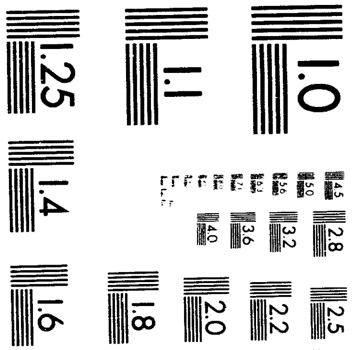
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CO_2 PELLET BLASTING LITERATURE SEARCH AND DECONTAMINATION SCOPING TESTS REPORT

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ABSTRACT

This evaluation report is a summary of the research efforts and scoping tests using the CO_2 pellet blasting decontamination technique. The purpose of these scoping tests was to determine the effectiveness of this decontamination technique in a variety of situations.

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ACRONYMS

DF	decontamination factor
ICPP	Idaho Chemical Processing Plant
NWCF	New Waste Calcine Facility
SIMCON	simulated contamination
WINCO	Westinghouse Idaho Nuclear Company
XRF	x-ray florescence
EG&G	Edgerton, Germeshausen and Grier
ECD	Environmental Control Division

CO_2 Pellet Blasting Literature Search And Decontamination Scoping Tests Report

1.0 INTRODUCTION

Past decontamination and solvent recovery activities at the Idaho Chemical Processing Plant (ICPP) have resulted in the accumulation of 1.5 million gallons of radioactively contaminated sodium-bearing liquid waste. Future decontamination activities at the ICPP could result in the production of 5 million gallons or more of sodium-bearing waste using the current decontamination techniques of chemical/water flushes and steam jet cleaning. Chemical decontamination flushes have been used and studied for the last ten years and have provided a satisfactory level of decontamination. However, this method requires repetitive flushes to achieve a clean surface while generating large amounts of sodium-bearing secondary waste. Steam jet cleaning has also been used with a great deal of success but cannot be used on concrete or soft materials. With the curtailment of reprocessing at the ICPP, the focus of decontamination is shifting from maintenance for continued operation of the facilities to decommissioning. As decommissioning plans are developed, new decontamination methods must be used which result in higher decontamination factors and generate lower amounts of sodium-bearing secondary waste.

Treatment of sodium-bearing waste is a particularly difficult problem due to the high content of alkali metals in the sodium-bearing liquid waste. It requires a very large volume of cold chemical additive for calcination. This is due to the low melting points of the sodium and potassium salts which contribute to the agglomeration of salts in the bed of the calciner. In addition, the sodium content of the sodium-bearing waste exceeds the limit that can be incorporated into vitrified waste without the addition of glass-forming compounds (primarily silicon) to produce an acceptable immobilized waste form.

The primary initiatives of the WINCO Decontamination Development Program is the development of methods to eliminate/minimize the use of sodium-bearing decontamination chemicals and to minimize all liquid decontamination wastes. One method chosen for cold scoping studies during FY-93 was CO_2 pellet blasting. CO_2 pellet blasting has been used extensively by commercial industries for general cleaning. However, using this method for decontamination of nuclear materials is a fairly new concept. The following report discusses the research and scoping tests completed on CO_2 pellet blasting. (Statements relating to particular products are not intended as factual certainties but rather reflect the opinion and belief of the author).

2.0 LITERATURE RESEARCH

The CO_2 pellet blasting system consists of liquid CO_2 at 200-300 psig, which is transported through a hose to a pelletizer machine where rapid expansion of the liquid in the chamber converts the CO_2 to a solid state of dry ice or snow. The snow is then compressed into pellets which are transported through a hose at 40 psig to a blasting nozzle. At the nozzle, the pellets are entrained in high pressure air (40-250 psig) and propelled from the nozzle onto the workpiece at 75-1000 feet per second. Another alternative is to transport the pellets through the hose with the high pressure air. The CO_2 pellet penetrates the coating (mechanical abrasion), "mushrooms" under the coating as it strikes the substrate, and then sublimes causing the coating to fall off leaving only the coating as waste while the CO_2 pellet returns to its natural state.

CO_2 pellet blasting is a non-destructive decontamination method. NDC (Non-Destructive Cleaning) has conducted studies and comparisons of CO_2 pellet blasting and water based decontamination systems. In their studies, they found that a laminar boundary layer of the water-based decontamination systems prevents the water from getting into the small fissures in the metal to remove contamination. Since the laminar boundary layer of the CO_2 gas is such smaller, the gas is able to penetrate the smaller fissures and remove more contamination.

2.1 Technical Performance

2.1.1 Operability/Simplicity

There are two basic CO_2 pellet blasting systems used in commercial and private industries. The two systems use the same basic equipment, but vary in the transportation and manufacturing of pellets. The Cold Jet System combines the pellets with dry air into one hose. The Alpheus System uses a two hose system, one hose for air and one for pellets.[1] The major problem with a one hose system is any kind of obstruction (such as an obstruction in the nozzle) causes the pellets to begin to sublime before they exit the nozzle.

