspends them.

b. Chem-Crest Ultrasonics sent samples of Chem-Crest #17 and Chem-Crest#200. Chem-Crest #17 contains no metallic salts, phosphates, or sulfur compounds. It is a biodegradable, nonalkaline liquid that is specially formulated for metal surfaces. Chem-Crest #200 is a slightly alkaline,white crystalline powder. It contains no phosphates, carbonates, sulfonates, or metasilicates.

c. Du Pont manufacturers a decontaminant called Count-Off. This chemical contains nonreactive emulsifiers for efficient substrate removal. A 2%solution is mildly alkaline.

d. ESPI produces Decontam-Q. This product contains no hazardous ingredients. It is a slightly alkaline liquid that is biodegradable,noncorrosive, and nonflammable.

e. Hi-Q Environmental Products manufactures Contrad 70 and Neutrad CRC.They are both phosphate/chlorine-free, biodegradable liquids. Neutrad CRC has a neutral pH.

f. Nutek sent samples of 750C, 75C/2X, and 600 EL. The 750C is a calcium sulfate scale remover. It is a noncorrosive, nonacid, biodegradable liquid with a nearly neutral pH. It should be effective on both stainless steel and the Inconel alloys. The 75C/2X is a neutral compound that dissolves oxides and other inorganic compounds from metallic surfaces. It is a nontoxic, nonacidic, biodegradable liquid that is recommended for use with stainless steel. The 600 EL is designed to remove smearable contamination and does not remove contamination incorporated with oxide films. It is a nonphosphate, nontoxic, neutral,biodegradable liquid.

g. Research Products International manufacturers Lift-Away. It is a noncorrosive, nonacidic, biodegradable liquid. It contains no phosphates, chromates, carbonates, borates, or halides.

h. Turco Products produces three decontamination chemicals selected for these tests: Decon 4306D, Decon 4518, and Decon 4521. Decon 4306D is a powder. It does not attack stainless steel. It has low chloride and fluoride impurities but does contain bisulfate. Both Decon 4518 and 4521 contain oxalic acid and are designed to decontaminate stainless steel.

i. Victoreen Nuclear Associates produces Isoclean and Rad-Con. Isoclean is advertised as having a cleaning power comparable to a hot sulfuric acid-dichromate mixture without the hazardous components. It is a mildly alkaline liquid. Rad-Con is a foam spray designed to remove smearable contamination. It is noncorrosive, but it contains phosphoric acid and pyrophosphates.

## EXPERIMENTAL PROCEDURE

Type 304L stainless steel and Iconel 625 metal coupons [1 in. (2.54 cm) x 3 in. (7.62 cm) x 1/16 in. (0.159 cm)] were used for these tests. Type 304L stainless steel with an ASTM Number 2B (hot-rolled, pickled, annealed, and cold-rolled) is the material presently used for the construction of process equipment at SRP. Inconel 625 was tested because it is an example of a more corrosion-resistant material than Type 304L stainless steel. Process equipment would have a longer lifetime if it could be fabricated from Inconel 625. This material is not presently used, because it is more difficult to decontaminate than Type 304L stainless steel.

The coupons were washed with soap and water, alcohol, and acetone. They were then contaminated with equal amounts of a water suspension of raw sludge from an SRP waste tank. The contaminant was diluted so that 0.05 mL resulted in a radioactivity level of approximately 25 mR/hr. Each specimen was contaminated with 0.05 mL of this material. The contamination was placed in the center of one face of the specimen.

TABLE I

Codes for Laboratory Experiments

| Detergents | | Fluorosurfactants | | Surfactants | |
|---|---|---|---|---|---|
| A: | Alconox | H: | Zonyl FSJ | N: | Alkanol 189S |
| B: | Liqui-nox | I: | Zonyl FSK | O: | Petrowet-R |
| C: | Terg-a-zyme | J: | Zonyl FSO | P: | Decon 4501A |
| D: | Detergent 8 | K: | Zonyl FSP | Q: | Decon 4502 |
| E: | Bio-T 250 | L: | Zonyl TBS | | |
| F: | Bio-T 200 | M: | Zonyl FSN | | |
| G: | Nutek 316 | | | | |

