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Development of Waste Minimization and Decontamination Technologies at the Idaho Chemical Processing Plant

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Introduction

Emphasis on the minimization of decontamination secondary waste has increased because of restrictions on the use of hazardous chemicals and Idaho Chemical Processing Plant (ICPP) waste handling issues. The Lockheed Idaho Technologies Co. (LITCO) Decontamination Development Subunit has worked to evaluate and introduce new decontamination methods to minimize secondary waste generation. The Decontamination Development Subunit has performed testing, evaluations, development and on-site demonstrations for a number of novel decontamination techniques that have not previously been used at the ICPP. This report will include information on decontamination techniques that have recently been evaluated by the Decontamination Development Subunit.

Concrete Decontamination Scoping Tests[1]

Past concrete decontamination efforts at the Idaho Chemical Processing Plant (ICPP) involved washing concrete with high pressure water or chemicals and crushing the concrete. These decontamination methods generate a large volume of secondary waste. In FY-94, the Decontamination Development Subunit conducted a series of concrete decontamination scoping tests to investigate methods that:

- have higher decontamination efficiencies,
- have increased flexibility,
- lower personnel exposure, and
- decrease the amount of secondary waste that is generated.

Three companies were subcontracted to perform the concrete cleaning demonstrations. The companies and the technique they used for the demonstrations are as follows:

1. Pentek (scabbling technique),
2. EET, Inc (chemical technique), and
3. Dry-Tec of North America (electro-osmotic pulse technique).

Each company was required to clean a radioactively contaminated concrete lid (approximately 24 ft^2) which was used in a settling basin. The basin had been filled with radioactively contaminated water and left in place for 20-25 years. The concrete lids were comprised of standard 3000 psi concrete with a matrix of rebar in the middle. The contamination consisted primarily of cesium, small amounts of uranium, plutonium, strontium, cerium, cobalt, europium and americium were also present.

The demonstrations were performed in a 12'x22'x8' tent which was divided into two compartments. The work was performed in one compartment while the other compartment contained a Constant Air Monitor (CAM) and was used as a step off area. To help control airborne activity, a 1500 cfm HEPA blower was connected to the first compartment. The HEPA blower was located outside of the tent.

Each company was given 7-10 days to perform their demonstration. During the testing, data was gathered on operability/simplicity, flexibility, decontamination efficiency, cleaning time and waste generation. One of the major goals was to determine if each technique could clean the concrete lid to the ICPP free release standards of:

- < 200 dpm Beta/Gamma (smearable),
- < 10 dpm Alpha (smearable),
- < 100 cpm above background Beta/Gamma (fixed), and
- No detectable Alpha (fixed).

Concrete Scabbling

For their demonstration Pentek, Inc. used an integrated vacuum and scabbling system designated as a Pentek VAC-PAK model 9. A pneumatically operated needle gun ("Corner-Cutter") and a floor scabbler ("Squirrel-III") was used for this demonstration. The "Corner-Cutter" used 3 mm, piston driven, reciprocating needles, while the "Squirrel-III" utilized 3, 1¾" diameter, 9 point tungsten-carbide tipped bits. Each of these tools was equipped with a 1½" vacuum hose and shroud to collect the dust and debris as it was removed from the surface and deliver it to the VAC-PAC system.

DISCLAIMER

The VAC-PAC is a HEPA filtered, air operated vacuum system which removes the scabbled debris from the tools and transports it directly into a 55 or 23 gal waste drum for disposal. This system allows the operator to fill, seal, remove and replace full drums with empty drums under vacuum conditions.

Scabbling Procedure The "Squirrel-III" was used to scabble ⅛" of the surface off the concrete lid. A 2" border was left around the edge of the lid. The "Corner-Cutter", with a flat shroud, was used to scabble the 2" border. During this process no dust as observed around the shroud. The CAM did not register any radioactive airborne particulates while the scabbling was taking place.

Scabbling Results The system was very flexible and easy to operate. The system was operated by a LITCO technician with no previous scabbler operating experience. Very little waste was generated and the lid surface, after cleaning, was level and did not have any peaks or valleys.

The total time to remove a ⅛" of concrete from the entire surface was 56 minutes. The squirrel was used for 36 minutes and the corner cutter for 20 minutes. After cleaning, the lid was divided into 4 areas for radiological surveys. The results of this demonstration can be found in **Table 1**. The Pentek scabbling system performed well. It was able to achieve good decontamination efficiencies while generating a minimal amount of secondary waste. The secondary waste generated by this system comprised of consumable items such as; sleeving, shrouds, needles and filters as well as the removed concrete.