The manufacturing of pellets also varies depending on the CO_2 pellet system being used. The Cold Jet utilizes a hydraulic ram that packs carbon dioxide snow against and then pushes the snow through a die. As the product exits the die, the material breaks off as a result of its own weight, producing pellets of uneven length and consistency. The Alpheus system utilizes a mechanical roller that continuously pushes the carbon dioxide snow through the die. As the product exits the die, the material is cut into pellets of uniform length and density.

Pellet usage and production by both systems is not totally efficient. When the trigger of the Alpheus system is not operating, the pelletizer discharges its pellets to the ground. From complete shutdown to start-up, the Alpheus system takes 20 minutes to produce pellets. Because the Cold Jet pellets are made at a slower rate then the nozzle discharges them, this operation requires a supply of pellets to be on hand or a waiting period must be considered before operations are initiated.

Rocky Flats has done a comparison of both the Cold Jet System and the Alpheus System.[1] They found that neither system performed flawlessly. The Alpheus System problems were more mechanical type problems like screws being loose or the failure of the diesel compressor battery. The Cold Jet System problems were more cleaning and design type problems. The Cold Jet System created hazardous working conditions for personnel in the contamination structure, namely the carbon dioxide levels were too high and the oxygen levels were too low. This indicates a large ventilation system will be required. Also, the Cold Jet System lowered the temperature of the object being cleaned so much that ice formed during cleaning. Although the ice eventually melted, the cleaning process caused moisture to build up in the room as the water evaporated. The roughing filters used to capture larger particles as they exited the contaminated room became clogged with moisture, lowering the efficiency of the air movers and taking longer for the air in the room to change. Therefore, Rocky Flats recommend the Alpheus system.

Vermont Yankee Nuclear Power Plant decontamination personnel indicated one of the most puzzling problems encountered when first using the Alpheus System was the inconsistent decontamination rates.[2] Irregular production and delivery of the CO_2 pellets was finally determined to be the cause. To correct the problem, the air dryer was adjusted to eliminate the frost build-up that was restricting the flow of pellets.

The CO_2 pellet blasting system can been used either inside or outside a module, depending on what is being decontaminated. For decontaminating in nuclear facilities, modules are usually built on site, however, there are companies that build modules that contain CO_2 pellet blasting systems. One module of particular interest is constructed of steel which combines a CO_2 pellet blasting system and a liquid abrasive grit blasting system into one module. It can be switched from one to the other by a switch on the outside panel. The module has a collection tray covered by a metal grating located at the bottom of the module for collection of both liquids and solids. The inside walls are covered with rubber liner to reduce noise and help protect the walls. All items being decontaminated are placed on a rolling tray inside the module. After the system has been used for long periods of time, the walls and floor are cleaned using the CO_2 pellet blaster.

There is also a CO_2 pellet blasting system which is located inside a mobile decontamination facility. The facility is housed in a stand alone, transportable, steel enclosure which can range in size from 16 x 20 to 16 x 40 feet in size. The only external service that the mobile facility requires is electrical power. The mobile decontamination facility has a decontamination room, decontamination cell room, count room, and HVAC equipment located inside. Most companies have opted to build their own module because of size restrictions and location of where they want to have the system.

Operation of the CO_2 pellet blasting system requires a minimum of two people; one person to work with the CO_2 pellet blasting nozzle and one to watch gauges and control the equipment. This system can also be used in a glovebox for work on small parts.

(There have been modifications made to the Environmental Alternatives system after companies have encountered problems with the pressure control devices of the system. More gauges have been added to make the system easier to use and help prevent the system from being shut down due to either high or low pressures).

2.1.2 Cleaning Rates and Decontamination Factors

Both CO_2 systems have been proven to be effective in removing loose contamination from stainless steel, carbon steel, concrete, glass, herculite, wood, plastic, weld slag, electric components, paints, lead, aluminum, rubber, handtools, small parts, and pumps (Appendix A, Tables A-1.0 & A-2.0). CO_2 pellet blasting does have a problem cleaning fixed contamination along with epoxy coated concrete, carbon steel, rusted carbon steel, complex geometries, and inside pipes.

The decontamination factors (DF) for this system range from 2 to 10 (Appendix A, Table A-2.0) depending on which material is being cleaned and which method is used. Pellet density, angle of impact, pressure changes, nozzle design, and stand-off distance are all factors in decontaminating material. All these factors need to be considered when using the CO_2 pellet blasting system.

The cleaning rate of CO_2 pellet blasting varies depending on the experience of the operators. A demonstration of CO_2 pellet blasting was conducted by Rocky Flats personnel and it was found that when the operators first used the system they could clean lead bricks on an average of 52.3 lbs./hr. After the system had been on site for a month, the rate of cleaning jumped to 72 lbs./hr.[1] Other companies have been able to process 70 to 90 lead bricks per day which equates to an average of 10,400 lbs. per week.

2.2 Remote Applicability

The CO_2 pellet blasting system can be used both in a in-situ and ex-situ decontamination situations. Decontamination can also be done remotely with this system. A nozzle mounted on a automatic computerized controlled remote arm is used.