| Decon Chemicals | | Metal Types | |
|---|---|---|---|
| R: | Radiacwash | 1: | Type 304L SS, ASTM #2B |
| S: | Chem-Crest #17 | 2: | Inconel 625 |
| T: | Chem-Crest #200 | | |
| U: | Decontam-Q | | |
| V: | Contrad 70 | Control Solution | |
| W: | Nutek 600 EL | | |
| X: | Lift-Away | 10 wt % oxalic acid | |
| Y: | Decon 4306D | | |
| Z: | Neutrad CRC | | |
| AA: | Decon 4521 | | |
| BB: | Decon 4518 | | |
| CC: | Rad-Con | | |
| DD: | Isoclean | | |
| EE: | Count-Off | | |
| FF: | Nutek 750C | | |
| GG: | Nutek 75C/2X | | |

The coupons were heated to fix the contamination in the oxide film formed on the surface during heating. After the contaminant was air-dried, the specimens were heated in air at 600C for 1 hour. After cooling to room temperature, the specimens were monitored to determine the initial levels of radioactivity. They were then soaked in the various decontamination chemicals at the concentration and temperature recommended by the manufacturers. The coupons were then monitored again to determine the change in radioactivity. All tests were conducted in a radioactive hood.

The measurement area consisted of a clean, elevated surface about 3 in. (7.62 cm) x 3 in. (7.62 cm) x 1 in. (2.54 cm). This area was surrounded by lead bricks to shield the coupon from background radiation while a measure ment was being taken. The same area was used for measuring all coupons. Since each solution required four coupons (two Inconel and two stainless steel), four hot plates, beakers, and thermometers were used for each solution. Agitation was supplied by magnetic stirrers.

## RESULTS

The top five chemicals cleaned the stainless steel (Tables III and IV), and the two highest ranking chemicals cleaned the Inconel (Tables V and VI). The top 10 chemicals were the same for both stainless steel and Inconel, although the order varied. The top 10 ranking chemicals all had a decontamination factor of 2 or greater.

The control solution of oxalic acid decontaminated the Inconel and stainless steel as well as the other decontamination chemicals did. The chemicals that gave zero readings for the stainless steel were Decon 4521, Decon 4518, Decon 4306D, Radiacwash, and the oxalic acid. For the Inconel, only the Decon 4521 and the oxalic acid gave zero readings.

Chemicals moderately effective on the stainless steel included:

- Nutek 75C/2X (final count: 0.25)
- Nutek 750C (final count: 1.5)
- Lift-Away (final count: 3.0)

Chemicals found to be moderately effective for the Inconel included:

- Decon 4306D (final count: 0.25)
- Radiacwash (final count: 0.25)
- Decon 4518 (final count: 1.0)
- Lift-Away (final count: 1.5)
- Nutek 75C/2X (final count: 2.0)
- Chem Crest #17 (final count: 5.5)
- Nutek 750C (final count: 6.0)
- Nutek 600 EL (final count: 6.5)

All chemicals that had a decontamination factor of less than 2 will be excluded from further testing. These included (for both Inconel 625 and Type 304L stainless steel) Decontam-Q, Isoclean, Chem-Crest #200, Contrad 70, Rad-Con, Count-Off, and Neutrad CRC.

