INEL/EXT-97-00117

January 1997

Idaho National Engineering Laboratory

CO_2 Pellet Blasting Studies

Kip E. Archibald

LOCKHEED MARTIN

DISCLAIMER

INEL/Ext-97-00117

CO_2 Pellet Blasting Studies

Kip E. Archibald

Published January 1997

Idaho National Engineering Laboratory
Lockheed Martin Idaho Technologies Company, Inc.
Idaho Falls, Idaho 83415

ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance of Mike Greene, Russ Ferguson, Julie Tripp, Rick Demmer, and Wayne Griffin for their patience and assistance in testing the CO_2 equipment. Without their assistance this testing could not have been completed.

TABLE OF CONTENTS

TABLES

CO_2 Pellet Blasting Studies

1.0 INTRODUCTION

Initial tests with CO_2 pellet blasting as a decontamination technique were completed in 1993 at the Idaho Chemical Processing Plant (ICPP) at the Idaho National Engineering Laboratory (INEL).[1] During 1996, a number of additional CO_2 pellet blasting studies with Alpheus Cleaning Technologies, Oak Ridge National Laboratory, and Pennsylvania State University were conducted. After the testing with Alpheus was complete, an SDI-5 shaved CO_2 blasting unit was purchased by the ICPP to test and determine its capabilities before using in ICPP decontamination efforts. Results of the 1996 testing will be presented in this report.

2.0 OBJECTIVES

The objectives of these blasting studies included:

1. Determine the effectiveness of the CO_2 systems for decontamination.
2. Determine the effectiveness of different blasting guns.
3. Determine the effectiveness of pellets versus shaved CO_2.
4. Compare the removal rates of the portable units versus the large stand alone units.
5. Determine how effective the CO_2 units are at general cleaning, including paint removal from wood, concrete, stainless and carbon steel.

3.0 CO_2 SYSTEMS INVESTIGATION

Six different units have been tested including the system used during the 1993 CO_2 blasting demonstration at the ICPP.[1] The effectiveness of these systems were compared using stainless steel coupons with simulated contamination (SIMCON) dried on the surface to represent loose contamination (SIMCON I) or baked on the surface to represent fixed contamination (SIMCON II).[2]

3.1 Cold Jet

A Cold Jet system was used during the 1993 CO_2 demonstration at ICPP. This was a large stand alone system that had the capability of producing its own pellets. These results have been previously reported[1] and are summarized in Tables 1 & 2.

3.2 Alpheus

Alpheus also has a large stand alone system capable of producing its own pellets along with a portable unit which requires externally made pellets. Alpheus has just recently developed a portable system (SDI-5) that is capable of using either blocks of CO_2 or pellets.

The tests with Alpheus equipment were conducted by sending SIMCON I and II coupons to Alpheus Cleaning Technologies in Rancho Cucamonga, California. They blasted the SIMCON coupons using their Model 250 stand alone system and their portable units, SDI-5 and MLB-5, which are pneumatically operated. The model 250 produces its own pellets while the model MLB-5 has to have pellets made and transferred to the system. The model SDI-5 unit uses blocks of CO_2 which are shaved by blades and the particles of CO_2 are then blasted onto the surface being cleaned. The coupons were blasted with the same optimum pressures and time determined during the 1993 testing. These results are summarized in Tables 1 and 2.

The main differences between the Alpheus and Cold Jet systems are the pellet delivery systems and how the pellets are produced. The Alpheus systems have a two hose delivery system were the Cold Jet systems have a one hose delivery system. The two hose delivery system helps prevent freezing when blasting at low pressures and delivers the pellets to the nozzle with very little pellet degradation. The Alpheus system produces pellets by means of a roller die system where the Cold Jet systems uses a hydraulic press system. The Alpheus pellets are more uniform in size and density than the Cold Jet system.

3.3 Centrifugal CO_2 System

The CO_2 system tested at Oak Ridge National Laboratory was a Centrifugal CO_2 system. This system uses CO_2 pellets that are loaded onto an accelerator wheel which accelerates them along a curved path and delivers them to the surface being cleaned. The pellets have a velocity range from 0 to 500 m/s. This system is not as mobile as the commercially available CO_2 systems and at the present time the items that are being cleaned have to be placed under the system.

However, Oak Ridge personnel were looking at mounting this system on a robot for movement over surfaces.