Chemical Technique

Environmental Extraction Technologies (EET) Inc. conducted the chemical concrete decontamination demonstration using their "TECHXTRACT" contamination extraction technology. This technology has been used to remove a variety of hazardous and radioactive contaminants from concrete, steel and other materials. The chemicals previously used at the ICPP were flushed over the surface creating large quantities of secondary waste and removing surface contamination only. A small amount of chemicals is applied to the surface which it penetrates, drawing the contamination out to the surface to be captured. The EET chemicals reduce the amount of chemicals required for decontamination, thus reducing the amount of secondary waste that is generated. The EET chemicals will not damage the surface or substrate.

Chemical Procedure The composition of the chemicals used by EET is proprietary, therefore the chemicals are referred to as 100, 200 & 300. The application series of the chemicals and the dwell times are as follows:

1. Chemical 100 was applied and left on overnight and then rinsed and vacuumed.
2. Chemicals 200 and 300 were applied and left to dwell 2 hours then rinsed and vacuumed.
3. Chemicals 200 and 300 were applied and left to dwell 2 hours then rinsed and vacuumed.
4. Chemical 100 was applied and left on overnight and then rinsed and vacuumed.
5. Chemicals 200 and 300 were applied and left to dwell 2 hours then rinsed and vacuumed.
6. Chemical 100 was applied and left to dwell for 2 hours then rinsed and vacuumed.

Chemical Results After the first application of 100, the contamination levels on the lid had increased to such high levels that Radiation Engineering approval had to be given before work could continue. After rinsing, the surface of the lid was again surveyed and the contamination levels decreased to below initial readings. This indicated that there was more contamination under the surface of the concrete and the first application of 100 had extracted and encapsulated the contamination into the chemical. Approximately 1 gallon of chemicals (which includes all three chemicals) was used during this demonstration and the total liquid waste generated was approximately 2.0 gallons, including the rinse water. Due to scheduling problems with the ICPP Support Personnel, we had to limit the number of chemical applications to three. Had we been able to apply more chemical applications to the concrete lid, the final results would have been significantly better. The results from EET demonstration can be found in **Table 1**.

Electro-Osmotic Pulse Technology

Electrical/kinetic concrete decontamination techniques are a fairly new concept in concrete decontamination. The Electro-Osmotic Pulse portion of this test was performed by Dry-Tec of North America. This technology removes contamination from concrete by setting up an electrical potential across the lid; copper coated steel rods are used as the cathodes and titanium bars as the anodes. When the electrical circuit is connected, a controlled cyclical voltage is applied to the system to cause osmotic migration of water from the anode to the cathode. As the moisture in the concrete is either pushed or pulled out of the concrete, contamination is also pushed or pulled through the concrete. This process was developed in Norway where it was installed in vaults, basements, and many other underground structures to prevent water from entering the structures. Dry-Tec's test at the ICPP was the first time this method had been tested to radiologically decontaminate concrete.

Electro-Osmotic Pulse Procedure The testing consisted of two different test set-ups with two lids. The tests ran simultaneously and were controlled by one central control unit. The tests were labeled wet and dry. The wet test consisted of putting the concrete lid into a wooden fiberglass lined pan with approximately 11 gallons of demineralized water and placing a small wooden ring filled with water on the top of the lid. The wooden ring was secured to the top of the lid with a caulking compound and the anodes (four connected titanium bars) were placed inside the wooden ring. The rebar eye lifts on the wet method were covered with a caulking compound. The dry method used the moisture already in the concrete. The concrete lid was placed into another pan filled with 11 gallons of demineralized water but no ring of water was placed on top. The anodes used for the dry method were the rebar lifting rings that were pre-cast into the concrete lid. The rebar eye lifts were sanded to remove as much rust as possible. Using the rebar eye lifts for the anodes had never been done before by Dry-Tec. The circuit was completed with a 110 V power source and the voltage and amperage were controlled by one 10 amp control unit. A small positive and negative pulse was used to pull the moisture and contamination from the lids in each test. The lids were placed into the pans and left to soak in the water for approximately 48 hours before the system was turned on. This allowed any loose contamination on the lid to disperse into the water throughout the demonstration. The water was sampled to determine the amount of contamination that had gone into the water. The water was also sampled at the end of the demonstration after the water had been pumped into a plastic drum.

