DP-MS-83-111

DECONTAMINATION OF DWPF CANISTERS BY GLASS FRIT BLASTING

by

Clyde R. Ward and W. Nevyn Rankin

E. I. du Pont de Nemours & Company
Savannah River Laboratory
Aiken, South Carolina 29808

A paper proposed for presentation (and publication) at the **Waste Management '84 Symposium** (and **Nuclear Technology**) at Tucson, Arizona on March 11-15, 1984

DECONTAMINATION OF DWPF CANISTERS BY GLASS FRIT BLASTING

Clyde R. Ward and W. Nevyn Rankin

E. I. du Pont de Nemours & Company
Savannah River Laboratory
Aiken, South Carolina 29808

ABSTRACT

High-Level radioactive waste at the Savannah River Plant will be incorporated in borosilicate glass for permanent disposal. The waste glass will be encapsulated in a 304L stainless steel canister. During the filling operation the outside of the canister will become contaminated. This contamination must be reduced to an acceptable level before the canister leaves the Defense Waste Processing Facility (DWPF). Tests with contaminated coupons have demonstrated that this decontamination can be accomplished by blasting the surface with glass frit. The contaminated glass frit byproduct of this operation is used as a feedstock for the waste glass process, so no secondary waste is created.

Three blasting techniques, using glass frit as the blasting medium, were evaluated. Air-injected slurry blasting was the most promising and was chosen for further development. The optimum parametric values for this process were determined in tests using coupon weight loss as the output parameter.

INTRODUCTION

The Defense Waste Processing Facility (DWPF) will immobilize radioactive waste in borosilicate glass. The molten waste glass at about 1050°C is poured into large (2-ft-dia, 10-ft-long) stainless steel canisters. During this operation the exterior of the canister reaches a temperature of up to 550°C and a thin oxide film is formed. This film must be removed to achieve the decontamination required before the canister leaves the DWPF canyon building.[1] By using glass frit for this decontamination no secondary waste is created.

Three different techniques of blasting with borosilicate glass frit were evaluated as candidates for canister decontamination. A temporary seal of the canister is made before decontamination and the final closure weld is made later. The temporary seal is required to prevent water from entering the canister interior. A dry blasting decontamination technique was evaluated because it would alleviate the water tight requirement for the temporary seal (see Fig. 1). A direct-pump slurry blasting technique was tested (see Fig. 2). This technique uses no air and would reduce the required air filtration capacity for the DWPF.

Finally an air-injected slurry blasting technique was evaluated (see Fig. 3). This technique allows the slurry to be pumped the distances that will be required in the DWPF.

Rinsing of the canister after blasting with 2000 psi water was the initial technique considered for the DWPF. This would require the development of high pressure jumpers. As an alternative, air-injected water rinsing was evaluated. This process would use the standard low pressure jumper design.

Glass frit is the standard feedstock for the glass melting process and it is angular in shape. Glass beads are spherical and are reported to produce less erosion in piping, pumps, and other components. Blasting was evaluated using glass frit and also glass beads.

