Testing of a Portable Ultrahigh Pressure
Water Decontamination System
(UHPWDS)

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*Testing of a Portable Ultrahigh Pressure
Water Decontamination System
(UHPWDS)*

*Adrian Lovell
Joel Dahlby*

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TESTING OF A PORTABLE ULTRAHIGH PRESSURE WATER DECONTAMINATION SYSTEM (UHPWDS)

by

Adrian Lovell and Joel Dahlby

ABSTRACT

This report describes tests done with a portable ultrahigh pressure water decontamination system (UHPWDS) on highly radioactively contaminated surfaces. A small unit was purchased, modified, and used *in situ*, (e.g., to work on a containment box while that containment box was still connected to its normal ventilation system) to change the waste level of the contaminated box from transuranic (TRU) waste to low-level waste (LLW). Low-level waste is less costly by as much as a factor of five or more if compared with TRU waste when handling, storage, and disposal are considered. The portable unit we tested is commercially available and requires minimal utilities for operation.

We describe the UHPWDS unit itself a procedure for its use, the results of the testing we did, and conclusions including positive and negative aspects of the UHPWDS.

INTRODUCTION

Our analytical chemistry group at LANL handles and analyzes many radioactive materials and does chemistry on many samples of these materials. In order to accomplish this work, elaborate stainless steel enclosures (containment boxes and/or glove boxes) are used. Periodically, because of programmatic changes or deterioration from corrosion, these containment boxes must be removed or reworked.

Where other more exotic methods are unavailable, a manual method is sometimes used for the decontamination of glove box interior surfaces. Manual cleaning consists of scrubbing bare metal with various acids and using chemical paint strippers for painted surfaces. This operation is time-consuming and involves many hours of hard work to convert one glove box from TRU level waste to LLW.

High-pressure water was used by Nuclear Fuels Services personnel⁽¹⁾ in Erwin, TN to decontaminate glove boxes and other equipment in a plutonium laboratory. Approximately 85% of TRU waste was converted to LLW. Their unit required the use of a room or chamber where the equipment was put inside along with a person in an air supply suit to do the decontamination with the high-pressure water.

We wanted to see if it was possible to have manufactured and use effectively a scaled down high-pressure water system that would be portable and could be used *in situ*. We purchased a UHPWDS and tested it on stainless steel surfaces that were contaminated with plutonium. Some of the criteria we were looking for in this decontamination system were efficient operation, ease of operation, portability, minimal operational utilities required, and safe operator equipment configuration.

EQUIPMENT DESCRIPTION

High-pressure Water Pump

The UHPWDS we purchased consists of a high-pressure water pump and a specially made gun-type water-jet cleaning tool. All moving parts are

enclosed within removable protective covers for operator safety. The high-pressure water pump (Fig. 1) is a *Cougar II* unit supplied by Flow International Corporation, of Kent, Washington. It is a compact unit measuring 32 inches high, 27 inches wide, and 25 inches deep. The unit weighs 475 pounds and is on casters for ease of mobility. One person can move it to different locations. An 11 horse power electric motor along with a triplex pump (Fig. 2) is used to achieve and maintain normal working water pressures of from 5,000 to 40,000 psi. The equipment has a pressure control valve that allows for operation of pressures within this range. Incoming water (minimum 1 gal/min at 30 psi) is dual filtered to remove particles larger than 0.5 microns. Water in the triplex pump is pressurized in a chamber of a high-pressure water cylinder (there are three cylinders total). The water pressure is the result of a plunger driven by the electric motor, reducing the water chamber volume. Figure 3 shows the electrical panel on the high-pressure water-pump system with the emergency shut-off button.

Hand-held Cleaning Tool

The gun-type cleaning tool is a Model A-3000 JetLance modified by Flow International Corporation. Because of limited space in our radioactive containment boxes, it was necessary to work with the manufacturer to radically reduce the dimensions and weight of this tool from how they originally supply it. The shortest unit they

Fig. 1. High-pressure water pump system.

normally supply is 10.5 inches high, 2.5 inches wide, and 26.0 inches length. The final design dimensions of our unit received from the manufacturer are 8 inches high, 14.5 inches wide, and 10.5 inches length (Figs. 4, 5, and 6). The weight of the unit and its accompanying multidirectional swivel coupling on the high-pressure water line is approximately 12 pounds. The reduction of the overall gun length was made possible because sashes and windows are normal parts of the containment boxes and fume hoods and thus protect the gun operator from water spray and any particulate projectiles. Figures 4, 5, and 6 also show the effect of cleaning (paint removal) on a chemistry hood that had a very difficult-to-remove "Plasite" painted surface.

After initial testing on a chemistry hood, we further modified this tool (Figs. 7, 8, and 9) to make

it more usable in the containment box. This modification made the tool much lighter and easier to handle. The optimum holding technique is to grasp the taped handle with one hand and the other hand on the high-pressure water hose with the other hand. The on/off switch that controls the high-pressure water to the cleaning gun was mounted on a plate and is foot-operated by the person controlling the cleaning gun (Fig. 10).

The rotating gun tip (Fig. 9) consists of four jets. Variations in jets and tips are available from the manufacturer, but for this test evaluation only the four-jet nozzle was used. The cleaning path width for this system is approximately one inch. To facilitate a multidirection movement and cleaning capability, the gun is fitted with a high-pressure swivel connection for the water supply.

Fig. 2. Triplex water pump.

Fig. 3. Electrical panel and connections.

Fig. 4. Cleaning head, front view.

Fig. 5. Cleaning head, back view.