Electro-Osmotic Pulse Results Approximately 21 gallons of contaminated water was generated during this test. A small portion of the liquid was lost due to evaporation. The final water samples indicated a total of 1.037×10^6 d/s for dry and 2.362×10^6 d/s for wet were removed. The voltage and amperage were measured on a daily basis. The voltage at the start of the test measured at 39.6 volts. The amperage to the wet system measured 265 mA and the dry system measured 1 amp. After the system had been operating for three weeks, the voltage measured 39.3 volts and the amperages on the wet and dry methods remained fairly constant. The results of this demonstration can be found in **Table 1**. This technique is a fairly easy system to install and requires very little labor to operate. The system is flexible, it can be used to decontaminate concrete and to helping to keep concrete rooms, vaults, and basins dry. The normal installation for drying rooms, vaults, and other underground structures would use graphite probes and cable instead of copper cathodes and titanium anodes. The cleaning time for this system varies on the condition and type of concrete to be cleaned. This method takes a longer period of time to work than the two previous methods but, in general, has lower labor needs. The moisture content of the concrete and the type of concrete has a direct effect on how long it takes before results can be seen.

Table 1. Concrete decontamination results.

METHOD	CONTACT β/γ mR/hr	CONTACT β/γ mR/hr	SMEARABLE β/γ/α d/m	SMEARABLE β/γ/α d/m	% Reduction
	BEFORE	**AFTER**	**BEFORE**	**AFTER**	
Scabbling	150	10	42,520 β/γ 184 α	2576 β/γ 96 α	93.3% (Contact) 93.9% β/γ 47.8% α
Chemical	150	100	21,000 β/γ 147 α	540 β/γ 14 α	33.3% (Contact) 97.4% β/γ 90.0% α
Electro-Osmotic (Wet Method)	150	30	17,253 β/γ 66 α	13,135 β/γ 35 α	80.0% (Contact) 23.8% β/γ 46.9% α
Electro-Osmotic (Dry Method)	150	25	13,923 β/γ 66 α	9,937 β/γ 32 α	83.0% (Contact) 28.6% β/γ 51.0% α

Laser Light Ablation Decontamination of Metal Surfaces

In the past, techniques such as abrasive grit blasting and chemical processes have been used to remove oxide films or paint on surfaces that may contain hazardous contaminates or radioactive contamination. These techniques typically generate a secondary waste or use chemicals that are hazardous to personnel and the environment. The Decontamination Development Subunit in conjunction with Ames Laboratory, at Iowa State University, has developed a proprietary laser light ablation system which uses a fiber optic delivered, acousto-optic, Q-switched, Nd:YAG laser. This technique can be used to ablate or remove contaminated material without generating a large quantity secondary waste. The ablated contaminates are collected via a particle collection cell and a HEPA (High Efficiency Particulate Air) filtered blower system. The contaminates are contained within the HEPA filter, which is the primary secondary waste.

Laser Light Ablation Background

Laser light ablation is a process of removing surface material by using a high intensity laser beam to irradiate the surface material. When a focused laser beam irradiates a solid surface a complicated interaction between the solid and the photon occurs. If the power density of the focused laser beam is high enough, the absorption of the photon on the solid surface will create a plasma plume and shock waves will eject the material into the surrounding environment. The ablated surface material is collected via a particle collection system. The particulate-laden off-gas is filtered to prevent redeposition onto the surface. High power, short pulse length (<150 ns) lasers were shown to effectively clean surfaces while producing minimal surface damage. Continuous wave (CW) or long pulse length lasers were shown to produce excessive material melting and caused the debris to be scattered over a larger area. Melting during surface decontamination could cause serious problems by driving the contaminates into the bulk of the material.