When testing the centrifugal CO_2 system, only SIMCON II coupons were sent to Oak Ridge National Laboratory. During this test the operators of this equipment varied the pellet speed, feed rate, scan rate, and pellet dosage to optimize the cleaning rate. The cleaning results from this testing are in Table 3.

3.4 Supersonic Abrasive Ice-Blasting

Tests were also conducted with Pennsylvania State University using their recently developed supersonic abrasive ice-blasting system. This system projects a stream of cold compressed gas and ice micro-particles at high speeds against surfaces that need to be cleaned. When the ice micro-particles impact the surface, they wear away soft coatings and radioactive residues without damaging the surface. The system was still in its final development and testing phase when these tests were performed. The cleaning results from this test can be seen in Tables 1 and 2.

3.5 SDI-5 Testing

After receiving the results from the Alpheus SDI unit testing, a unit was purchased and tested at the INEL. This portable mini-blast SDI-5 system is a pneumatically operated CO_2 blasting system that uses blocks of CO_2 instead of pellets. The size of the unit is 24" wide X 36" long X 42" high and weighs 280 lbs dry. The system has an adjustable dry ice feed rate from 1.5-4.5 lbs/min and a blasting pressure from 50-300 psi. A minimum air supply of 80 psi @ 80 cfm is required. The hopper capacity is 120 lbs. Figure 1 shows the SDI-5 system.

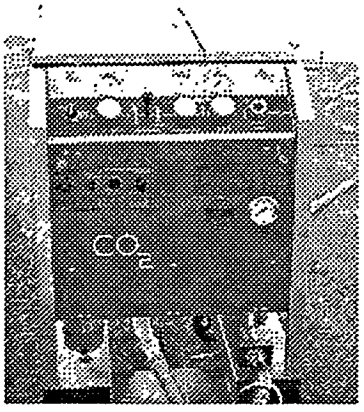

Figure 1 - SDI-5 System.

During the testing of the SDI-5 system at the INEL, a portable (150 psi/110cfm) compressor was used. This compressor limited the blasting pressure of the system during the testing to between 50 and 100 psi. Also, during this testing period an air dryer for the compressor could not be located. This caused some freezing problems around the nozzle stinger because of the moisture in the air line.

The testing of the SDI-5 CO_2 system was organized in four distinct phases. The first phase concentrated on varying the

pressures, blast guns and time while cleaning SIMCON coupons. The second phase involved general cleaning which consisted of paint removal from concrete, wood, carbon and stainless steel along with removing tape, rust, and stains from the above mentioned substrates. The third phase consisted of testing a special heating unit which can be attached to the SDI-5 unit before the blasting gun. The heating unit is used to heat the blast air before it reaches the gun which helps reduce condensation on the item being blasted. The final phase of testing was to evaluate a new swivel fan gun that Alpheus has developed.

During the first phase of testing there was a learning period to determine how to operate the equipment correctly. This system is a fairly easy system to operate but does take time to understand how and when to adjust the ice rate and feeder pressure to obtain the proper blasting conditions. After learning how to operate the system, each of two guns (Duck, Anteater) were tested by blasting SIMCON coupons at different pressures and times to determine the cleaning efficiency of each gun. Figures 2 and 3 show the blasting guns that were used. During this phase of testing freezing problems were encountered when blasting continuously for 5 to 10 minutes. The moisture from the compressor was accumulating in the system and causing ice to build up around the nozzle stinger which in turned blocked the flow of CO_2 particles. The cleaning results from the first phase of testing can be seen in Table 4. Figure 4 shows the location of the stinger.

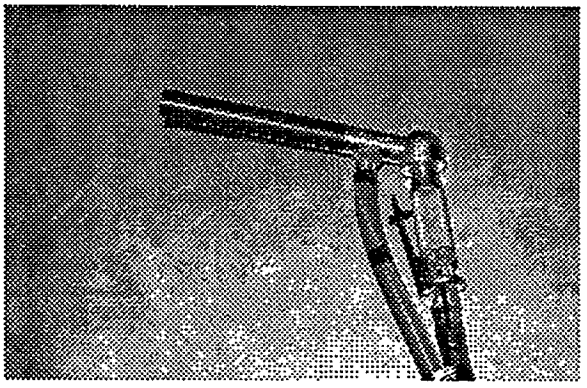

Figure 2 - Duck.