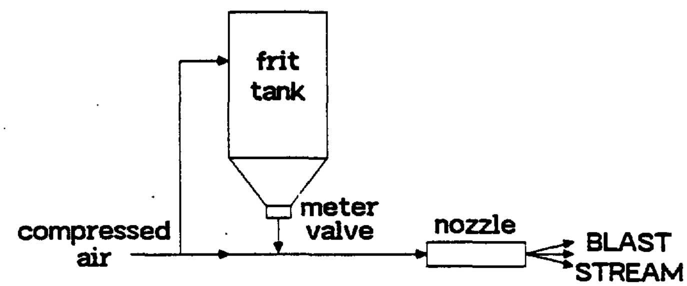

FIG. 1. Dry Pressure Blasting

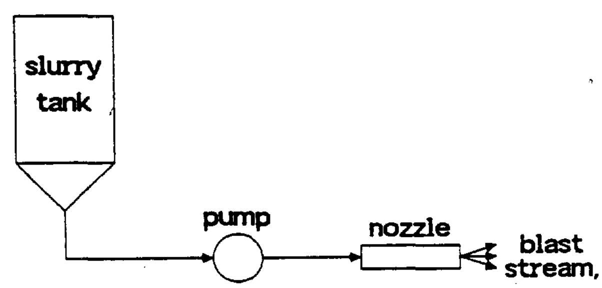

FIG. 2. Direct-Pump Slurry Blasting

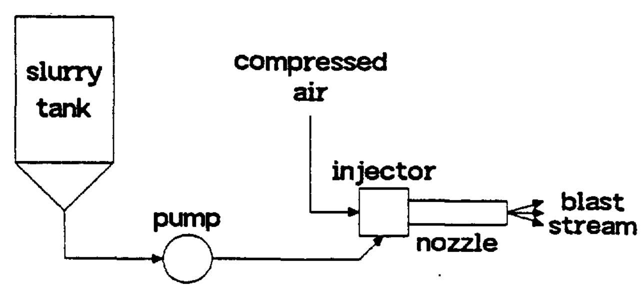

FIG. 3. Air-Injected Slurry Blasting

Because tests with coupons contaminated with radioisotopes are time-consuming, limited in scope by available facilities and create waste disposal problems, as much of the testing as possible was done using non-radioactive coupons. However, some tests with radioactively contaminated coupons are indispensable and were used where required.

Cold Tests Comparing Blasting Techniques

The nonradioactive tests were performed in a small frit blaster at the Equipment Test Facility (ETF). The blaster has a blast cabinet that is approximately a cube with each side being 4 feet. An exhaust air flow of approximately 200 scfm keeps the cabinet at a slight negative pressure. The blast nozzle is attached to a motor driven arm and the velocity of the arm in the vertical direction can be accurately controlled. Plates can be blasted by the nozzle passing across the surface of the plate.

In the cold tests comparing the different blasting techniques, one foot square plates were blasted. The 304L stainless steel plates were 1/4 inch thick. They were baked in an oven at 600°C for 16 hours to produce an oxide layer similar to that produced on canisters by the pouring process being used at that time. The parameters for each blasting technique were varied to produce the cleanest strip at a fixed nozzle velocity. Each technique at its best conditions was then used to remove all visible oxide on a plate.

Based on the results of these tests, it was calculated that dry blasting and air-injected blasting would each require a maximum of 1,000 lbs of frit to clean a canister. Using glass beads, each process would require about 2,000 lbs. Since there is only about 2,300 lbs of glass inside each canister and a once through frit blasting process was desired, blasting with glass beads was not considered a viable option. During the dry blasting tests with frit, the frit hopper discharge and the blast nozzle plugged several times. After dry blasting, frit dust would cling to all surfaces inside the cabinet. A portion of the dust would become airborne when the blast cabinet was opened and some of the dust remained on the surfaces and was difficult to remove. When glass beads were used for dry blasting, no clogging occurred and dusting was minimal.

The tests indicated that direct pump slurry blasting would require about 6,000 lbs of glass to clean a canister. This amount was unacceptable and this technique was abandoned.

The most promising technique was air-injected slurry blasting and this technique was chosen for further development.

Cold Tests to Optimize Air-Injected Slurry Blasting

Visual oxide removal was not sufficiently precise to allow accurate optimization of the air-injected slurry blasting technique. There is a direct correlation between oxide removal, decontamination and weight loss. The weight loss produced by blasting a coupon was used as the analytical response for the optimization tests. The coupons were 2 inches by 3 inches and 1/4 inches thick and could be weighed down to 10^{-4} grams. The oxide produced by baking these coupons at 600°C for one hour was similar to the oxide produced on canisters with the present glass pouring process. To visually remove the oxide, a weight loss of approximately 3×10^{-2} grams was required. The nozzle velocity across the coupons was held constant as each parameter was varied through its range. Following is a brief description of the effect of varying each parameter of the air-injected slurry blasting technique.

Air Pressure and Air Flow Rate

Air pressure was varied from 65 psig to 100 psig. Weight loss increased as air pressure increased. However, the increase in weight loss was less pronounced above 95 psig. This effect is shown in Fig. 4 with weight loss per scfm plotted along the Y-axis. Weight loss per scfm increased 50% as air pressure increased from 65 to 95 psig (46%); however, weight loss per scfm actually decreased slightly as air pressure increased from 95 to 100 psig (5%). The air flow rate at 65 psig was 52 scfm and at 100 psig it was 79 scfm.