2.3 Waste Considerations

The reduction of secondary waste while using CO_2 blasting systems has been investigated and found to be highly favorable. Chem-Nuclear Systems, Inc. found that the only secondary waste generated during testing of this system was the disposable protective clothing, a vacuum cleaner filter, and the roughing filter installed in the ventilation duct.[3] A calculation was performed to estimate the amount of waste that would be generated to remove 3 mil thick layer of paint from a 20,000 square foot floor. The result was 5 cubic feet of loose paint, that could be disposed of in one 55 gallon drum. A comparison of CO_2 pellet blasting to sandblasting was made and removal of this paint by sandblasting would require approximately 10 pounds of sand per square foot of area to be cleaned. The cleaning of 20,000 ft^2 would require 222 drums for disposal.

The system is fully compatible with ICPP processes. The CO_2 goes to the atmosphere after being vented through HEPA filters. Spent HEPA filters will require treatment (like the filter-leach system) if they are considered mixed waste. The solid waste can be collected in drums.

2.4 Environmental, Safety and Health Considerations

Ventilation (air changes) is the biggest concern while using this system. The ventilation off-gas (VOG) system must be able to handle the large amount of system off-gas. There have been modifications to some systems which involved removing the roughing filters and inserting removable in-line filters. These filters can be removed periodically to determine the amount of contamination passing through the system. Tests have been run to determine the amount of contamination passing through the system as well as the location of the contamination after decontamination. Environmental Alternatives conducted a CO_2 pellet blasting test on a piece of material with a spot reading of 30 mR. After the test was complete and the filters were examined no contamination could be found on the filters. The conclusion was that the contamination was dispersed throughout the filter.

Chem-Nuclear Systems, Inc. conducted tests on concentrations of airborne radioactive materials before, during, and after decontaminating materials with the CO_2 pellet blasting system (Appendix A, Table A-3.0)[3] .Three types of air samples were collected during testing. First, a high volume air sampler was positioned adjacent to the workpiece during decontamination activities. Second, a low volume air sampler was used to sample the air in the cell area outside of the decontamination booth. A sample was collected every 15 minutes from the sampler. Third, a continuous air monitor was positioned to collect samples at the entrance to the decontamination booth. All samples were counted for one minute. The highest concentration of airborne activity occurred during decontamination of the hot spots on the concrete floor, but was still less than 10% of the NRC limit for working without respiratory protection. The airborne concentrations during all other decontamination activities remained below the NRC maximum permissible for unrestricted release to the environment.

The safety concerns of CO_2 pellet blasting have been researched. Personnel using this system have found that even when then the CO_2 pellets have hit bare or covered skin, there is a stinging effect but no penetration. A respirator is required but a bubble suit with a fresh air supply would be better. The noise level of the system varies from about 75 to 125 dB, depending on the operating pressure.[4] Hearing protection would be required to use the system.

In order to operate the system at the ICPP in a full production mode, air permitting would be required. The question of the effect on atmosphere of releasing the CO_2 gas has been addressed by CO_2 Cleanblast personnel.[4] About 90% of commercial CO_2 is produced as a by-product of other chemical processes. Gas that would have been discharged into the atmosphere is actually reclaimed. By reclaiming this gas and purifying it, and then by getting useful work from it, the commercial CO_2 market is not a true source of CO_2 pollution. A CO_2 system operating one shift per day returns about a ton of CO_2 into the atmosphere each day. This quantity is very low considering the more significant sources of CO_2 in the US. A typical American family of three generates 34 tons of CO_2 annually, from direct and indirect consumption of fossil fuels. A single 100 KW coal-fired generator plant releases 1,850 tons of CO_2 daily. That is the equivalent of more than 1,500 CO_2 pellet blast systems.

2.5 Costs

The development costs of using CO_2 pellet blasting will be low due to the recent development of this technique throughout industry. The full scale equipment costs range from $250 K to $300 K. Labor costs are low due the simplicity of the system.

3.0 SCOPING TEST

The literature investigation clearly demonstrated that CO_2 pellet blasting was a viable alterative to the liquid based methods traditionally utilized at the INEL. The existing literature base lacks the data needed to evaluate the facility air permitting impacts or cleaning results of various lead shapes, and decontamination factors achieved for the range of materials and levels of radioactive contamination common at the INEL and throughout the DOE complex. This report will give the results and evaluation of the CO_2 pellet blasting demonstration that was conducted at the ICPP.

The demonstration consisted of performing tests to validate quantified air emissions from the application of this technology, media/performance standard applicability for debris treatment, cleaning results of various lead shapes, and decontamination factors achieved for the range of materials and levels of radioactive contamination common at the INEL. This demonstration was a joint venture between WINCO and EG&G. The work was completed under a NEPA CX (Categorically Excluded) permit approval and an exemption to state air permitting.

After the literature review was complete, it was determined that the Alpheus equipment was more suited for the particular application at the INEL. Consequently, the request for proposal was written around the performance achieved by the Alpheus based CO_2 pellet blasting system. However, the low bidder, Environmental Control Division (ECD) out of Denver, Colorado uses the Cold Jet system and was awarded the contract. ECD was able to meet the specifications in the proposal by enhancements made to their system by Clean-Kool and Mercer Engineering Research Center such that it can achieve the same performance as an Alpheus based system. This resulted in an additional purpose for the verification testing, to test the claim that the modifications to the Cold Jet equipment do in fact result in performance equal to the Alpheus based system.