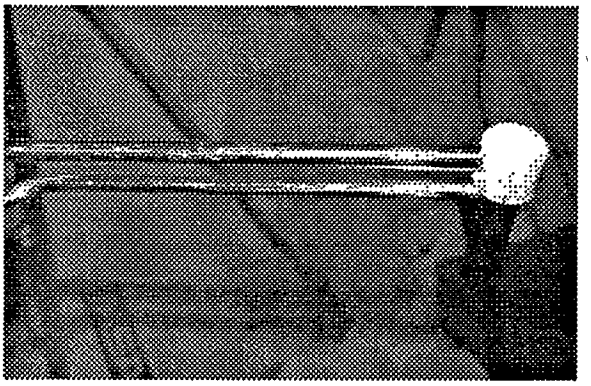

Figure 3 - Anteater.

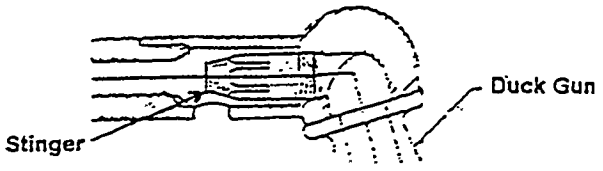

Figure 4 - Stinger Location.

The results from the second phase of testing indicated the SDI-5 system is very effective for general cleaning. The SDI-5 system removed rust, tape, stains and enamel paint from a variety of materials. The system was able to remove epoxy paints but at a slower rate than the enamel paints.

During the third phase of testing a 9KW,480V portable heater which was mounted on a hand cart was tested. The heater was attached to the blast hose on the air outlet side of SDI-5 system. The heater is used to reduce the amount of condensation that can accumulate on the material being blasted. During the heater tests, the off gas didn't seem to be as noticeable as when the heater wasn't used. This reduction in off gas would be very beneficial when working in glove boxes or confined spaces. The heater also helped eliminate the freezing problems that occurred during the first phase of testing. When the heater was used the blasting gun was warm to the touch and there was no sign of an ice build up on the stinger. The cleaning results from the testing with the heater can be seen in Table 4. Figure 5 shows the portable heater.

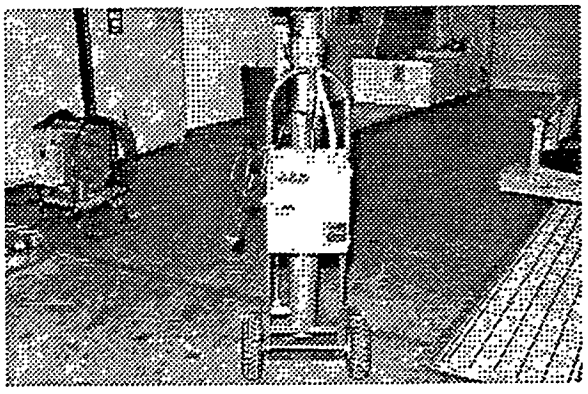

Figure 5 - Portable Heater.

In the final phase a new swivel fan gun developed by Alpheus was tested. This gun was approximately 16 inches long and had a fanning length of approximately 2.5 inches. The gun was tested using the heater and pressures of 50 to 100 psi. The gun was used to clean painted items (fencing, stainless steel, plastic, etc.). The gun was easy to handle and was able to remove paint on flat surfaces faster than either the Duck or Anteater guns. During this phase of testing, there were no freezing problems with the nozzle stinger or system. Figure 6 shows the swivel fan gun.

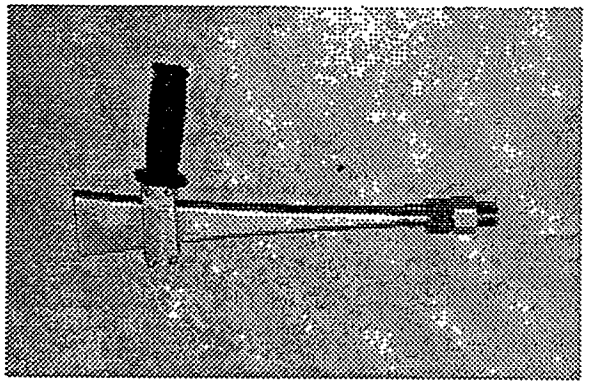

Figure 6 - Swivel Fan Gun.