The cleaning gun utilizes the high water pressure with relatively low water volumes (only up to 0.4 gal/min) and high nozzle rotation speeds. This combination provides, in many cases, excellent contamination removal rates while generating minimum waste. One obvious advantage of this system is that no chemical stripper or decontamination agents are used. Solids such as paint and rust residues can be collected, dried, measured, and discarded using existing TRU waste streams. Another advantage is that there are no abrasives used to clean the surfaces. Cleaning action relies totally on the high water pressure and tip rotation.

Other Associated Equipment

Another component of the UHPWDS is a small frame-like unit called the "tumble box" (Figs. 11

and 12). The tumble box (12 inches high, 18 inches wide, and 12 inches deep) contains an ultrahigh-pressure on/off valve, air filter, air lubricator (for the high-speed rotating nozzle), air pressure gauge, air regulator, and air pressure on/off valve. It is connected between the high-pressure water pump and the cleaning gun. In addition to the water supply, an 80 psi at 32 scfm air supply is required. A peristaltic-type pump (Fig. 13) was used to remove water from cleaning operations because a sink was not available in the test box. The pump routed water to a sink near the operation and was screened on the uptake end to prevent clogging and to consolidate the removed contaminated material.

All fittings and hoses are rated to handle 60,000 psi, which gives an added safety limit above the

Fig. 6. Cleaning head, held during cleaning operation.

Fig. 7. Cleaning head, modified for glove box operation.

Fig. 8. Close-up view of cleaning head, modified for glove box operation.

Fig. 9. Front view of cleaning head, modified for glove box operation.

system operating pressure of 40,000 psi. The 11 hp motor uses 208Vac and requires a 50-amp circuit to handle the high-pressure water pump. The 208Vac is the commonly used voltage at our facility. Any other high voltage required can be supplied by the manufacturer.

The decontamination operation using the UHP-WDS utilizes a two-man rule to facilitate equipment shut down should this become necessary in an emergency situation. Complete equipment specifications for the equipment we bought are given in Appendix #1. The cost of the unit we bought using these specifications was about \$60,000.

Fig. 10. Foot switch for operation of cleaning gun.

Fig. 11. Tumbler box, top view.

Fig. 12. Close-up side view of tumbler box.

Fig. 13. Pump for removal of waste water.

TESTING CONDITIONS (Nonradioactive)

Preliminary tests were conducted on a chemical fume hood located in a nonradioactive area (Fig. 5). This hood effectively simulated a contaminated containment system as it had seen constant use and had many coats of paint similar to that found on radioactive-contaminated systems throughout our facility. Multicoat paint removal is one of the primary procedures assessed as this condition is prevalent throughout the stainless steel glove box containment systems in our analytical chemistry labs.

We quickly determined that working at <40,000 psi was inefficient and that when the pressure was dropped from 40,000 to 35,000 psi, the cleaning time (e.g., paint removal) for the same area was almost doubled. At 40,000 psi it took the modified cleaning head approximately 7 minutes to clean a 1ft² surface area to a bright metal surface. A quick calculation of the surface square footage of one of our standard glove boxes (ft² of box space [less windows] = 35.6 ft²) showed that if the jet spray system was used continuously it would take less than five hours to decontaminate the box. Mechanical means using strippers and abrasives have taken weeks of manual labor to accomplish the same square footage of cleaning. This bright metal surface is very desirable because it is a good indicator of contaminant removal and indicates a total surface interaction with the water jet. Another desirable feature is that the process wets all surfaces, thus reducing the chance spread of airborne contamination.

A test was run to see if the high speed rotation of the water-jet nozzle was necessary to the cleaning operation. The cleaning head uses a continuous air flow of 32 scfm at 90 psi via a 1/2 inch id air hose. This is a considerable volume of air, and it was important to see if this air demand was necessary because a large industrial compressor or other large air source is needed. At our facility we have access to portable liquid argon dewars, and argon was initially tried as a gas-pressure source to drive the rotating water-jet head. The rapid flow of the argon from the dewar chilled the equipment and caused the high-pressure on/off valve for the water jet to fail in a continuous open mode,

consequently this pressure form was discontinued. When a suitable air source such as the industrial compressor used to supply air through our facility was utilized, all systems performed as per manufacturer's specification. This compressor maintains a constant pressure of approximately 80 psi, however, it was found that allowing it to catch up every few minutes increased the jet cleaning action. Without rotation of the jet nozzle the cleaning effect is essentially a parallel line-type cleaning on the surface which is *very* inefficient and necessitates much more operator movement of the cleaning head. The rotating jet, on the other hand, allows for a quicker, more efficient, and more thorough cleaning swath (approximately one inch).

A scratch or nick in the paint prior to cleaning helps paint removal and chipping, and angling the water-jet nozzle at the surface to be cleaned increases the cleaning efficiency. Very controlled edging is possible in the event that there are some areas (glass, rubber, hands, etc.) that should not come in contact with the water jet.

A slow constant movement of the water jet is preferred to quick back and forth motions, and it should be noted that the water-jet tip must be almost in direct contact with the surface to be cleaned. Cleaning efficiency drops off significantly at a two-inch distance from the surface. A test showed that the water jet will not penetrate glove box gloves at a distance of three to four inches; however, it is imperative that the operator keep his or her hands away from the water jet. The water jet was intentionally used on various materials to determine both cleaning and destructive power. A standard rubber glove box glove (0.15 inch thick) was intentionally exposed to the water jet and it was severely lacerated in approximately eight seconds after direct contact with the jet (Fig. 14). The jet spray chipped and etched thick glass in <20 seconds (Fig. 15). Polyethylene that was 0.072 inches thick was shredded and cut through in <5 seconds (Fig. 16). From these studies it is obvious that glove box gaskets, windows and gloves should receive no direct exposure during the cleaning process.