The specific enhancements deal with pellet consistency and integrity. Clean-Kool, Inc. installs a pellet making upgrade for the Cold Jet Equipment that improves the hardness and pellet integrity such that a consistent quality of pellets is produced throughout the desired range of sizes and hardness. The second enhancement is to the delivery system. The liquid nitrogen enhanced delivery system developed by Mercer Engineering Research Center lowers the temperature of the pellet air stream at the pellet hopper to eliminate almost all of the pellet degradation experienced by conventional systems.

3.1 Experimental Equipment

The cold and hot testing was performed in the Hot Shop of the New Waste Calcining Facility (NWCF). The Hot Shop is a 40'x 55' room adjacent to the decon area of the NWCF with a stainless steel floor, HEPA filtered ventilation, and direct outside access. Figure 1 shows general layout of the CO_2 pellet blasting system which was located outside the Hot Shop. Figure 2 shows the layout of the enclosure inside the Hot Shop. To operate the CO_2 pellet blasting system, a large generator was brought on-site, along with liquid nitrogen, liquid carbon dioxide, and fuel supply tanks. All of the equipment except the nozzle and hose were located outside the Hot Shop.

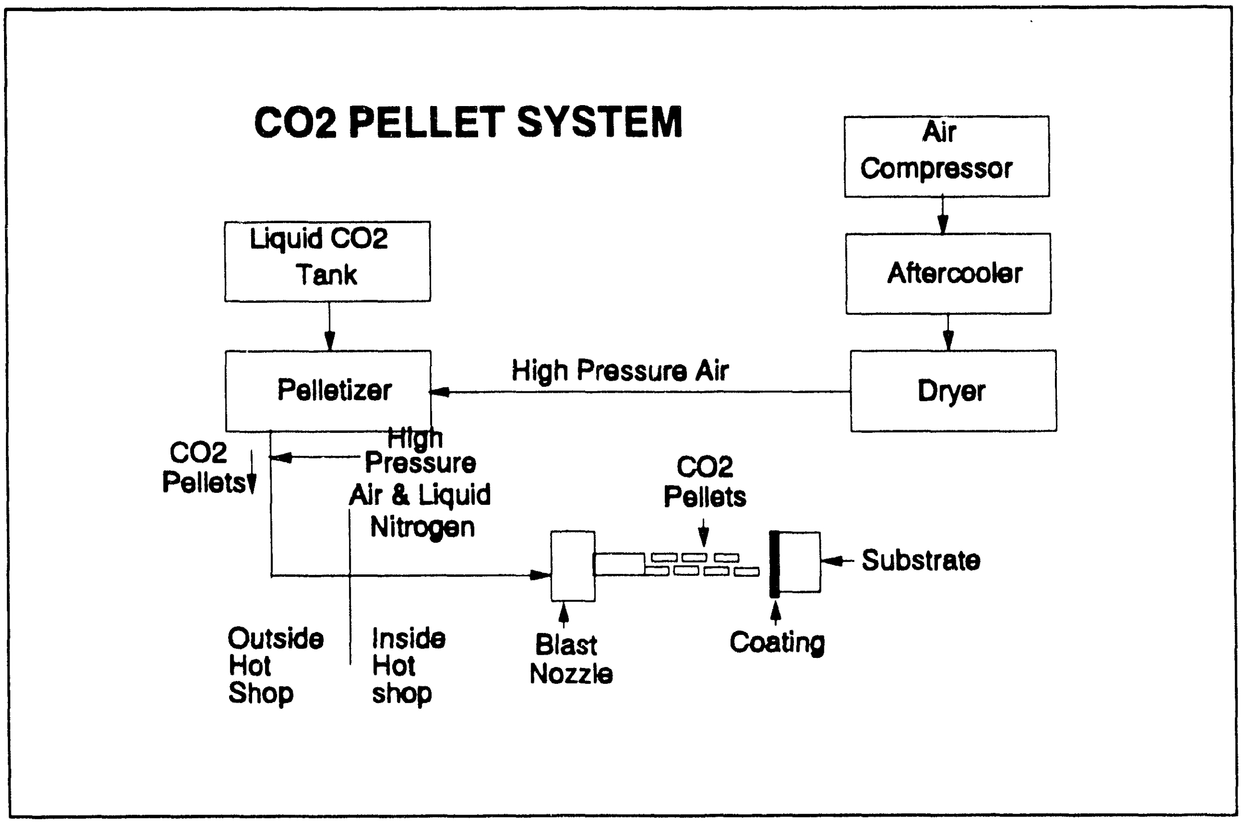

Figure 1 - CO_2 Pellet Blast System

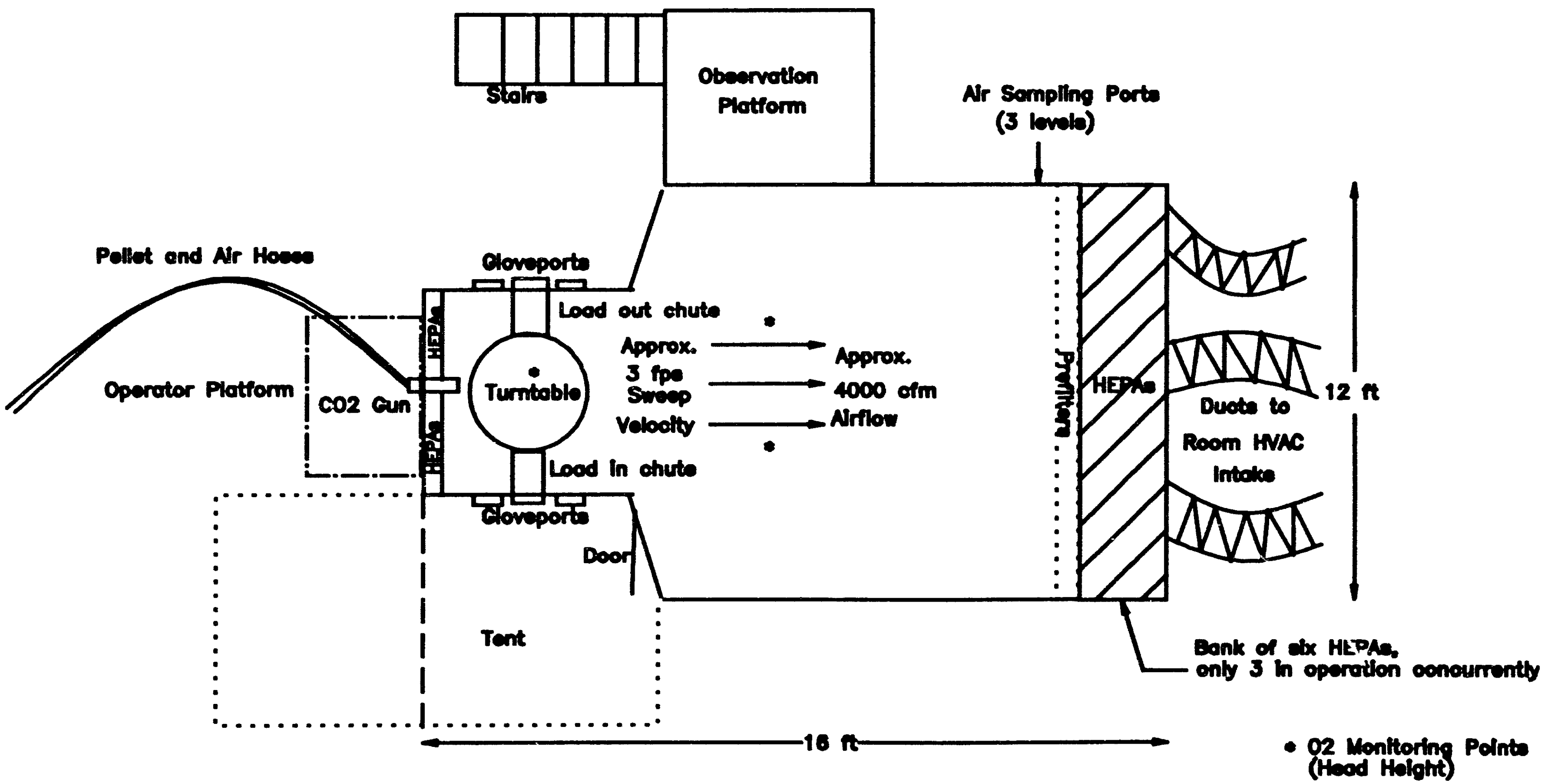

Figure 2 — CO2 Demonstration Enclosure Layout