4.0 RESULTS

After all the testing was complete, the results were compiled in the following tables (attached) to show the percent removal of Cs and Zr on SIMCON I & II coupons. The results indicate that the Alpheus systems were more effective at removing fixed contamination than the other systems. When comparing the removal of loose contamination the Alpheus systems were slightly more effective than the Cold Jet system used during the ICPP demonstration.

The coupons blasted by Alpheus with the SDI-5 system were cleaner than those done with the INEL SDI-5 system. However, once the INEL had some experience operating the SDI-5 system, results were obtained similar to those obtained by Alpheus.

The results also showed that the coupons blasted with the heater/CO_2 system were cleaner then those blasted without the heater. This could have been because the coupons that were blasted without the heater were the first coupons blasted prior to system operation optimization. The combination of the heater and guns showed that the system was faster and more effective at removing paint when the heater was used than when it wasn't used. The heater also eliminated the freezing problems encountered during the first phase of testing.

A videotape of the SDI-5 blaster and CO_2 demonstration at the ICPP is available.

Table 1

SIMCON 1 - Percent Removal

Alpheus Model 250

Time	:30 sec.	1:30 min.	2:00 min.
Constants: Pellet size (.125), Pressure (150 psi)	Cs-100% Zr-100%	Cs-100% Zr-100%	Cs-100% Zr-100%

Cold Jet

Time	:30 sec.	1:30 min.	2:00 min.
Constants: Pellet size (.125), Pressure (150 psi)	Cs-83% Zr-87%	Cs-91% Zr-92%	Cs-90% Zr-92%

Alpheus Model SDI-5 (Portable -Shaved)

Pressure	50 psi.	80 psi.	150 psi..
Time (1:00 min.)	Cs-100% Zr-99.7%	Cs-100% Zr-100%	Not Blasted
Time (1:30 min.)	Not Blasted	Not Blasted	Cs-100% Zr-100%

Alpheus Model MBL-5 (Portable-Pellets)

Pressure	50 psi.	80 psi.	125psi.
Time (1:00 min.)	Not Blasted	Cs-100% Zr-100%	Not Blasted

Supersonic Ice Blasting

Ice Pellet Size	Impact Speed	Cleaning Time	% Removed
70 um	230 m/s	8-12 sec.	Cs - 92.0 Zr - 93.2

Table 2

SIMCON 2 - Percent Removal

Alpheus Model 250

Time	:30 sec.	1:30 min.	2:00 min.
Constants: Pellet size (.125), Pressure (125 psi)	Cs-64.5% Zr-98.0%	Cs-81.3% Zr-100%	Cs-75.1% Zr-98.8%

Cold Jet

Time	:30 sec.	1:30 min.	2:00 min.
Constants: Pellet size (.125), Pressure (125 psi)	Cs-41% Zr-79%	Cs-63% Zr-78%	Cs-57% Zr-74%

Alpheus Model SDI-5 (Portable -Shaved)

Pressure	50 psi.	80 psi.	125psi.
Time (1:00 min.)	Cs-74.3% Zr-95.1%	Cs-66.5% Zr-97.2%	Not Blasted
Time (1:30 min.)	Not Blasted	Not Blasted	Cs-84.8% Zr-100%

Alpheus Model MBL-5 (Portable-Pellets)

Pressure	50 psi.	80 psi.	125psi.
Time (1:30 min.)	Not Blasted	Not Blasted	Cs-75.3% Zr-98.6%

Supersonic Ice Blasting

Ice Pellet Size	Impact Speed	Cleaning Time	% Removed
70 um	230 m/s	8-12 sec.	Cs - 3.6 Zr - 59.0

Table 3
SIMCON 2 - Percent Removal

Centrifugal CO_2 Results

Pellet Speed (m/s)	Pellet Feed Rate (kg/hr)	Scan Rate (mm/s)	Pellet Dosage (Kg/m^2)	% Removed
350	170	5	126	Cs - 55.0 Zr - 95.4
350	170	2	315	Cs - 83.4 Zr - 98.4
350	150	12	28	Cs - 4.4 Zr - 91.1
350	150	9	37	Cs - 27.1 Zr - 93.4
350	150	6	55	Cs - 28.0 Zr - 93.9
350	150	3	110	Cs - 27.0 Zr - 93.6
350	150	2	165	Cs - 43.0 Zr - 92.3
290	120	9	30	Cs - 60.0 Zr - 90.3
290	120	6	44	Cs - 79.2 Zr - 96.4
290	120	3	89	Cs - 59.3 Zr - 93.3
290	120	2	133	Cs - 46.0 Zr - 82.0