Prolonged operation of the water jet does not seem to pose any problems for the box, however, with the small amount of air flow through the containment box there is some dripping due to

condensate. If the spray tip is activated at any significant distance from the surface to be cleaned, there is considerably more water mist and some fogging in the containment box. But, as stated earlier, the optimum spray distance is very close to the work surface. Excess air is exhausted through a muffler at the jet gun. The air-release noise level is minimal when the gun is used inside a containment box. If the unit is in operation and resting on the glove box floor the air muffler can blow water around, so precautions such as a flexible line attached to the muffler should be taken. The pump is noisy, but common ear plugs solve the problem if the noise became tedious.

Fig. 14. Damage to rubber glove box glove.

Fig. 15. Damage to glass.

Fig. 16. Damage to polyethylene plastic.

TESTING CONDITIONS (Radioactive)

After the initial testing under nonradioactive conditions was completed and modifications were made to the system, testing of the UHPWDS was continued on a radioactively contaminated glove box.

Preparation for Testing

A Radiation Work Permit (RWP), which is a formal document describing the radioactive operation, was finalized and a glove box used for radioactive work with Pu-239 was prepared for the radioactive decontamination testing portion of this project. Also, a standard operating procedure, Appendix-2, was prepared to document the safe operation of this equipment. The glove box was prepared as follows: (1) plastic drapes were placed over the areas surrounding the glove box, (2) the end-plate bolts and exhaust ducting plenum bolts were tightened to ensure proper sealing, (3) plastic catch envelopes with adsorbent material (cheese cloth) were attached at all potential leak points at the bottom of the box, and (4) a commercial sealant was applied to all utilities fittings at the point of their penetration of the box to prevent leakage (Figs. 17 and 18).

A 1/4 inch id Tygon tube was used in conjunction with a commercial peristaltic pump to move water, generated by the UHPWDS system, to a drain system. The pump was run at half-speed (approximately 0.4 gal/min). To filter the intake end of the

pump tubing, a screen (6 x 6 inches) and cheese cloth combination were used to screen out large particles (Fig. 13).

Test on Actual Containment Box Surface

The test on a contaminated glove box end-plate was done as follows: the painted surface was cleaned using a reduced pressure (20,000 psi spray) to remove any loosely adhering contamination, and the paint was removed by increasing the pressure spray stream to 40,000 psi. This test glove box had been in constant use for over 20 years for handling Pu-239 oxides and the dissolution of these oxides with a large variety of acids. The painted surface had a measured contamination of many million counts-per-minute per square inch (counts/min/in²). During the second step of the decontamination process (40,000 psi spray), the paint came off in large sheets. It is not expected that the paint will come off as easily in most situations. The paint in the chemical fume hood, which was used for earlier testing, was much more adherent. The paint in this glove box may have become brittle due to the acid dissolution procedures performed in the glove box, or possibly because the original surface preparation for the painting was not adequate.

After decontaminating the glove box end-plate using the two-step procedure described above, an alpha survey probe was inserted into the glove box and used to get an accurate contamination reading. It indicated no detectable alpha counts.

Fig. 17. Glove box plastic "catch pans."

Fig. 18. Plastic drapes under glove box.

Fig. 19. Typical coupon (#3), after contamination.

Radioactively Contaminated Coupon Tests

Over a six month period, eleven test coupons of stainless steel were exposed to various sources of contamination and mechanical abrasion by putting them inside nuclear material containment boxes. The coupons were placed where the highest possibility of contamination and operator interaction would take place. A typical coupon is shown after it was contaminated (Fig. 19) and after about a 2 in² section in the center of it was decontaminated (Fig. 20).

A brief summary of these tests indicates that painted surfaces are easily decontaminated using the two-step procedure outlined above. Unpainted surfaces are harder to decontaminate, especially if they are etched and/or exposed to acids containing radioactive material. Pu-238 on unpainted steel

Fig. 20. Typical coupon (#3), after decontamination.

is not easy to decontaminate to low-level waste (LLW). Nine of the 11 test plates were decontaminated to LLW (less than transuranic [TRU] levels or 100 nanocuries per gram of waste). The decontamination was accomplished by applying the UHPWDS for <10 minutes per square foot of test plate.

Decontamination treatment of the coupons using the UHPWDS consisted of first cleaning the surface using 20,000 psi water pressure in the cleaning tool to remove any loose surface contamination. Then the pressure was increased to 40,000 psi, which was used for removing the more adherent contamination as well as the paint on the surface. Operation of the UHPWDS in the glove box on a coupon is shown in Fig. 21 & 22).

Fig. 21. Cleaning a coupon inside glove box.

Fig. 22. Close-up, cleaning of coupon inside glove box.

Detailed Description of the Coupon Tests

Coupon #1: This coupon of bare stainless steel was placed in a containment glove box where Pu-238 oxide powder was handled on a daily basis. The coupon was placed on the floor of the glove box beside a balance where samples were weighed. The coupon was very heavily contaminated and measured much greater than a million counts/min/in².

Although the decontamination was partially effective, there still remained over a million counts/min/in² after cleaning with the UHPWDS. However, it should be remembered that the Pu-238 is approximately 200 times more alpha active than the Pu-239.

Coupon #2: This coupon of painted stainless steel was placed in a containment glove box where Pu-238 oxide powder was handled on a daily basis. The coupon was placed on the floor of the glove box beside a balance where samples were weighed. The coupon was very heavily contaminated, and measured much greater than a million counts/min/in².