The Cold Jet blasting system used for this demonstration is a portable unit which means that the pelletizer, hopper, and air handling units were all separate components making it more maneuverable. These components all fit into a 15' long X 8' wide trailer. The large stationary unit combines all of these components into one single unit.

A large generator had to be brought on site because of the power required to run this CO_2 pellet blasting system (480V/ 3 phase / 200 amp circuit) is not standard. ECD is working on converting their system so that it can be used with standard power supplies (480V/ 3 phase / 70 amp circuit) .

The enclosure was supplied by ECD from a design by Los Alamos Technical Associates Inc. (LATA) for doing decontamination work. The enclosure walls were 3 inch white vinyl-faced hardboard with a plexiglass ceiling. The front panel of the containment structure was replaced with a aluminum panel containing louvers to aid in air flow. WINCO modified these louvers by covering them with HEPA filters to prevent contamination backflow out of enclosure. WINCO provided a plexiglas window with a port hole for the front of structure so that the gun could be placed into the containment structure while the operator stood outside the structure and shoots the CO_2 pellets into the containment structure. WINCO also provided gloveports for bagin & bagout and a tented entry way for the enclosure for contamination control.

The nozzles that were used during the demonstration were rectangular in shape and varied in sizes from 1 to 8 inches in width with a 1/2" to 1-1/2" nozzle opening.