Laser Light Ablation Development

Initial testing was performed with an excimer laser (with a mixture of Kr and F_2 in Ne gases) operated at 248 nm, in the ultraviolet spectrum, with a pulse width of ~28 ns and an electro-optic, Q-switched, Nd:YAG (Neodymium Yttrium Aluminum Garnet) operated at 1064 nm, in the near-infrared spectrum, with a pulse length of ~ 10 ns. Both of these lasers were shown to be effective in removing surface contamination. Tests were also performed with a "pulsed" or "free-running" Nd:YAG and a CW CO_2 lasers. The pulsed Nd:YAG and the CW CO_2 lasers were not effective at laser ablation due to excessive material heating. It was shown that for the Nd:YAG laser, a Q-switching mechanism must be used to get required combination of irradiance (or power intensity) and pulse length required to perform laser ablation. For both the excimer and the electro-optic, Q-switched, Nd:YAG lasers, a series of mirrors and lenses are used to transmit or reflect the laser beam to the item being cleaned. In most of the experiments, the laser beam was held in a stationary position while the material was rastered, under the laser beam, by a worktable under computer control. This beam delivery method proved to be very effective in a laboratory setup and applicable in certain field applications. For applications that require the laser light ablation cleaning process to be conducted in a remote location that is not in "line-of site" of the laser head, a sophisticated robotically controlled mirror and lens beam delivery system is needed. Extensive system setup time to ensure proper alignment of the optics would be required and significant power losses may be experienced due to the attenuation of the optics.

A priority was placed on the development of a fiber optic beam delivery system for use in laser light ablation. A fiber optic beam delivery system has several advantages over a typical mirror and lens beam delivery system. It would allow the expensive laser head and electronics to remain completely isolated from the contaminated environment. The flexible fiber optics can bend around corners, over obstructions and can thus be used to perform the laser light ablation cleaning process in a remote location without requiring sophisticated robotics to maintain alignment of mirror and lens optics.

The Nd:YAG laser operates at a wavelength that can be transmitted fiber optically. There are commercially available fiber optically delivered Nd:YAG laser systems but these systems operate in a CW or pulsed mode. Fiber optic compatibility tests were performed with the electro-optic, Q-switched, Nd:YAG laser. For these tests the laser was operated at repetition rate of 30 Hz with a 10 ns pulse width at 1060 nm wavelength. A 1 mm laser compatible optical fiber was tested with this setup. The fiber was designed to transmit up to 500 mJ/pulse of Q-switched Nd:YAG output. For the first set of tests the fibers were polished by hand. A second series of tests were conducted to determine if fibers prepared by a commercial vendor would increase power transmission. The commercial vendor's preparation included annealing the fibers and special end polishing and cleaning. Additional modifications were made to position the focal point of the laser inside the fiber including use of a 0.75 aperture for full containment of the beam inside the fiber. During these tests with the electro-optic, Q-switched, Nd:YAG laser, 40 mJ/pulse of laser energy was transmitted through the fiber optics, which was far less than the 190 mJ capability of the electro-optic, Q-switched, Nd:YAG laser. Attempts to transmit greater than 40 mJ/pulse with a 10 ns pulse width produced an irradiance (or power intensity) level that caused breakdown of the optical fiber by exceeding the energy threshold of the optical fiber.

To develop a fiber optically delivered laser light ablation system, research was conducted to determine the minimum pulse length and irradiance (or power intensity in W/cm^2) to achieve efficient surface cleaning and not cause gas breakdown in a normal air environment. It was shown that a irradiance of greater than $1x10^7$ W/cm^2 and a pulse length less 150 ns at a 1064 nm wavelength was required for efficient ablation of stainless steel surface material.

A proprietary, high repetition rate, acousto-optic, Q-switched, fiber optically delivered, Nd:YAG, laser light ablation system was developed which met the minimum requirements for efficient ablation of stainless steel surface material. This technology is unique due to the integration of: 1). A high power, high repetition rate, acousto-optic, Q-switched, Nd:YAG laser with 2). A fiber optic beam delivery system, in conjunction with 3). A particle collection cell and filtration system. This system has the proper combination of wavelength, pulse length, irradiance and particulate collection for efficient laser light ablation or laser surface decontamination.

Laser Light Ablation Test Results

To test the efficiency of laser light ablation, SIMCON (simulated contamination) coupons were used. Two types of SIMCON coupons were used for these tests. SIMCON I coupons, which represent "loose" or surface contamination, consist of known quantities of Cs and Zr nitrate salts that are dried on the surface of a 1" dia. stainless steel coupon. SIMCON II coupons, which represent "fixed" contamination, consist of known quantities of Cs and Zr nitrate salts which are baked at high temperature for a period of 24 hrs. SIMCON I coatings are easily removed. SIMCON II coatings are tenacious and difficult to remove. X-ray fluorescence spectrometry was used to determine the amount of Cs and Zr on the surface of the coupons both before and after cleaning with the laser. These SIMCON coupons are a good representation of the types of contamination that can be found in an environment that may contain radioactive contamination.