## TABLE II

### Concentration and Temperature Conditions

| Chemical | Concentration | Temperature, °C | Time, hr |
|---|---|---|---|
| Radiacwash | 5 to 40 parts water; add 350 mL of Radiacwash to 150 mL of water. | 60 to 70 | 1 |
| Chem-Crest #17 | 1-3 oz/gal of water; add 12 mL of Chem-Crest #17 to 500 mL of water. | 50 to 70 | 1 |
| Chem-Crest #200 | 85 g/gal of water; add 11.23 g of Chem-Crest #200 to 500 mL of water. | 50 to 80 | 1 |
| Decontam-Q | 15% solution; add 75 mL of Decontam-Q to 425 mL of water. | 90 to 100 | 1 |
| Contrad 70 | Use a 2-5% solution; add 25 mL of Contrad 70 to 475 mL of water. | 80 to 90 | 1 |
| Nutek 600 EL | Use a 2% solution; add 10 mL of Nutek 600 EL to 490 mL of water. | 93 to 99 | 1 |
| Lift-Away | 10-40 parts water; add 300 mL of Lift-Away to 200 mL of water. | 60 to 70 | 1 |
| Decon 4306D | 6-12 oz/gal of water; add 37.44 g of Decon 4306D to 500 mL of water. | 66 to 70 | 1 |
| Neutrad CRC | Use a 5% solution; add 25 mL of Neutrad CRC to 475 mL of water. | 80 to 90 | 1 |
| Decon 4521 | 238.46 g/gal of water; add 37.44 g of Decon 4521 to 500 mL of water. | 80 to 85 | 1 |
| Decon 4518 | 340.15 g/gal of water; add 37.44 g of Decon 4518 to 500 mL of water. | 85 to 93 | 1 |
| Rad-Con | Spray thickly. | Room temperature | 1 |
| Isoclean | Use a 5% solution; add 10 mL of Isoclean to 490 mL of water. | 80 to 90 | 1 |
| Count-Off | Use a 5% solution; add 25 mL of Count-Off to 475 mL of water. | 32 | 1 |
| Nutek 750C | Use a 5% solution; add 25 mL of Nutek 750C to 475 mL of water. | 93 to 99 | 1 |
| Nutek 75C/2X | Use a 5% solution; add 25 mL of Nutek 75C/2X to 475 mL of water. | 93 to 99 | 1 |
| 10% Oxalic Acid--Control | Use a 10 wt % solution; add 50 g of oxalic acid to 500 mL of water. | 100 | 1 |

## TABLE III

### Radioactive Levels on Type 304L Stainless Steel Before and After Soaking in the Decontaminant

| Coupon No. | Count before Fixing at 600°C | | Count after Fixing at 600°C | | Count after Soaking | |
|---|---|---|---|---|---|---|
| | Count | Date | Count | Date | Count | Date |
| 1-R1 | 27 | 7-1 | 27 | 7-2 | 0 | 7-23 |
| 1-R2 | 25 | 7-1 | 26 | 7-13 | 0 | 7-23 |
| 1-S1 | 25 | 7-1 | 25 | 7-2 | 9 | 7-15 |
| 1-S2 | 24 | 7-1 | 25 | 7-13 | 9 | 7-15 |
| 1-T1 | 26 | 7-2 | 24 | 7-2 | 18 | 7-23 |
| 1-T2 | 23 | 7-2 | 27 | 7-13 | 21 | 7-23 |
| 1-U1 | 22 | 7-2 | 24 | 7-2 | 17 | 7-17 |
| 1-U2 | 25 | 7-2 | 25 | 7-13 | 15 | 7-17 |
| 1-V1 | 25 | 7-2 | 23 | 7-2 | 18 | 7-24 |
| 1-V2 | 22 | 7-2 | 23 | 7-13 | 21 | 7-24 |
| 1-W1 | 25 | 7-2 | 27 | 7-2 | 9 | 7-16 |
| 1-W2 | 24 | 7-2 | 25 | 7-13 | 16 | 7-16 |
| 1-X1 | 25 | 7-2 | 26 | 7-2 | 6 | 7-21 |
| 1-X2 | 27 | 7-2 | 27 | 7-13 | 0.5 | 7-21 |
| 1-Y1 | 25 | 7-2 | 24 | 7-2 | 0 | 7-21 |
| 1-Y2 | 27 | 7-2 | 24 | 7-13 | 0 | 7-21 |
| 1-Z1 | 26 | 7-2 | 25 | 7-2 | 20 | 7-20 |
| 1-Z2 | 29 | 7-2 | 30 | 7-13 | 25 | 7-20 |
| 1-AA1 | 25 | 7-2 | 22 | 7-2 | 0 | 7-14 |
| 1-AA2 | 25 | 7-2 | 22 | 7-13 | 0 | 7-14 |
| 1-BB1 | 28 | 7-2 | 28 | 7-2 | 0 | 7-17 |
| 1-BB2 | 28 | 7-2 | 26 | 7-13 | 0 | 7-17 |
| 1-CC1 | 30 | 7-2 | 28 | 7-2 | 21 | 7-24 |
| 1-CC2 | 27 | 7-2 | 26 | 7-13 | 20 | 7-24 |
| 1-DD1 | 26 | 7-2 | 26 | 7-13 | 17 | 7-23 |
| 1-DD2 | 26 | 7-2 | 27 | 7-13 | 16 | 7-23 |
| 1-EE1 | 26 | 7-2 | 20 | 7-13 | 20 | 7-21 |
| 1-EE2 | 32 | 7-2 | 31 | 7-13 | 25 | 7-21 |
| 1-FF1 | 25 | 7-2 | 23 | 7-13 | 4 | 7-20 |
| 1-FF2 | 18 | 7-2 | 18 | 7-13 | 0.5-1 | 7-20 |
| 1-GG1 | 19 | 7-2 | 19 | 7-13 | 0 | 7-17 |
| 1-GG2 | 17 | 7-2 | 17 | 7-13 | 0-0.5 | 7-17 |
| 1-CONT1 | 18 | 7-2 | 18 | 7-13 | 0 | 7-17 |
| 1-CONT2 | 15 | 7-2 | 15 | 7-13 | 0 | 7-17 |