3.2 Experimental Procedure

The testing of the CO_2 pellet blasting system was organized in three distinct phases. The first phase concentrated on cold surrogate materials to verify the effectiveness of the containment, ventilation, cleaning abilities, and to gather initial data of operating parameters prior to hot operation. The second phase involved testing, both for decontamination and debris treatment, of low-level radioactively contaminated materials and tools. As lower levels of contamination were successfully handled, the testing progressed to higher levels of contamination. The final phase of testing encompassed radioactively contaminated lead. The testing varied the key operating parameters (pellet density, nozzle type, pressure, stand-off distance, and angle of nozzle) to gather data for optimizing performance. Data was also gathered on atmospheric conditions inside and outside the containment structure during blasting operations. The data showed that the O_2 levels did not fall below the limits specified in 29 CFR 1910.1025. The usage rates of liquid CO_2, liquid nitrogen, and fuel for operating the air compressor will be supplied in a report from ECD which is currently being prepared.

The cold testing was made up of the following two parts:

1) **General Cleaning Ability.** Rust, tape, polyken wrap, and enamel paint were removed from the stainless steel, plastic, concrete, wood, and carbon steel. Substrate removal from wood and concrete was also tested.

2) **Simulated Contamination Cleaning Ability.** The cleaning ability of the system was tested by determining the amount of known simulated contamination (SIMCON) that could be removed from stainless steel coupons. SIMCON 1 coupons consisted of cold zirconium and cesium dried onto the surface. SIMCON 2 coupons consist of cold zirconium and cesium dried onto the surface and then baked in an oven at 700 deg C for 24 hours. SIMCON 1 is comparable to loose surface contamination and SIMCON 2 is comparable to fixed contamination.

   Two tests were run using SIMCON coupons. During the first test, pressure and die size were varied. During the second test, pressure and die size were held constant and the cleaning time was varied.

The hot testing was made up of the following two parts:

1) **Low Level Radioactively Contaminated Materials.** The cleaning ability of the system was tested by determining the amount of fixed and loose contamination that could be removed from construction type tools and materials. The free release criteria for ICPP is as follows:

   1) <200 dpm Beta/Gamma (smearable)

   2) <10 Alpha dpm (smearable)

   3) <100 cpm > background Beta/Gamma (fixed)

   4) No detectable Alpha (fixed)

2) **Radioactively Contaminated Lead Bricks.** The cleaning ability of the system was tested by determining the amount of fixed and loose contamination that could be removed from lead bricks. The portion of testing was conducted by EG&G.

3.3 Analysis

XRF (X-Ray Florescence) analysis was used to determine the amount of zirconium and cesium on the SIMCON coupons both before and after cleaning. The zirconium and cesium levels were measured in micrograms. The XRF is capable of measuring down to 1 microgram, anything below 1 microgram is considered below detectable limits. The effectiveness of the CO_2 pellet blasting system was determined by the ability to reduce the amount of zirconium and cesium to below detectable limits (less than 1 microgram). Therefore 100% reduction would mean that the zirconium or cesium was reduced to below detectable limits.

3.4 Results

General Cleaning Ability - The results from cold testing indicate that the CO_2 pellet system is very effective for general cleaning. The system removed rust , tape, polyken wrap, and enamel paint from a variety of materials. Substrate removal was also investigated using wood and concrete. The system removed the substrate from wood, but was very limited on concrete. The only part of the substrate removed from the concrete was the top layer which consisted of cement and sand. After the top layer was removed and aggregate was exposed, the system was not effective.

Simulated Contamination Cleaning Ability - The first test performed involved maintaining a constant cleaning time of 1 minute and varying the pressure and die size. The pressure used varied from 125-205 PSI. All of the pressures and dies were effective on cleaning SIMCON 1, however, the system was not as effective on SIMCON 2. The average removal rates for both SIMCON 1 & 2 can be seen in Tables 1 and 2.

TABLE 1
SIMCON 1
Percent Removal

Pressure	205 psi	150 psi	125 psi
Die .080	Cs-94% Zr-93%	Cs-93% Zr-93%	Cs-94% Zr-94%
Die .125	Cs-91% Zr-92%	Cs-95% Zr-96%	Cs-89% Zr-92%

TABLE 2
SIMCON 2
Percent Removal

Pressure	205 psi	150 psi	125 psi
Die .080	Cs-15% Zr-83%	Cs-39% Zr-78%	Cs-35% Zr-80%
Die .125	Cs-18% Zr-78%	Cs-20% Zr-70%	Cs-54% Zr-80%

After the data was evaluated from SIMCON 1 and 2 coupons, it was determined that the .125" die and 150 psi had the highest cleaning efficiency for SIMCON 1. For SIMCON 2 the highest cleaning efficiency was obtained using the .125" die at 125 psi. From this data a second test was run using the same type of coupons but using a pressure of 150 psi, a .125" die, and varying the cleaning time. The average removal rates for both SIMCON 1 & 2 can be seen in Tables 1A and 2A.

TABLE 1A
SIMCON 1
Percent Removal

Time	:30 sec.	1:30 min.	2:00 min.
Die .125	Cs-83% Zr-87%	Cs-91% Zr-92%	Cs-90% Zr-92%

TABLE 2A
SIMCON 2
Percent Removal

Time	:30 sec.	1:30 min.	2:00 min.
Die .125	Cs-41% Zr-79%	Cs-63% Zr-78%	Cs-57% Zr-74%

When this data was evaluated and compared to the first tests ran on SIMCON coupons, it was determined that to obtain the highest cleaning efficiency for SIMCON 1 would be to use the .125" die at 150 psi for 1:00 minute. To obtain the highest cleaning efficiency for SIMCON 2 the cleaning time would have to be increased to 1:30 minutes.