The decontamination was effective, resulting in less than 250 counts/min/in² mainly because the painted surface contained most-to-all of the contamination, so when the paint was removed there was no residual contamination on the stainless steel.

Coupon #3: This coupon of painted stainless steel was placed in a containment glove box where Pu-239 dissolved in acid solutions had been handled and fumed with acids (e.g., HCl, HNO₃, H₂SO₄, HF, etc.) on a daily basis. The coupon was placed on the floor of the containment box in front of the hot plate where the samples were fumed, resulting in a level of 40,000 counts/min/in². The coupon was heavily stained on the painted surface by reaction with the chemicals used in the area.

The treatment of the painted surface at 20,000 psi water pressure using the UHPWDS lowered the contamination level to approximately 750 counts/min/in². With further treatment using the 40,000 psi water pressure, the decontamination,

resulted in less than 250 counts/min/in². This effective decontamination is mainly due to the painted surface having contained most-to-all of the contamination, so that when the paint was removed there was no residual contamination on the bare stainless steel metal.

Coupon #4: This coupon of bare stainless steel was placed in a containment glove box where Pu-239 oxide powder was handled on a daily basis. The coupon was placed on the floor of the glove box beside a balance where samples were weighed, resulting in very heavy contamination greater than a million counts/min/in².

Although the decontamination was somewhat effective, there still remained about 10,000 counts/min/in² after cleaning with the UHPWDS at 40,000 psi.

Coupon #5: This coupon of painted stainless steel was placed in a containment glove box where Pu-239 oxide powder had been handled on a daily basis. The coupon was placed on the floor of the glove box beside a balance where samples were weighed, resulting in contamination of about 300,000 counts/min/in². It should be noted that this painted coupon remained less contaminated than the unpainted coupon (#4) from the same area. The lesser level of contamination is a good indication that painted surfaces are easier to clean and decontaminate and form less radioactive material bonding than painted surfaces.

The treatment of the painted surface at 20,000 psi water pressure by the UHPWDS lowered the contamination level by about a third to 100,000 counts/min/in². With further treatment at 40,000 psi water pressure, the decontamination was resulted in less than 250 counts/min/in². This effective decontamination is mainly due to the painted surface having contained most-to-all of the contamination, so that when the paint was removed there was no residual contamination on the bare stainless steel.

Coupon #6: This coupon of bare stainless steel was placed in a containment glove box where Pu-239 dissolved in acid was handled and analyzed on a daily basis. The coupon had been placed on the

floor of the containment box in the area where the samples were routinely handled. This was the place where the highest possibility of contamination would take place; however, the fact that quantitative analysis was being done on these samples indicates that little to no spillage of the samples occurred. The coupon was contaminated to a level of 3,000 counts/min/in².

Treatment of the unpainted surface at 20,000 psi water pressure using the UHPWDS was effective in lowering the contamination level to about 1,000 counts/min/in². With further treatment at 40,000 psi water pressure, the decontamination resulted in approximately 300 counts/min/in².

Coupon #7: This coupon of painted stainless steel was placed in a containment glove box where Pu-239 dissolved in acid had been handled and analyzed on a daily basis. The coupon was placed on the floor of the containment box in the area where the sample were routinely handled. This was the place where the highest possibility of contamination would take place; however, the fact that quantitative analysis was being done on these samples indicates that little to no spillage of the samples occurred. The coupon was contaminated to a level of 3,000 counts/min/in².

Treatment of the painted surface at 20,000 psi water pressure using the UHPWDS was effective in lowering the contamination level to approximately 1,500 counts/min/in². With further treatment at 40,000 psi water pressure, the decontamination was nearly complete, resulting in less than 250 counts/min/in². The effectiveness of decontamination is mainly due to the painted surface having contained most to all of the contamination, so that when the paint was removed there was no residual contamination on the bare stainless steel.

Coupon #8: This coupon of bare stainless steel was placed in a containment glove box where Pu-239 (metal and oxide) dissolved in an acid solution containing 3M HNO₃, 3M HCl, 3M H₂SO₄, and 0.1 M HF was purposely spilled on the surface, then wiped up. After this treatment the coupon was contaminated to a level of 300,000 counts/min/in².

The decontamination was not very effective, resulting in 100,000 counts/min/in² after treatment using 40,000 psi water pressure.

Coupon #9: This coupon of painted stainless steel was placed in a containment glove box where Pu-239 (metal and oxide) dissolved in an acid solution containing 3M HNO₃, 3M HCl, 3M H₂SO₄, and 0.1 M HF was purposely spilled on the surface, then wiped up. After this treatment, the coupon was contaminated to a level of 15,000 counts/min/in².

Note the difference in initial contamination levels between coupon #8 (unpainted surface) and coupon #9 (painted surface). This difference shows that the painted surfaces do not become decontaminated as easily.

Even the treatment of the painted surface at 20,000 psi water pressure in the UHPWDS was effective in lowering the contamination level to about 900 counts/min/in². With further treatment at 40,000 psi water pressure, the decontamination was essentially complete, resulting in less than 250 counts/min/in². This effective decontamination is mainly due to the paint having contained most to all of the contamination, so when it was removed there was no residual contamination on the bare stainless steel.

Coupon #10: This coupon of bare stainless steel was placed in a containment glove box where Pu-239 oxide was purposely spilled on the surface, rubbed in, then wiped up. After this treatment, the coupon was contaminated to a level of 250,000 counts/min/in².