Slurry Pressure and Slurry Flow Rate

With all other parameters fixed, slurry flow rate varies directly with slurry pressure. With air pressure constant, frit blasting efficiency decreased as slurry flow rate increased. A plot of weight loss per volume of slurry (lbs/gal.) vs. slurry flow rate is shown in Fig. 5. Flow rates below 2.6 gpm were not tested as they are not sufficient to maintain the frit in suspension in the line sizes that will be used in the DWPF.

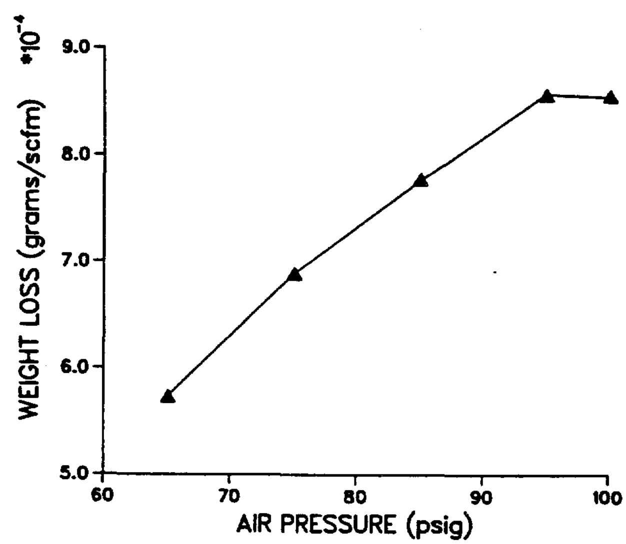

FIG. 4. Air Pressure

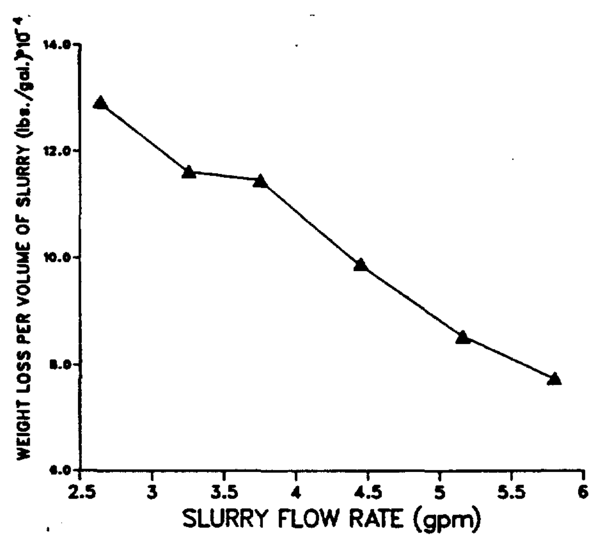

FIG. 5. Slurry Flow Rate

Slurry Concentration

Slurry concentration was varied from 20 to 55 wt % frit. During the test the frit began to accumulate on the vertical walls of the blast cabinet at 40 wt % and became about 2.5 inches thick at 55 wt %. At 20 wt % the diaphragm pump may be stopped for a few minutes and restarted. At 55 wt % the pump must be flushed with water before stopping even for a few seconds or it cannot be restarted. The maximum frit efficiency as shown in Fig. 6 occurred at 30 wt % slurry concentration. Below 25 wt % and above 40 wt % the efficiency drops off rapidly.

Incidence Angle

The incidence angle is defined as the minimum angle formed between the coupon surface and the nozzle axis. The angle was varied in a plane normal to the nozzle travel direction. The incidence angle was varied from 30° to 90°. The most efficient angle is 45° as shown in Fig. 7.

Stream Distance

The canisters must be blasted at distances up to 20 inches for the neck area. Efficiency decreased as the distance between the end of the nozzle and the coupon increased. In Fig. 8 the weight loss is shown vs. distance. The incidence angle was fixed at 45°. At 2 inches away the cleaned area was approximately 1 inch wide. This width increased to approximately 1.5 inches at 9 inches away. At 17 inches away the cleaned area was about 1.25 inches wide.

