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DEVELOPMENT PROCESS FOR THE STABILIZATION OF INCINERATOR BOTTOM ASH AND SIZING BAGHOUSE DUST MATERIAL

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SUMMARY

EG&G Idaho Inc. has initiated a program to develop safe, efficient, cost-effective treatment methods for the stabilization and subsequent disposal of some of the hazardous and mixed wastes generated at the Idaho National Engineering Laboratory (INEL). Lab-scale testing has shown that Extraction Procedure (EP) toxic wastes can be successfully stabilized by solidification, using various binders to produce nontoxic, stable waste forms for safe, long-term disposal.

Drum-scale testing was previously conducted on incinerator flyash from the Waste Experimental Reduction Facility (WERF). This testing demonstrated that the lab-scale formulas could be successfully adapted into a production operation. This operation has subsequently received Environmental Protection Agency (EPA) acceptance as to its adequacy in satisfying Resource Conservation and Recovery Act (RCRA) regulations.

The purpose of this report is to present the results of drum-scale testing of WERF incinerator bottom ash and WERF sizing baghouse dust. The drum-scale test program was conducted to determine if a production procedure that would produce a waste form which was suitable for disposal as a low-level radioactive waste could be developed.

As an associated objective, the use of 71-gallon square drums for solidification processing were evaluated. The evaluation showed that square drums could be used. The WERF ash collection system has been modified to accommodate either square or round drums.

During the test program, eleven drums of ash material were solidified. All of the samples from all of the drums passed the EPA leach test criteria.

Although there is a distinct weight addition associated with the solidification process, there is no relative volume increase.

Based on the data presented in this report, the production procedures developed for the bottom ash and sizing baghouse dust will produce a stabilized waste monolith which contains no free liquids, no leachable metal levels in excess of EPA limits, and which can therefore be disposed of as a low-level radioactive waste.

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1. BACKGROUND

In response to the need to develop safe, cost-effective methods for treating hazardous and mixed wastes at the Idaho National Engineering Laboratory (INEL), and based on knowledge of solidification methods, the Waste Engineering Development (WED) unit of EG&G Idaho initiated a program to include the following:

- Identify hazardous and mixed waste streams at the INEL.[1]
- Identify treatment options available for each waste (see Reference 1). This resulted in a list of wastes which are candidates for stabilization by solidification.
- Investigate available commercial waste solidification methods and determine their applicability to INEL wastes.[2]
- Conduct lab-scale tests of solidification methods for developing waste formulas (binder-to-waste ratios) for flyash from the Waste Experimental Reduction Facility (WERF) incinerator (see Reference 2).
- Test samples of the lab-scale stabilized waste to verify that they pass Environmental Protection Agency (EPA) toxicity leach criteria (see Reference 2).
- Conduct drum-scale testing of solidification methods developed during lab-scale testing.[3]
- Test samples of the drum-scale stabilized waste to verify that they pass EPA toxicity leach criteria (see Reference 3).

The overall purpose of the stabilization program is to successfully demonstrate that Extraction Procedure (EP) toxic characteristic wastes can be stabilized by solidification to produce nonhazardous waste forms which can then be disposed of as general or low-level radioactive waste, depending on the radioactivity content.

After the successful drum-scale testing of WERF flyash, WED began a similar development program for solidifying WERF bottom ash and sizing baghouse dust. This development process and pertinent analyses are presented in this report.

1.1 Waste Characterization and Treatment Options Evaluation

The initial phase of the stabilization program was to determine waste volumes and characterize the identified wastes (see Reference 1). This effort used a previously generated inventory, updated the estimates of volume contained therein, analyzed chemical and radiological composition, and determined the annual generation rates and waste locations.

Treatment option evaluations were then performed for each waste identified and characterized. This involved evaluating treatment options based on the waste characteristics. The treatment options considered were incineration, solidification, neutralization, recycling, refining, or storing the waste until a processing technology can be developed. Commercial disposal off site was also considered as an option for hazardous wastes. Disposal on site was not considered an option because it has been decided that neither hazardous nor mixed waste will be disposed of at the INEL.