During the development of this laser ablation system, several tests were conducted to determine the optimum operating parameters to achieve the maximum ablation efficiency. These operating parameters are also vital for determining the operating envelope that is required for robotic deployment. Tests results on SIMCON II coupons cleaned using the optimum operating parameters indicate an average of **100% of the Cs and 95.14% of the Zr** simulated contaminates were removed. When SIMCON II coupons were cleaned within the operating range, an average of **99.43% of the Cs and 93.32% of the Zr** simulated contaminates were removed.

Since this system was developed for decontamination of hot cells and hot cell equipment, radiation exposure tests were conducted on the fiber optics and the output focusing lens. Three 1 meter fiber optics were prepared and tested to determine the power transmission of the fiber prior to irradiation. These fiber optics and output focusing lens were then exposed to a high energy gamma radiation source. The three 1 meter fiber optics were then tested to determine their power transmission after irradiation. The results of these tests can be found in **Table 2**. No significant degradation of the fiber optics was observed.

Additional tests were conducted utilizing radioactively contaminated material (REALCON 1). This material was used in a calcining facility at the ICPP and had previously been chemically decontaminated but still retained residual contamination. The samples were made of Stellite 25 (also known as Haynes 25) which is an extremely hard and durable material composed primarily of Cobalt. An excimer laser had been used to clean this sample type once before without success. For this experiment, only a flat portion of the sample's curved surface was cleaned. The initial activity for the sample was 4500 cpm (counts per minute). Using the laser's optimum operating parameters the activity dropped to 2000 cpm after the first pass. The activity continued to decrease and reached 1300 cpm after the fourth pass. No further reduction of activity was noted after additional surface scans. This was most likely due to measurement of background activity from the surfaces that were not cleaned or activity in the bulk of the material. Nevertheless the high repetition rate, acousto-optic, Q-switched, fiber optically delivered, Nd:YAG, laser light ablation system clearly succeeded in reducing the contamination levels of one of the hardest know alloys. Approximately 80% of the contamination, on the cleaned surface, was removed on the first pass of the laser beam.

Table 2. Effects of radiation exposure on fiber optic laser transmission.

SAMPLE	Exposure to 26,496 R/hr source (min.)	Equivalent Exposure (days in a 100 R/hr hot cell)	Total Dose to fiber (R)	Pre-Irradiation Output power (W)	Post-Irradiation Output power (W)
A	38.1	7	16,800	154	153
B	76.2	14	33,600	154	153
C	152.4	28	67,200	154	153

Chemical Decontamination of Metal Surfaces

Novel low-sodium chemical decontamination methods were tested during the decontamination development activities. Eight different chemical cleaning solutions were compared. These chemicals can be broken down into three major families: oxidation/reduction chemistry, chelating/complexing chemistry and acid dissolution.

Chemical Decontamination Procedure

In the evaluation tests, SIMCON II coupons were placed in a beaker of the chemical and heated to 55 C and stirred for a period of 3 hours. After this chemical soak, the coupons were rinsed with water, dried with compressed air and submitted for XRF analysis to give the comparative effectiveness results. A PAIR (Polarization Admittance Inductive Resistivity) corrosion instrument was used to determine metal corrosion. Computer modeling of evaporation, storage and calcination of the different solutions used gave overall waste generation volumes.

Chemical Decontamination: Results

The most common type of decontamination system is the oxidation/reduction chemistry. An alkaline potassium permanganate (AP) is typically used in this system as the oxidative step, followed by a oxalic acid based reduction. In the evaluation tests, an AP solution of TURCO 4502 was compared with a nitric acid/permanganate solution (NP) for the oxidative step. A reductive step of nitric acid/oxalic acid was typically used for both solutions. Traditional alkaline permanganate (AP) decon solutions are generally preferred to acidic permanganate (NP) because of their lower corrosion of metals (due to their basic nature). Corrosion remains fairly well controlled with AP solutions even when used at high concentrations. However, strongly alkaline solutions are inherently high in sodium and potassium hydroxide, resulting in high waste volumes added to the ICPP waste calcination system. The test results (**Table 3**) reveal that the NP can be an effective and controllable alternative with far less waste volumes than the AP solution. ICPP use of the NP/nitric oxalic decontamination solutions have confirmed about a 60% overall removal per cycle.