Treatment of the surface at 20,000 psi water pressure in the UHPWDS lowered the contamination level to about 10,000 counts/min/in². With further treatment at 40,000 psi water pressure, the decontamination resulted in 2,500 counts/min/in² after treatment.

Coupon #11: This coupon of painted stainless steel was placed in a containment glove box where Pu-239 oxide was purposely spilled on the surface, rubbed in, then wiped up. After this treatment, the coupon was contaminated to a level of 600,000 counts/min/in². The higher contamination level

than coupon 10 resulted because the special nuclear material (SNM) was ground into the painted surface so that it remained there after a casual wiping.

Treatment of the painted surface at 20,000 psi water pressure using the UHPWDS lowered the contamination level to about 250,000 counts/min/in². With further treatment at 40,000 psi water pressure, the decontamination was nearly complete, resulting in less than 250 counts/min/in². The effectiveness of the decontamination is mainly due to the painted surface having contained most of the contamination, so that when the paint was removed there was no residual contamination on the bare stainless steel.

CONCLUSIONS FROM TESTS ON RADIOACTIVELY CONTAMINATED MATERIALS

Although the decontamination of the section of test glove box was very successful (the original contamination level of many millions counts/min/in² went to <250 counts/min/in² after decontamination, giving a decontamination factor [DF] of >4000 as defined in Equation 1 below), some caution in declaring total success is in order because the effectiveness of the system depends on a variety of factors.

The effectiveness of this system in decontaminating TRU-level materials is contingent on (1) the type of contamination (e.g., contamination from dry oxide or from acid solutions), (2) the surface preparation before contamination takes place (e.g., painted or coated surfaces), (3) the activity levels (curies per gram) of the nuclear material contamination, and (4) the weight of the material being decontaminated (e.g., a thick-walled material can have more residual contamination left on it and still meet the <100 nanocuries per gram limit for LLW than a thin-walled material can, simply because of the weight difference).

Overall, the decontamination factors of the test panels showed that the effectiveness of this system ranged from quite effective (DF = >4,000) to not very effective (DF = 3).

A coated surface, such as a painted metal surface, permitted a more effective decontamination job because the process could be carried out in two steps (first using 20,000 psi then using 40,000 psi).

Bare metal was cleaned fairly effectively if it was contaminated with only the oxide of Pu-239. However, if the bare metal surface was corroded by acid solutions containing Pu-239, it was very difficult to attain effective decontamination (DF = 3). This lack of effective decontamination could be caused by the Pu becoming chemically bonded to the metal or from the solution becoming "trapped" in the micro cracks in the metal. In any case, bare metal corroded by acid solutions which were contaminated with nuclear materials was only minimally decontaminated.

Equation 1:

$$\frac{\text{Original contamination level in counts/min/in}^2}{\text{Final contamination level in counts/min/in}^2} = \text{Decontamination Factor (DF)}$$

For Pu-238 on a painted surface, the decontamination was very effective (DF = >4,000); however, it is doubtful bare metal can be made into LLW by this technique, mainly because of the higher activity level of that isotope (Pu-238 has nearly 200 times more alpha activity than Pu-239).

The UHPWDS itself worked well, although the spray jet assembly was somewhat cumbersome and heavy because of the stiffness of the 1-inch-thick high-pressure water line connected to it. We consider the weight a major disadvantage of this technique from an ergonomics standpoint. A more flexible and smaller diameter line would be much better.

Since most of our containment boxes have a painted surface, this system should be very successful in decontaminating them. However, bare metal is not as easily decontaminated.

No contamination escaped from the glove box during this testing, and no major problems were encountered.

We realize that in some facilities it might be more practical to save the waste water and treat it for reuse in the system rather than use a radioactive drain system. An effective system for cleaning the water is described in a report entitled, "Polymer Filtration: A New Technology for Selective Metals Recovery," by B. F. Smith, T. W. Robison, M. E. Cournoyer, K. V. Wilson, N. N. Sauer, K. I. Mullen, M. T. Lu, and J. J. Jarvinen.⁽²⁾ This compact and portable system should be able to easily filter and clean the water for reuse, nearly eliminating any waste except for the small volume of concentrated radioactive material.

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(2) B. F. Smith et. al, "Polymer Filtration: A New Technology for Selective Metals Recovery," *Plating and Surface Finishing*, (in press, Spring 1996).

APPENDIX 1

EQUIPMENT MANUFACTURING SPECIFICATION

EQUIPMENT PURPOSE AND TYPE

This specification defines the minimum requirements for a high-pressure water spray cleaning system to be manufactured and furnished by the vendor. The system will be used to clean the inside of a stainless steel enclosure. The enclosure is approximately 3 ft. wide by 2 ft. deep by 3 ft. high. The front of the enclosure is 3/8 inch safety glass. The spray wand will be manually manipulated inside the enclosure through glove box ports. This system is to be used in a laboratory environment to determine its effectiveness for long term use in cleaning of similar enclosures.

The vendor shall furnish one fully operational, cart-mounted, electric motor-driven pressure system to include: motor, pump, water pre-filter, gages, valves, controls, and also associated equipment such as hoses, cleaning tool (gun), spray heads, etc., each of which is further defined below. The system will use a city water source, employing a once-through water system. A reservoir is not required.

HIGH-PRESSURE WATER GENERATOR UNIT

Unit must be mounted on a cart or skid with lockable wheels to facilitate movement. Unit width should be 3 feet 6 inches wide or less and less than 6 feet tall. State overall dimensions with quote. State total weight and operating noise level of system with quote.