## TABLE IV

### Order of Effectiveness of Decontaminant Solutions, the Percent Change in the Radioactivity Level, and the Decontamination Factor for Each Solution for Type 304L SS

| Rank | Solution | % Change | Decontamination Factor |
|---|---|---|---|
| 1 | AA: Decon 4521 | 100 | Infinity |
| 2 | BB: Decon 4518 | 100 | Infinity |
| 3 | Y: Decon 4306D | 100 | Infinity |
| 4 | CONT: Oxalic Acid | 100 | Infinity |
| 5 | R: Radiacwash | 100 | Infinity |
| 6 | GG: Nutek 75C/2X | 98.6 | 72 |
| 7 | FF: Nutek 750C | 92.7 | 13.7 |
| 8 | X: Lift-Away | 88.7 | 8.83 |
| 9 | S: Chem-Crest #17 | 64 | 2.8 |
| 10 | W: Nutek 600 EL | 51.9 | 2.08 |
| 11 | U: Decontam-Q | 34.7 | 1.53 |
| 12 | DD: Isoclean | 37.7 | 1.66 |
| 13 | T: Chem-Crest #200 | 23.5 | 1.31 |
| 14 | V: Contrad 70 | 15.2 | 1.18 |
| 15 | CC: Rad-Con | 25.5 | 1.34 |
| 16 | EE: Count-Off | 11.8 | 1.13 |
| 17 | Z: Neutrad CRC | 18.2 | 1.22 |

## TABLE V

### Radioactive Levels on Inconel 625 Before and After Soaking in the Decontaminant

| Coupon No. | Count before Fixing at 600°C | | Count after Fixing at 600°C | | Count after Soaking | |
|---|---|---|---|---|---|---|
| | Count | Date | Count | Date | Count | Date |
| 2-R1 | 28 | 7-13 | 28 | 7-14 | 0-0.5 | 7-23 |
| 2-R2 | 31 | 7-13 | 30 | 7-14 | 0-0.5 | 7-23 |
| 2-S1 | 30 | 7-13 | 30 | 7-14 | 6 | 7-15 |
| 2-S2 | 30 | 7-13 | 30 | 7-14 | 5 | 7-15 |
| 2-T1 | 24 | 7-13 | 23 | 7-14 | 17 | 7-23 |
| 2-T2 | 27 | 7-13 | 28 | 7-14 | 21 | 7-23 |
| 2-U1 | 28 | 7-13 | 27 | 7-14 | 17 | 7-17 |
| 2-U2 | 24 | 7-13 | 27 | 7-14 | 17 | 7-17 |
| 2-V1 | 22 | 7-13 | 28 | 7-14 | 17 | 7-24 |
| 2-V2 | 28 | 7-13 | 30 | 7-20 | 20 | 7-24 |
| 2-W1 | 24 | 7-13 | 25 | 7-14 | 6 | 7-16 |
| 2-W2 | 25 | 7-13 | 26 | 7-14 | 7 | 7-16 |
| 2-X1 | 12 | 7-13 | 11 | 7-14 | 0.5-1 | 7-21 |
| 2-X2 | 20 | 7-13 | 20 | 7-14 | 1.5 | 7-21 |
| 2-Y1 | 21 | 7-13 | 23 | 7-14 | 0 | 7-21 |
| 2-Y2 | 23 | 7-13 | 23 | 7-14 | 0.5 | 7-21 |
| 2-Z1 | 24 | 7-13 | 24 | 7-14 | 18 | 7-20 |
| 2-Z2 | 26 | 7-13 | 26 | 7-14 | 20 | 7-20 |
| 2-AA1 | 23 | 7-13 | 24 | 7-14 | 0 | 7-24 |
| 2-AA2 | 27 | 7-13 | 26 | 7-14 | 0 | 7-24 |
| 2-BB1 | 27 | 7-13 | 26 | 7-15 | 1 | 7-17 |
| 2-BB2 | 25 | 7-13 | 25 | 7-15 | 1 | 7-17 |
| 2-CC1 | 19 | 7-13 | 18 | 7-15 | 13 | 7-24 |
| 2-CC2 | 17 | 7-13 | 18 | 7-15 | 12 | 7-24 |
| 2-DD1 | 22 | 7-13 | 22 | 7-15 | 12 | 7-23 |
| 2-DD2 | 20 | 7-13 | 20 | 7-15 | 13 | 7-23 |