Nozzle Length

Abrasive blasting nozzles with a 3/8 inch throat are commercially available in lengths of 4 and 7 inches. These nozzles, both of the converging-diverging venturi design were compared under the same parametric conditions at 6 and 20 inches away from the coupon. The longer nozzle was about 20% more efficient at 6 inches away and almost 90% more efficient at 20 inches away. The results are shown in Fig. 9.

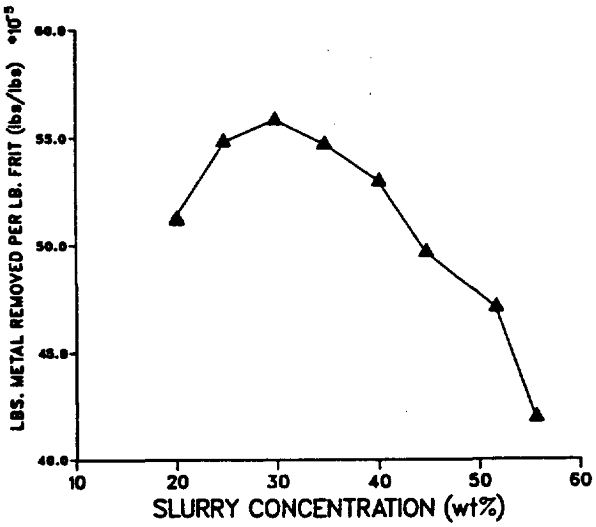

Fig. 6. Slurry Concentration

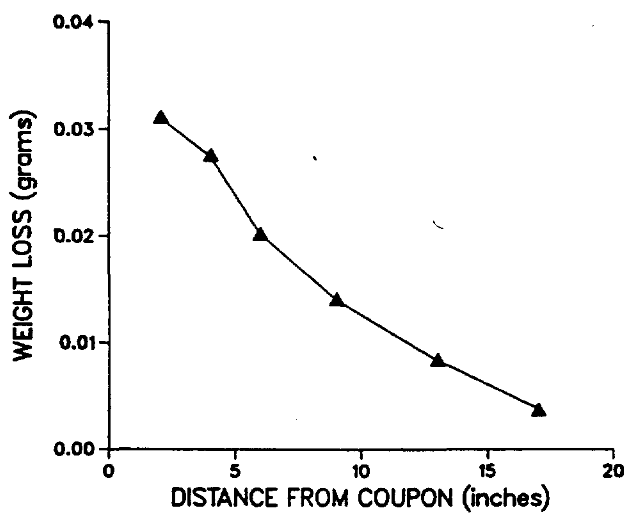

FIG. 8. Weight Loss

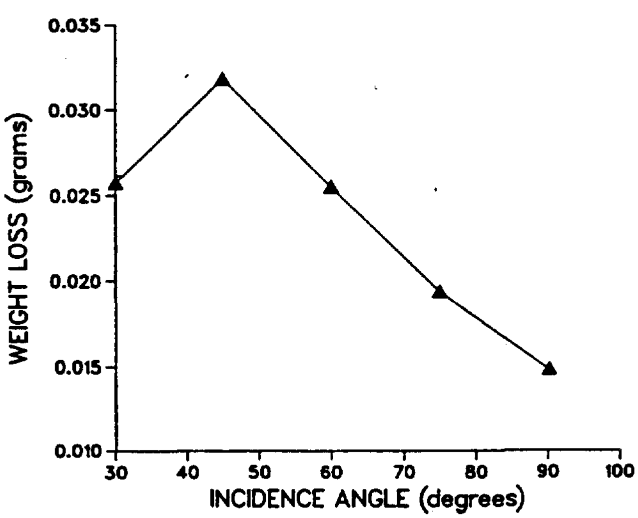

FIG. 7. Incidence Angle

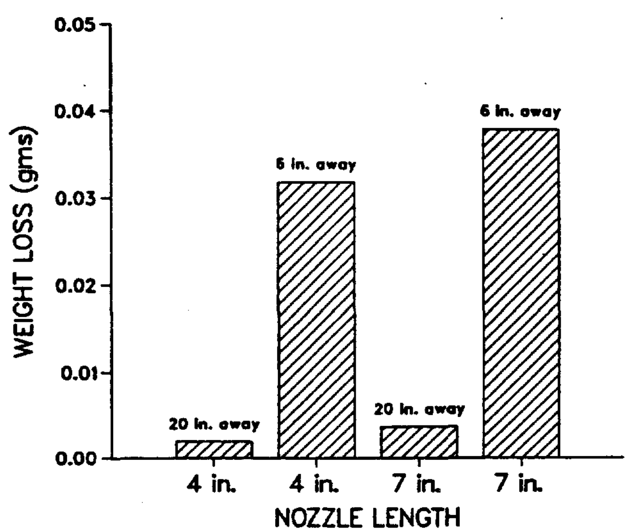

FIG. 9. Nozzle Length

Slurry Feed Orientation

The efficiency of air-injected slurry blasting decreases rapidly as stream distance increases. In most blasting tests the air was injected axially into the gun and entrained the slurry which entered through the annular space. In an attempt to improve efficiency at long distances; the inlets for slurry and air were reversed. The results are shown in Fig. 10. By introducing the slurry axially, the efficiency was reduced for blasting distances of both 6 inches and 20 inches.

Frit Size