During the cleaning of the coupons, the system was also tested to determine if liquid nitrogen would enhance the cleaning efficiency. One set of coupons was cleaned without using the liquid nitrogen enhancement and results indicated that the cleaning efficiency was reduced by 2-3 percent. In order to obtain a better feel for whether the system is better with or without the liquid nitrogen, more testing would have to be performed.

Low Level Radioactively Contaminated Materials- The tested performed used a feed rate of 70% and the optimum pressures of 125 psi and 150 psi using the .125" and .080" dies that were found during the first phase of testing. These pressures and dies produced a "clean release" of the construction tools. The results from this testing can be seen in Table 3.

TABLE 3
Tools Cleaned At ICPP

TEST PIECE	FIXED β/γ c/m	FIXED β/γ c/m	SMEARABLE β/γ/α d/m	SMEARABLE β/γ/α d/m
	BEFORE	AFTER	BEFORE	AFTER
Wire Brush	500	<100	<200 β/γ <10 α	<200 β/γ <10 α
Pipe Cutter	1,000	120	962 β/γ <10 α	<200 β/γ <10 α
Hammer	1,200	500	937 β/γ 14 α	<200 β/γ <10 α
Pliers	1,600	1000	2125 β/γ 142 α	<200 β/γ <10 α
Screw Driver	450	<100	800 β/γ 40 α	<200 β/γ <10 α
Jack Handle	350	100	600 β/γ 42 α	<200 β/γ <10 α
*Crit. Barrier (top)	22,000	1,000	328 β/γ <10 α	<200 β/γ <10 α
*Crit. Barrier (bottom)	10,000	200	218 β/γ <10 α	<200 β/γ <10 α

*Criticality barrier used for fuel storage spacing made of 304L stainless steel.

Radioactively Contaminated Lead Bricks- The final phase of the CO_2 pellet blasting demonstration was conducted by EG&G Idaho at the ICPP with support from WINCO's Decontamination Development Group in the Applied Technology Department. During this testing phase, lead bricks with high alpha levels were decontaminated.

At the start of this phase, ECD was asked to lower the blasting pressures to a range of 40-50 psi to help prevent the possibility of driving the contamination into the surface of the lead. WINCO Decontamination Development suggested the lower pressures because research, including conversations with vendors who have successfully decontaminated lead, indicated the best results could be obtained at these pressures using Alpheus equipment. Additionally, the lower blasting pressures were recommended because ECD had no experience in decontaminating lead and WINCO was unable to obtain information on decontaminating lead using Cold Jet equipment. The Cold Jet equipment was not designed to work at these low pressures. The only way ECD could get their equipment to reach the pressures was to bypass the shut off switch (at 100 psi) and reduce the feed rate of pellets to help prevent the auger from freezing.

The first attempt at decontamination was performed on nine lead bricks with fixed contamination to determine if the system could adequately maintain the low pressures.

The second part of the test involved blasting bricks with both loose and fixed contamination with high levels of alpha. During this blasting, WINCO noticed that when the feed rate was reduced to 25-35%, no noticeable pellets came out of the nozzle. This indicated that the system was not cleaning properly. The feed rate was then increased to 70% which caused the auger in the hopper to freeze. ECD then had to stop blasting for the day so that the auger could thaw. Additionally, the amount of liquid nitrogen introduced into the system had to be adjusted according to the pressure and feed rate used to help prevent further freezing. These problems were encountered throughout the lead decontamination testing.

After the first several high alpha contaminated bricks were blasted, EG&G was concerned about the possibility of cross contamination of the brick while being pushed through the load out chute. A method of moving the brick across the table and through the chute without it being in direct contact with the table or chute was needed. EG&G developed a small pull cart that was placed on top of the turntable. The pull cart had a set of spikes mounted on top of the pull cart so the bricks could be held without direct contact with the table. After the bricks were blasted, a bag was placed over the top of the bricks, the cart pulled over to the load out chute where the brick was then pulled through the chute. This new method helped reduce the amount of cross contamination.

EG&G decided to use higher pressures part way through the demonstration was due to conversations with ECD president and because of a video EG&G had seen that showed lead brick being cleaned by a CO_2 pellet blasting system. No bricks were cleaned to "free release" criteria but levels of alpha contamination were greatly reduced. WINCO feels that lead cleaning has been successfully completed by other companies, vendors, and government sites using CO_2 pellet blasting. This technique is proven successful but the equipment used for lead cleaning is a very important factor. A more detailed report of the results from this part of the test is being prepared by EG&G[5].