Table 4
SDI-5 TESTING

Test #1
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi

Feeder Pressure: 50 psi
Ice Rate: 70 psi
Coupons Turning at 100 rpm

Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 59 %, Zr - 87%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 64 %, Zr - 80%

Test #1
Gun Type: Anteater
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 90 psi

Feeder Pressure: 40 psi
Ice Rate: 60 psi
Coupons turning at 100 rpm.

Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 67 %, Zr - 86%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 68 %, Zr - 91%

Test #2
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 90 psi

Feeder Pressure: 50 psi
Ice Rate: 50 psi
Coupons Turning at 600 rpm

Time (:30 sec.)	SIMCON 1 Coupons	Average % Removal Cs - 94 %, Zr - 92%
Time (1:30 min.)	SIMCON 1 Coupons	Average % Removal Cs - 98 %, Zr - 97%

Table 4 (Cont.)
SDI-5 TESTING

Test #2
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 90 psi

Feeder Pressure: 50 psi
Ice Rate: 50 psi
Coupons Still on Plate (sweeping)

Time (:30 sec.)	SIMCON 1 Coupons	Average % Removal Cs - 98 %, Zr - 97%
Time (1:30 min.)	SIMCON 1 Coupons	Average % Removal Cs - 99 %, Zr - 98%

Test #2
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi

Feeder Pressure: 50 psi
Ice Rate: 50 psi
Coupons Turning at 600 rpm

Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 71 %, Zr - 87%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 49 %, Zr - 81%

Test #3 (Heater)
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi
Heater Temp. 145°F

Feeder Pressure: 60 psi
Ice Rate: 50 psi
Coupons not spinning
CO_2 Blocks had been in Box For 2 ½ Weeks

Time (:30 sec.)	SIMCON 1 Coupons	Average % Removal Cs - 99 %, Zr - 99%
Time (1:30 min.)	SIMCON 1 Coupons	Average % Removal Cs - 99 %, Zr - 99%

Table 4 (Cont.)
SDI-5 TESTING

Test #3 (Heater)
Gun Type: Duck/ Anteater
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi
Heater Temp. 145°F

Feeder Pressure: 60 psi
Ice Rate: 50 psi
Coupons Not Spinning
CO_2 Blocks had been in Box For 2½ Weeks

Time (:30 sec.)	SIMCON 2 Coupons	Average % Removal Cs - 63 %, Zr - 91%
Time (:30 sec.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 75 %, Zr - 95%
Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 93 %, Zr - 99%
Time (1:30 min.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 88 %, Zr - 100%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 93 %, Zr - 98%
Time (3:00 min.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 71 %, Zr - 98%

Test #3 (Heater)
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi
Heater Temp. 145°F

Feeder Pressure: 60 psi
Ice Rate: 50 psi
Coupons Spinning At 100 RPM
CO_2 Blocks had been in Box For 2½ Weeks

Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 71 %, Zr - 96%

Table 4 (Cont.)
SDI-5 TESTING

Test #3 (Heater)
Gun Type: Duck/ Anteater
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi
Heater Temp. 145°F

Feeder Pressure: 60 psi
Ice Rate: 50 psi
Coupons Spinning at 100 RPM
CO_2 Blocks had been in Box For 2½ Weeks

Time (:30 sec.)	SIMCON 2 Coupons	Average % Removal Cs - 60 %, Zr - 91%
Time (:30 sec.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 50 %, Zr - 88%
Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 88 %, Zr - 94%
Time (1:30 min.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 61 %, Zr - 100%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 71 %, Zr - 98%

5.0 REFERENCES

[1] Archibald, E. K., "CO_2 Pellet Blasting Literature Search and Decontamination Scoping Tests Report", WINCO-1180, December 1993.

[2] Demmer, R. L., "Development of Simulated Contamination (SIMCON) And Miscellaneous Scoping Tests", WINCO-1188, January 1994