A frit particle size range of -80+325 mesh is in general use for the glass melting process. A test was conducted to determine the effect of particle size on blasting efficiency. The frit was screened into approximately equal parts by screening to -80+140 mesh and -140+325 mesh. The results are shown in Fig. 11. At 6 inches away the coarser frit was about 45% more efficient than the finer frit. At 20 inches away the difference is much more pronounced and the coarser frit is 190% more efficient.

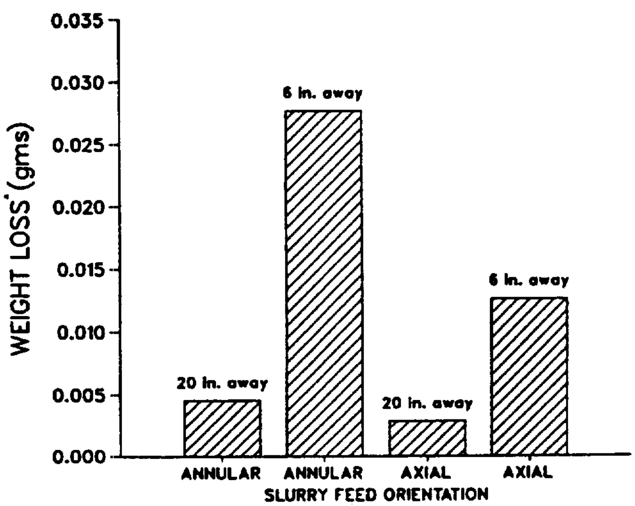

FIG. 10. Slurry Feed

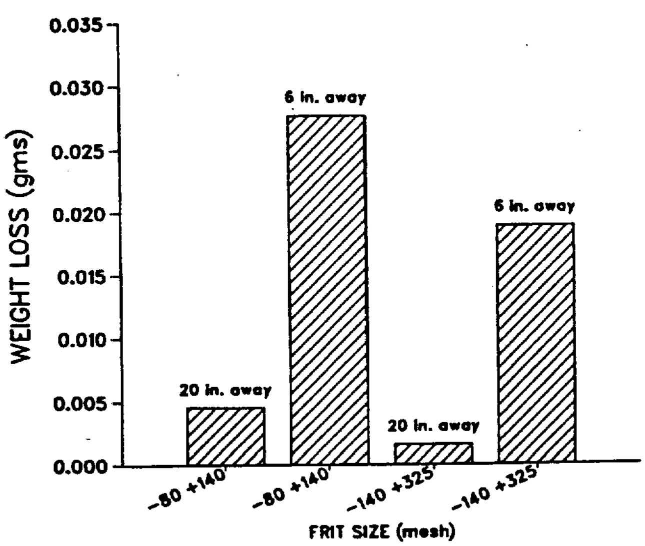

FIG. 11. Frit Size

Annulus Size

The slurry feeding annulus created between the end of the air jet and the coverging portion of the nozzle can be adjusted by moving the jet in the axial direction. The annulus size was determined by sliding the jet forward until it contacted the nozzle and then sliding it back in the axial direction a specified distance. The results of a test with three different annulus sizes are shown in Fig. 12. As the size was increased from 0.03 inches to 0.5 inches a dramatic increase in efficiency was observed. As the size was increased from 0.5 inches to 1.05 inches a modest increase in efficiency was observed.