The organic acids and Ionquest 201 are examples of chelants that can be used in decontamination. A solution of organic acids (ethylenediamine tetraacetic acid (EDTA), oxalic, citric and ascorbic acids each at 1% concentration) was employed in these tests. Moderately good decontamination was achieved using this solution alone, and it is also an effective reductant for use in the two step process. Ionquest 201 is a strong complexing reagent marketed by Albright and Wilson chemical company. This is a proprietary chemical that is an organic, phosphonic acid. Preliminary results show that Ionquest 201 is also successful at removing SIMCON II type contaminants. Aluminum nitrate was tested as a chelant. This chemical receives widespread used at the ICPP, so it's decontamination effectiveness was tested simply to validate that potential use.

The results of these tests can be found in **Table 3**[2]. The best solutions tested were acids that contained some fluoride. The best decontamination was achieved by a 1 molar solution of fluoroboric acid, with the next best solution being a 800 ppm solution of hydrofluoric acid in 3.5 molar nitric acid. The least waste was also generated by the dilute fluoride/nitric acid solution. This solution is highly recommended for use, but is not favorably viewed by ICPP process engineers because of the potential deleterious effects of fluoride. The ICPP use of NP oxidative chemical in the denitrator area reduced radiation fields from approximately 80 mr/hr at contact to about 3 mr/hr. A 2' hot spot in the 40' line remained at 20 mr/hr after two cycles of NP - nitric/oxalic acids and was shielded locally. The NP minimized the waste volume by about 94% over AP, based on calcined volumes.

Table 3. Chemical Effectiveness, Corrosion and Waste Generation.

Chemical Reagent	SIMCON 2 Cs-Df	SIMCON 2 Zr-Df	Corrosion (mil./yr.)	Evaporated Volume(m^3/m^3)	Calcine Volume(m^3/m^3)
Turco 4502	5.5	(0)	90	0.45	0.34
Nitric Permanganate	2.8	1.1	100	0.0125	0.019
Aluminum Nitrate	1.8	1.7	*	0.273	0.23
Organic Acids	3.1	1.6	0.1	0.26	0.07
Nitric/Oxalic	4.5	1.3	0.1	0.67	0.18
TUCS	4.8	3.3	*	1	0.27
Nitric 800ppm Hydrofluoric	6.1	13.8	0.08	0.0525	0.0058
Fluoroboric Acid	12.6	37.2	0.1	2	0.26

* this data unavailable

Conclusions

Concrete Decontamination Scoping Tests

The purpose of this demonstration was to evaluate three concrete decontamination techniques that have not previously been used at the ICPP and to determine how well each method performed. The results from the concrete decontamination tests shows that all three methods were effective at decontaminating concrete. However, when choosing a concrete decontamination methods, several aspects have to be considered. These include; type of concrete, location, condition, cleaning time requirements and whether the concrete is being cleaned for disposal or re-use. The scabbling and chemical concrete cleaning techniques are well developed, straight forward techniques. Further testing with the electro-osmotic pulse technique may be necessary to fully understand the method's potential and limitations. Based on the results of these tests, the Decontamination Development Subunit and the ICPP D&D Subunit each purchased a VAC-PAC scabbling system. The EET chemicals have been used at the NWCF Decontamination Facility to perform several successful decontaminations of various materials to below background levels.

Laser Light Ablation: Decontamination of Metal Surfaces

The proprietary laser light ablation system that has been jointly developed by the INEL and Ames Laboratory, shows great potential for use in decontamination of metal surfaces. This technique generates very little secondary waste while being an aggressive decontamination method. The system can be used to remove only the surface contamination or it can remove the surface as well as the fixed contamination which resides in the material substrate. The INEL and Ames Laboratory are currently working to develop real time process monitoring equipment and to integrate the laser ablation system with robotic and computer control. The INEL and Ames Laboratory are also actively seeking industrial partners to help commercialize this technology.

Chemical Decontamination of Metal Surfaces

The testing of novel, non-sodium, chemical decontamination solutions has resulted in the identification of several decontamination solutions which have higher decontamination efficiencies and generate lower final waste volumes. A priority will be place on implementing these new chemical decontamination solutions in future ICPP decontamination activities.

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