TABLE V, Cont'd.

| Coupon No. | Count before Fixing at 600°C Count | Date | Count after Fixing at 600°C Count | Date | Count after Soaking Count | Date |
|---|---|---|---|---|---|---|
| 2-EE1 | 15 | 7-13 | 16 | 7-15 | 12 | 7-21 |
| 2-EE2 | 13 | 7-13 | 14 | 7-15 | 10 | 7-21 |
| 2-FF1 | 21 | 7-13 | 23 | 7-15 | 6 | 7-20 |
| 2-FF2 | 21 | 7-13 | 22 | 7-15 | 6 | 7-20 |
| 2-GG1 | 20 | 7-13 | 20 | 7-15 | 2 | 7-17 |
| 2-GG2 | 20 | 7-13 | 21 | 7-15 | 2 | 7-17 |
| 2-CONT1 | 26 | 7-13 | 25 | 7-15 | 0 | 7-17 |
| 2-CONT2 | 23 | 7-13 | 23 | 7-15 | 0 | 7-17 |

TABLE VI

Order of Effectiveness of Decontaminant Solutions, the Percent Change in the Radioactivity Level, and the Decontamination Factor for Each Solution for Inconel 625

| Rank | Solution | % Change | Decontamination Factor |
|---|---|---|---|
| 1 | AA: Decon 4521 | 100 | Infinity |
| 2 | CONT: Oxalic Acid | 100 | Infinity |
| 3 | Y: Decon 4306D | 98.9 | 92 |
| 4 | R: Radiacwash | 99.1 | 116 |
| 5 | BB: Decon 4518 | 96.1 | 25.5 |
| 6 | X: Lift-Away | 89.7 | 11.6 |
| 7 | GG: Nutek 75C/2X | 90.2 | 10.25 |
| 8 | S: Chem-Crest #17 | 81.7 | 5.45 |
| 9 | FF: Nutek 750C | 73 | 3.75 |
| 10 | W: Nutek 600 EL | 76.5 | 3.92 |
| 11 | EE: Count-Off | 26.7 | 1.36 |
| 12 | DD: Isoclean | 40.5 | 1.68 |
| 13 | CC: Rad-Con | 30.6 | 1.44 |
| 14 | U: Decontam-Q | 37 | 1.59 |
| 15 | V: Contrad 70 | 36.2 | 1.57 |
| 16 | T: Chem-Crest #200 | 25.5 | 1.34 |
| 17 | Z: Neutrad CRC | 24 | 1.32 |

## PROGRAM

Oxalic acid is undesirable at SRP as it precipitates on the process equipment and obstructs the flow of fluid. The two best chemicals identified in these tests (Decon 4521 and Decon 4518) contain oxalic acid. Decon 4306D was the most effective chemical that does not contain oxalic acid. Therefore, tests are planned using Decon 4306D with full-size equipment.

The ability of additions of the detergents and surfactants to increase the effectiveness of the decontamination chemicals will also be evaluated. Plans are to increase the bonding between the contamination and the specimen by increasing the temperature to which the specimens are heated. This will make decontamination more difficult. This will be continued until specimens are produced that can be only partially decontaminated with the most effective decontamination chemical. Then, the ability of the additives to increase the effectiveness of the decontaminating chemical will be evaluated.

## ACKNOWLEDGMENT

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