Electric Motor Driven Pressure Washer

- Motor voltage: 208V three-phase is preferred. If this motor is not available, state voltage and start-up amperage requirements of motor with quote. State voltage of unit quoted and motor horsepower.
- Motor/Unit to have control panel/box. State what controls are on unit (start, stop, variable controls, etc.).
- Electrical housings are to be NEMA 4 rated.
- TEFC Motor (Totally Enclosed Fan Cooled).
- Skid or cart to have power cord with twist lock plug and 20 ft of power cord (i.e.: for 20A service use a NEMA type L22-20R receptacle and plug). Supply one receptacle with system for field installation and state NEMA type with system documentation.

Pump

- Pump is to achieve an operating pressure between 35,000 and 40,000 psia. State operating pressure of pump with quote, and if there is a variable range state the range and method used to control pressure.
- Required operating gallons per minute flow is 0.3 to 0.5 gallons per minute. If the system has a variable range, state complete range with quote. State method used to control variable flow rate.
- Water supply feed must connect to 1/2 inch hose. Provide coupling threaded to pump feed connection and two mating hose couplings for 1/2 inch hose.

- Requirements for any other supply streams (type, flow rate, connection requirements, etc.) must be furnished with quote.

Water Pre-filter

A pre-filter system must be incorporated with the unit to prevent particles from plugging the spray head, including the following:

- Filter rating of 1 micron or less. State the expected life per filter with quote.
- Describe valve and pressure gage configuration of filter system.

Other Gages, Valves, and Controls

- Provide the necessary equipment to permit safe use of system. Provide a system schematic showing valves, instruments, gages, etc.

PRESSURE SYSTEM HOSES

- Provide two bulkhead connections for each required penetration (one set will be available as a spare) as illustrated in Fig. 2. The required glove box wall penetrations are to be as small as possible; state size of hole required for fitting with quote.
- Hoses as necessary, a minimum of 20 feet long, to connect the pressure generating system to the bulkhead (see Fig. 2).
- Hoses are to be pressure rated to 2.5 times their normal operating pressure.

HAND-HELD CLEANING TOOL (gun)

- Overall length: twelve (12) inches or less.
- Operated by one hand or two hands (one-hand operation is preferable if the system can be safely operated with one hand).
- Weight: twelve (12) pounds or less; state weight of gun.
- Rated for operating pressure range of pressure system (state pressure rating of the gun with quote).
- Water flow rate for operation is 0.3 to 0.5 gallons per minute. Gun must be rated for flow range of system pump. State rating of gun with quote.
- Two sets of hoses are required to connect the gun to the bulkhead fitting. The first set is to be 3 feet in length, and the second 5 feet in length. Each set is to have fittings to mate to bulkhead listed above and as shown in Fig. 2. Hoses are to be disconnectable from bulkhead and gun for length change. State type of connection to gun. Connection should be threaded, or if of quick disconnect type it should be lockable.
- The gun trigger is used to control spray operation. Release of trigger is

to stop water flow (normally closed/off). Describe trigger control philosophy and related safety features.

- The gun is to produce a coherent cleaning stream at the stated pressures, 1 inch or wider, up to 1—1.5 inches from the gun tip.

SPRAY HEADS

- Capable of cleaning a path width of one (1) inch or greater per pass at a distance of 1—1.5 inches from the tip at the rated pressures.
- Fan jet and rotating tip styles, two each.
- State rotating tip revolutions per minute range and method of rotation.
- State requirements for changing tips and orifices and tools required. The system should include the tools required for orifice and tip changing.

SPARE PARTS

- All parts required to keep the system in operation for 500 hours (list types and quantity).
- Spare orifices and tips, as required for 500 hours of operation. List quantity (in addition to the two spray heads required above).

MANUALS

- Two (2) operation manuals
- Two (2) maintenance manuals

ACCEPTANCE

- Start up and performance testing at manufacturer's site in presence of LANL engineer with verification of full system testing prior to LANL's acceptance and shipment.
- Training for LANL engineer at the manufacturer's site prior to shipment of system, scheduled at LANL's option.

SHIPPING

- Required shipment to LANL six weeks after receipt of order.
- Any changes or other custom designs subject to LANL's approval of design. Changes may affect delivery schedule. Identify custom items and impact on delivery schedule.

OTHER

- All wetted materials are to be stainless steel or other corrosion-resistant material.
- In addition to the system as specified above, vendor is allowed to quote alternatives for LANL consideration (alternatives will not necessarily be considered as equals or be acceptable).

APPENDIX 2

LANL STANDARD OPERATING PROCEDURE (SOP) FOR OPERATION OF HIGH-PRESSURE WATER DECONTAMINATION SYSTEM

Introduction

A high-pressure system will be used to decontaminate the inside of glove boxes so they can be disposed of as low-level waste. This SOP describes the safe use of this system which consists of a high-pressure water generating unit, a cleaning tool (gun), and associated equipment.

In this SOP This SOP covers the following topics:

Topic	See Page
Description of the operation _____	19
What hazards are involved _____	20
How hazards are controlled _____	21
How waste is handled _____	22
Health physics and protective clothing requirements _____	23
When procedures are changed _____	24
What training is required _____	24
What to do in an emergency _____	25

Description of the Operation

Introduction The high-pressure water decontamination system (HPWDS) will be used to decontaminate the inside of glove boxes.