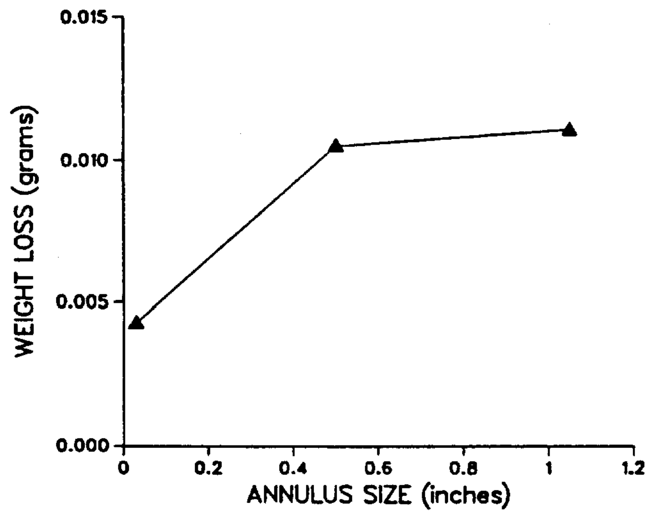

FIG. 12. Annulus Size

Radioactive Tests

The ability of candidate abrasive blasting and rinsing techniques to remove radioactive contamination from Type 304L stainless steel specimens was quantitatively determined using the type of contamination, the amount of contamination, and the heating conditions spanning the range of conditions expected in the DWPF.

The specimens used in the tests were 1 inch by 3 inch coupons. The type and amount of contamination used was based on the characterization of contamination removed from beakers filled with actual waste glass and on the experience of the French. Specimens were contaminated with a water suspension of equal volumes of washed raw sludge enriched with volatile components collected in the plenum of a melter producing radioactive waste glass. Approximately 1/2 cm^2 of each specimen was contaminated to a level of 1500 mR/hr. This level of contamination is an estimate of the maximum amount of contamination possible in the DWPF. Specimens were contaminated by placing 0.05cc of the contaminate in the center of one face. The specimen was slowly dried on a warm hot plate. Contamination was baked on the surface of the specimens using a heating cycle that simulates the condition at the 66 inch elevation on the outside of a full-size waste glass canister while it was filled with waste glass. Then the specimens were blasted.

After blasting was completed the air-injected slurry blasted specimens were rinsed with 2000 psi water and all specimens were blown with compressed air to remove loosely adhering material and to dry the specimens. The portion of the specimen that had been contaminated was smeared to determine the amount of transferable contamination remaining. Finally the specimen was monitored to determine the amount of nontransferable contamination.

Abrasive Blasting Tests

The effect of the following variables were investigated:

1) Blasting Technique (dry; air-injected slurry).
2) Abrasive Shape (angular; spherical).
3) Surface Finish (#1; #2B).

The data from the Abrasive Blasting Tests are given in Table 1 and discussed below:

- Effect of Blasting Technique

Both dry abrasive blasting and air-injected slurry blasting decontaminated all specimens sufficiently to meet the DOT shipping regulations. Decontamination factors around 10^4 to 10^5 were achieved by each process.

Airborne contamination was higher with dry abrasive blasting. Air samples taken during dry blasting ranged from 1,000-2,500 c/m β/γ. An air sample taken during air-injected slurry blasting contained 357 c/m β/γ.

The lowest level of nontransferable activity was achieved by air-injected slurry blasting using angular frit. Non-transferable activity was lower with either process using angular frit. This effect is shown in Fig. 13.

- Effect of Abrasive Shape

TABLE 1

DATA FROM

ABRASIVE BLASTING TESTS

Technique	Measurement	#1 Spherical Frit	#1 Angular Frit	#2B Spherical Frit	#2B Angular Frit
Dry	Air Sample c/m	1500	1000	2500	2000
	DF	$1.0(10^5)$	$3.1(10^5)$	$2.8(10^4)$	$5.0(10^5)$
	Non-transferable c/m	11246	3602	35918	22419
Slurry	Air Sample c/m	357	---	---	---
	DF	$4.0(10^5)$	$2.6(10^5)$	$1.4(10^4)$	$5.2(10^4)$
	Non-transferable c/m	28101	2099	34740	1149