3.5 Conclusions / Recommendations

From the first set of tests conducted it is clearly evident that the CO_2 pellet blasting system is effective for every day type cleaning. The second test showed this method of decontamination is highly effective for cleaning radioactively contaminated tools and materials. When evaluating the results from this demonstration, it can be seen that this decontamination method is more effective on cleaning loose contamination than fixed. However, during the testing it was noticed that the system does remove large amounts of fixed contamination. This testing confirmed what all of the reports and vendors have said about the system being non-destructive. The tests also showed that to achieve the best cleaning results for stainless steel 304L, construction tools and materials with Cesium and Zirconium type contamination that the pressure should range from 125 psi to 150 psi using the .125" and .080" pellet die. However, during the first phase of testing, it could be seen that depending on the substrate and type of contamination, pressures and die sizes will have to be varied to achieve better cleaning efficiency. This method of decontamination is an alternative to some of the current liquid decontamination methods that are currently being used at the ICPP. Also, during this demonstration it should be noted that not only did the CO_2 pellet blasting system work with a great deal of success but the system did not produce any secondary waste beyond the filters and enclosure. Installation of CO_2 pellet blasting at the NWCF will not eliminate all of the chemical decon but will help reduce the amount of sodium waste that is being generated with the current decon techniques.

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APPENDIX A

TABLES

Table A-1.0 Environmental Alternatives

PRE-DECONTAMINATION	POST-DECONTAMINATION
Scaffolding-2mR/Hr Gamma, 8mR/Hr Beta (contact), 20kDpm/100 Cm_2, (smearable)	<100 ccpm-Direct Frisk, <1000 Dpm/100 Cm_2
Contractors Jacks-3 to 4 kDpm/100 Cm^2 in tight locations	<100 ccpm-Direct Frisk, <1000/100 Cm^2
Chain Hoists-200 ccpm on swivel joint, 5kDpm/100 Cm^2 (smearable)	<100 ccpm-Direct Frisk, <1000 Dpm/100 Cm^2
CDR Motor Cover-50 kDpm/100 Cm^2,250 ccpm on remote spot	<1000 Dpm/100 Cm^2, <1000 ccpm-Direct Frisk
RHR Orifice Plate- 8mR/Hr Beta (contact), 16 mR/Hr Beta (smearable)	10,000 to 20,000 ccpm, <1000 Dpm/100 Cm^2.
Safety Injection Orifice-32 mR/Hr Beta (contact), 50,000 Dpm/100 Cm^2 (smearable)	200 ccpm-Direct Frisk, <1000 Dpm/100 Cm^2
Safety Injection Orifice-12mR/Hr Beta (contact), 7000 Dpm/100 Cm^2 (smearable)	10,000 ccpm-Direct Frisk, <1000 Dpm/100 Cm^2
Safety Injection Orifice-<1mR/Hr Gamma (contact), 20,000 to 50,000 Dpm/100 Cm^2	200 to 2000 ccpm-Direct Frisk, <1000 Dpm/100 Cm^2
Motor for operation-200 to 400 ccpm, 5kDpm/100 Cm^2 (smearable)	<1000 Dpm/100 Cm^2, <100 ccpm-Direct Frisk

Table A-2.0 Chem-Nuclear Systems, Inc. - Contamination Levels ($dpm/100\ cm^2$)

TEST PIECE	FIXED	FIXED	SMEARABLE	SMEARABLE	DECON FACTORS AND RATES (1)
	BEFORE	AFTER	BEFORE	AFTER	
Bare Concrete Floor General Area	120mR/Hr	120mR/Hr	1000	254	3:1 @ 90 Ft^2/Hr
Concrete Block	10,000	2400	1420	N.D. (3)	4:1 @ 10.7 Ft^2/Hr
Drywall	7,000	1000	1622	802	7:1 @ 20 Ft^2/Hr
Carbon Steel Sprocket	10,000	1000	888	196	10:1 @ 160 in^2/Hr
2 x 4 x 24 Wooden Block	4,000	N.D. (2)	68	79	4000:1 @ 8 Ft^2/Hr
2 x 3 x 8 1/4 Angle Iron	5,000	N.D. (2)	1250	231	5000:1 @ 8Ft^2/Hr
Carbon Steel Gear Puller	8,000	2000	1500	184	4:1 @ 10 in^2/Hr
Stainless Steel Cylinder 2"0 x 24"	10,000	2000	1600	126	5:1 @ 5 Ft^2/Hr

(1) Decontamination factors and rates given are for removal of fixed contamination.
(2) N. D. - None detectable, less than 52 CPM.
(3) Decontamination factors and rate for hot spots were 6:1 @ 2.6 Ft^2/Hr.

Table A-3.0 Airborne Activity Conc. During Co_2 Decon Tests

	INITIAL CONCENTRATIONS
Cell	**2.24×10^{-11} uCl/ml**
Decontamination Booth	**2.06×10^{-10} uCl/ml**
	CONCENTRATIONS DURING TESTING
Workpiece	Airborne Concentration (uCi/ml)
Gear Puller	1.69×10^{-10}
Stainless Steel Cylinder	1.69×10^{-10}
Bare Concrete Floor	9.25×10^{-10}
Concrete Block	1.02×10^{-10}
Drywall	6.4×10^{-10}
Carbon Steel Sprocket	1.02×10^{-10}
Wooden Block	1.99×10^{-10}
Angle Iron	2.76×10^{-10}

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