**The operation:
preparation of
glove boxes**

The glove boxes must be prepared before they are decontaminated so the operation can be safely done. Prepare the glove boxes as follows:

Step	Description
1	Consult with ESH-1 (Health Physics) and with their aid fill out a Radiation Work Permit.
2	Make sure there is a water drain in the box and that the drain has a screen on it to prevent debris from entering the drain line. If no drain is present, a pump and hose will be used to move water to a nearby drain.
3	Put plastic under the box to catch any water that may leak from the glove box gaskets. Put catch pouches with absorbent material in them below box seams. Wipe down the glove box.
4	Disconnect all electrical power from the glove box.
5	Make the required penetrations through the box wall for the coupling, and connect the hoses.
6	Establish a "leak-tight" barrier for any instrument or centrifuge wells; e.g., the items not designed to contain liquids.

- 7 Remove all unnecessary items from the area.
- 8 Establish a water barrier for any open-slot box decontamination.
- 9 Use a sealant on joints, openings, etc. on the outside of the glove box if there is any reason to suspect liquid leakage.
- 10 Review any special precautions needed for glove box inlet filters.
- 11 Assure all bolted connections are reasonably torqued or tightened to help prevent liquid leakage.

**The operation
of the HPWDS**

The unit is made up of a water pressure generating unit and the cleaning tool with associated connecting hoses. The following describes the safe operation of this system:

Operation	Description
1	Two people are required for this operation. One to operate the cleaning tool and one to stand by the high-pressure pump unit.
2	The high-pressure water generation unit should be kept in the corridor outside the lab being worked on if possible. (It is good practice to avoid taking unnecessary materials into a controlled area.)
3	Both hands of the operator are to remain on the cleaning gun handle.
4	If one-handed operation is needed, <i>the free hand must be outside the glove box to prevent injury</i> . (If the water spray hits your hand, it could seriously injure it).
5	The jet spray is always directed away from operator.

What Hazards Are Involved

Types of hazards This operation involves three potential hazards:

- high-pressure water
- electric shock
- ionizing radiation

**High-pressure
water hazard**

The high-pressure water hazard is due to the 40,000 psi of hydraulic water pressure generated. (Danger of cutting nonmetallic materials, e.g., gloves, etc.)

**Electrical shock
hazard**

The electrical shock hazard comes from either the high-pressure water generating unit or failure to properly disconnect all electrical power to glove box to be cleaned.

**Ionizing radiation
hazard**

The primary hazard is ionizing radiation from the glove boxes that have been used for the handling of plutonium.

How Hazards Are Controlled

Introduction

The operator performing the work controls the hazards by carefully following the procedures, never working alone, and paying attention to monitoring instruments.

Controlling high pressure water

The unit is commercially designed for safe operation at the stated hydraulic water pressures of up to 40,000 psi. If a hose breaks with 40,000 psi in it, the size of the hose is such that the water would be expelled at a very low pressure and flow rate. Water flow rate is adjustable from 0.1 to 0.4 gallons per minute. A single foot control valve is used by the spray gun operator to control jet flow action. By releasing the foot-control valve of the cleaning tool, the pressure output from the tool is stopped. The cleaning gun is designed to "fail safe" (i.e., high-pressure water will immediately shut if the foot control valve is released because the water spray could seriously injure the operator's hands). When two hands are required for the operation of the cleaning tool, one hand is on the gun handle, and the second hand holds the one inch high-pressure hose for additional support. At no time is the cleaning tool pointed at the gloves. The gloves are cleaned by other techniques (e.g., washing them with water and tissues). Controls on high-pressure water pump include: start, stop, emergency stop, and pressure control/relief valve.

Follow these precautionary measures

- Ensure that the glove box has no material in it that can be damaged with the water spray.
- Ensure that the electricity has been disconnected from the glove box.
- Ensure that another person is standing by the HPWDS unit to act as a backup to turn the unit off in case of problems.
- Ensure that all glove box preparations are complete.
- Ensure that all documentation and reviews are in place.

Controlling electrical shock

The unit was designed to work under 40,000 psi pressure and 0.4 gallons of water delivered per minute. Follow these general rules:

- No water leaks near the energized electric motor are permitted.
- Assure the unit is plugged into a grounded outlet.
- Operate the unit with guards in place.
- Be sure that at least a 50 amp service is used to run the pump.

Controlling ionizing radiation

The ionizing radiation is a 5-MeV alpha particle. This particle is completely stopped within 5 cm by interactions with the atmosphere in the glove box and within 0.1mm by the walls of the glove box itself. Nevertheless, the operator must take positive steps to avoid radiation exposure. Follow these guidelines:

- Fill out a Radiation Work Permit with the aid of ESH-1 personnel.
- Put plastic on the floor, walls, adjacent equipment, etc.
- Put a "catch bag" of plastic under the glove box at seams.
- Ensure that monitoring instruments provided by ESH-1 are in working order and are used regularly.
- Seal any suspected leak sites on the glove box.

Notify ESH-1 Follow these general rules:

- Notify ESH-1 before beginning this operation (7-4093).
- Notify ESH-1 if any contamination is found outside the glove box.

How Waste Is Handled

Introduction Waste generated by this operation includes water from the cleaning tool and associated material removed from the glove box walls. The drain, or tube connected to a pump, will be screened to collect any solid materials, (e.g., paint) and disposed of by using group and building waste management procedures.

Waste-handling procedure Waste generated in our group is handled according to the guidelines presented in the group's Waste-Handling Procedure, CST-SOP5-007. This procedure is reviewed by the CMR Facility Waste Coordinator.

Waste minimization The group's waste minimization effort is covered in CLS-1-OP-2, CLS-1 Spill Procedure and Waste Minimization Plan.