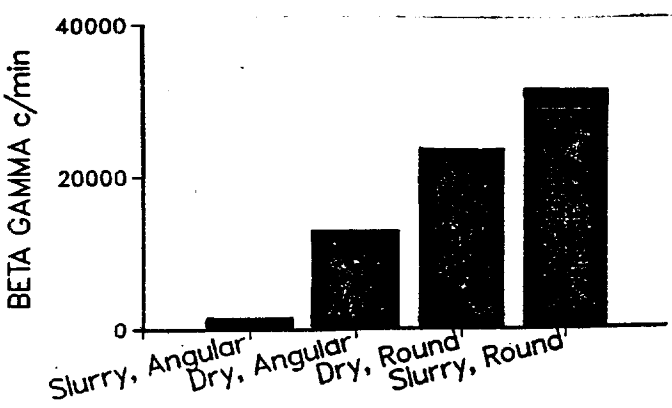

FIG. 13. Non-Transferable Activity

The average decontamination factor with angular frit averaged twice the average decontamination factor with spherical beads. The beads left more activity fixed on the surface. Bead consumption would also be much higher. As found in previous tests at ETF, cleaning with spherical beads takes about twice as long as cleaning with angular frit. This means that about twice as much spherical beads are used to do the cleaning. The results of these tests show that beads do not get the surfaces as clean. This difference is attributed to the difference in the abrasiveness of the two shaped particles. Thus, use of angular frit is preferable for decontamination.

Airborne contamination with spherical beads and angular frit was similar. More dusting occurred with angular frit. This apparently did not significantly affect the level of airborne activity. The shape of the particles affected the final surface finish. Angular particles produced a matte finish. Spherical particles produced a more reflective surface.

Water-Only Tests

The effect of air-injected water and 2,000 psi water rinsing was investigated. Specimen preparation was similar to the preparation of the specimens for the abrasive blasting tests.

The results from the water-only tests are given in Table 2. Neither water only process decontaminated the postoxidized specimens sufficiently to meet DOT shipping regulation. The DF's achieved by either water-only technique with postoxidized specimens were approximately 100 compared with a DF of 10^4 to 10^5 with abrasive blasting techniques. Air-injected water is a more effective rinsing technique than 2,000 psi water. Higher decontamination factors were achieved with air-injected water than with 2,000 psi water (96 vs. 26).

TABLE 2

DATA FROM

WATER-ONLY TESTS

Measurement	Air-Injected Water	2000 psi Water
DF	96	26
Non Transferable (c/m)	461,740	264,150

SUMMARY

The cold tests were instrumental in identifying the best frit blasting technique and in optimizing the air-injected slurry blasting process. By using the parametric values shown in Table 3, a total of 500 lbs of frit is predicted for decontamination of a canister. This is half the amount predicted when using the parametric values in use before the optimization program.

The ability of candidate abrasive blasting and rinsing techniques to remove radioactive contamination from Type 304L stainless steel specimens was quantitatively determined in the radioactive tests. Conclusions from these tests were:

- All abrasive blasting techniques decontaminated sufficiently to meet transportation requirements (DF of approximately 10^4 observed).
- Less airborne contamination is produced by air-injected slurry blasting than by dry blasting.
- Water-only blasting techniques could not reduce the contamination level sufficiently to meet transportation requirements.
- Air-injected water is a more effective rinsing technique than 2,000 psi water.

TABLE 3

Optimum Slurry Blasting Parameters

AIR PRESSURE = 95 PSIG MIN.
AIR FLOW RATE = 70 SCFM MIN.
SLURRY PRESSURE = 35 PSIG MIN.
SLURRY FLOW RATE = 2.6 GPM
SLURRY CONCENTRATION = 30 WT. % FRIT
PARTICLE SHAPE = ANGULAR
PARTICLE SIZE = 80 MESH
STREAM LENGTH = 2 INCHES
INCIDENCE ANGLE = 45 DEGREES
NOZZLE LENGTH = 7 INCHES
SLURRY FEED = ANNULAR

ACKNOWLEDGEMENT

The information contained in this article was developed during the course of work under Contract No. DE-AC09-76SR00001 with the U. S. Department of Energy.

REFERENCE

1. W. Nevyn Rankin, "Decontamination Processes for Waste Glass Canisters," Nuclear Technology, 59, (Nov. 1982).