Health Physics And Protective Clothing Requirements

Introduction	The protection of personnel from ionizing radiation depends on both administrative and physical considerations including protective clothing and the use of monitoring instrumentation.
ALARA	The extent to which the analysts protect themselves against radiation is described in the concept of ALARA: As Low As Reasonably Achievable. Our group has an ALARA procedure, CST-SOP-063.
Protective clothing	<p>(A) Whenever you are in a radiologically controlled area, you must wear appropriate protective clothing (e.g., when preparing the glove box and lab for this operation). This clothing and other items include the following:</p> <p><i>In a laboratory module</i></p> <ul style="list-style-type: none">• laboratory coat• shoe covers• eye protection• TLD badge <p><i>Working in a fume hood or glove box</i></p> <ul style="list-style-type: none">• All the protective clothing required for presence in a laboratory module• Surgical gloves <p>(B) For this specific operation the additional personnel protective equipment needed and other precautions taken (e.g., special air testing) is specified in the following:</p> <ul style="list-style-type: none">• A Radiation Work Permit (RWP) is generated, with help from ESH-1 personnel, for each decontamination job this equipment is used for. The RWP outlines the specific personnel protective equipment that is required for safe operation.
Monitoring	<p>Laboratory areas are monitored routinely.</p> <p><i>Area monitoring:</i></p> <ul style="list-style-type: none">• floors• equipment• alpha swipes• continuous radiation air monitoring (CAM) <p><i>Self-monitoring</i></p> <ul style="list-style-type: none">• in the laboratory module• when exiting a laboratory module• when exiting a controlled area <p><i>Other monitoring:</i></p> <ul style="list-style-type: none">• routine urine specimens• whole-body counting

When Procedures are Changed

Introduction	As we develop new analytical methods or the character of samples or tasks change, new classes of hazards may be introduced into our operation.										
Guidelines	Whenever a new class of hazards is introduced into operations, the following guidelines apply.										
	<table><tr><th>Stage</th><th>Description</th></tr><tr><td>1</td><td>The appropriate safety personnel are consulted before the operation is changed.</td></tr><tr><td>2</td><td>The existing SOP is updated.</td></tr><tr><td>3</td><td>Personnel using the SOP are trained in the new procedure.</td></tr><tr><td>4</td><td>The procedure is reviewed annually.</td></tr></table>	Stage	Description	1	The appropriate safety personnel are consulted before the operation is changed.	2	The existing SOP is updated.	3	Personnel using the SOP are trained in the new procedure.	4	The procedure is reviewed annually.
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4	The procedure is reviewed annually.										

What Training is Required

Introduction	Laboratory personnel must undergo extensive training before they are allowed to work with radioactive or hazardous materials. This training is updated on a regular basis.
Kinds of training	The training received by each group member is commensurate with the types and levels of hazards each individual is potentially exposed to. In all cases, however, training includes formal class work accompanied by one-on-one on-the-job training that focuses on the specific tasks that the operator must perform.
This SOP	This SOP is distributed to the personnel who operate this equipment.
General training requirements	<p>The training required for working in our area within the CMR Building includes the following:</p> <ul style="list-style-type: none">• general employee training (GET)• radiation worker II training• CMR Building facility-specific training• hazard communication training• hazardous waste generator training• General Electrical Safety training
Specific training requirements	Training from the manufacturer is required for at least one operator of this equipment. That person then trains other operators. All operators have a copy of this SOP. Training is documented in the Group and LANL training computer data bases.

What to Do in an Emergency

Introduction Sometimes emergencies occur in our work area. We need to be aware of the kinds of emergencies that can occur and what to do when they happen.

Kinds of emergencies Among the typical emergencies that can occur are the following:

- accidents/injuries
- fire
- chemical spills
- hazardous chemical spills
- radioactive contamination

In case of emergency In case of emergency, follow the guidelines listed below.

In case of ...	Do the following ...
<i>Any emergency</i>	<ol style="list-style-type: none">1. Contact the group office, 7-40872. Contact CST-DO, 7-4457.3. Contact CMR Facility Manager, 7-7586
<i>CAM alarm</i>	Contact ESH-1, 7-4093
<i>Accident/injury</i>	<ol style="list-style-type: none">1. Call 911.2. Summon CMR Emergency Response Team. (Pager 104-1997)3. Apply first aid if qualified.4. Move injured person to safety only if necessary. REFERENCE: CST-1 Safety Manual and Building Emergency Plan
<i>Fire</i>	<ol style="list-style-type: none">1. Pull fire alarm.2. If the fire is small and you have the appropriate training, use the fire extinguishers located in the hallways.3. Evacuate the area.
<i>Chemical spill</i>	<p><u>Skin:</u></p> <ol style="list-style-type: none">1. Immediately flush affected area with cold water for 15 min. Call for help.2. If necessary, use emergency shower.3. Call ESH-2, 7-7839. (Nurse's station) <p><u>Eyes:</u></p> <ol style="list-style-type: none">1. Flush eyes with cold water for 15 min. in eyewash station or other immediate potable water source.2. Call ESH-2, 7-7839. (Nurse's station)

Testing of a Portable Ultrahigh-pressure Water Decontamination System

Hazardous chemical spill

1. Stop source of spill if possible to eliminate danger to personnel.
 2. Notify CMR spill coordinator, 7-1904 or 104-1729.
 3. Use spill kits as appropriate.
- REFERENCE: Group Spill Procedure

Hazardous gas leak

1. Stop leak if possible.
2. Evacuate laboratory module.
3. If the leak continues, call 911.
4. Call ESH-5 (5-4427) to monitor the air.
5. Notify CMR spill coordinator, 7-1904 or 104-1729.

Radioactive contamination

Contact ESH-1 at the following number:
LocationPhone Number
TA-3-29 7-4093

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