The treatment options evaluation was conducted to identify wastes which are candidates for stabilization by solidification. The results of the waste characterization and treatment options evaluation are presented in detail in Reference 1.

1.2 Solidification Systems Evaluation

The next phase of the stabilization program was investigation of available commercial waste solidification methods (see Reference 2). This included a literature review, contacting companies involved in waste solidification, and visiting operating waste solidification facilities. At the time of this investigation, none of the companies contacted had completed more than an introductory amount of work on stabilization of hazardous wastes. However, there had been a substantial amount of work done in solidification to provide a better waste form for disposal. The systems investigated were comparatively evaluated as to how they would adapt to the stabilization of hazardous wastes, and as to their applicability to the specific INEL hazardous and mixed wastes considered to be candidates for stabilization by solidification.

1.3 Lab-Scale Testing

The third phase of the stabilization program was lab-scale testing of actual and laboratory-prepared samples of the waste to be solidified in order to develop optimum binder-to-waste ratios (see Reference 2). Procedures were developed to provide instructions for lab-scale solidification. The procedures provided formulas for solidification, helped ensure the safety of personnel, provided documentation of work performed, ensured that all required methods were properly and accurately performed, and that all applicable regulations were met.

The variables considered in the development of optimum binder-to-waste ratios were:

- Optimization of set time to reduce void space and provide for complete reaction

- Minimization of volume increase to minimize cost and the amount of disposal space required

- Leachability to meet EPA regulations

- Monolith characteristics, including strength, and uniformity of waste distribution within the monolith

- Use of various available waste binders

- Elimination of free liquids.

Lab-scale solidification successfully developed optimum binder-to-waste ratios for the available wastes, and demonstrated stabilization by solidification to be a safe and effective treatment for EP toxic hazardous and mixed wastes. The resulting waste form will pass the EPA leach test, and can therefore be disposed of as a nonhazardous waste. Reference 2 provides detailed information on the lab-scale development program.

1.4 Drum-Scale Flyash Testing

The next phase in the development program was drum-scale testing. The first waste chosen for drum-scale testing was the WERF incinerator flyash. The flyash was an excellent candidate for solidification because the absence of significant quantities of organic compounds in the ash increased the efficiency of the grout as a binder. This is also true for the sizing baghouse dust and incinerator bottom ash, the wastes discussed in this report.

Drum-scale testing of flyash demonstrated that the lab-scale formulas could be successfully adapted into a production operation, which would produce a waste form suitable for disposal as a low-level waste. The results of the drum-scale flyash testing are presented in detail in Reference 3.

2. FACILITY AND SYSTEM DESCRIPTIONS

The drum-scale development system for solidification of bottom ash is located in the basement of the Waste Engineering Development Facility (WEDF, the former SPERT-II building, shown in Figure 1). The WEDF is located within the boundaries of the Power Burst Facility (PBF) area. The SPERT-II building was chosen to house the development system for several reasons. It was close to WERF, which will be the production-scale facility for bottom ash solidification; used an available, vacant facility; provided room for expansion as necessary; required only minor modifications to accommodate the solidification system; provided space for laboratory facilities; and provides space for additional future WED activities. The solidification equipment (except for the grout mixer and grout transfer pump) is located in a basement room, which is a contained area with a separate HEPA-filtered ventilation system.

The equipment used in the solidification process includes:

- A drum tumbler, which provides end-over-end tumbling of the drum at a speed of 18 rpm, and has an 800-pound capacity. The tumbler requires 480-volt power for operation.

- A weighing platform with an electronic digital readout. The platform scale has a capacity of 1000 pounds and requires 110-volt power for operation.

- A beam trolley and chain hoist for drum handling.

- A 34-gallon grout mixer which has an air-driven mixing blade motor. Mounted on the platform under the mixing tank is an air-driven grout transfer pump that provides the pressure for grout injection through the hose and probe and into the drum. These units are shown in Figure 2 and are located in a noncontaminated area outside the solidification room.

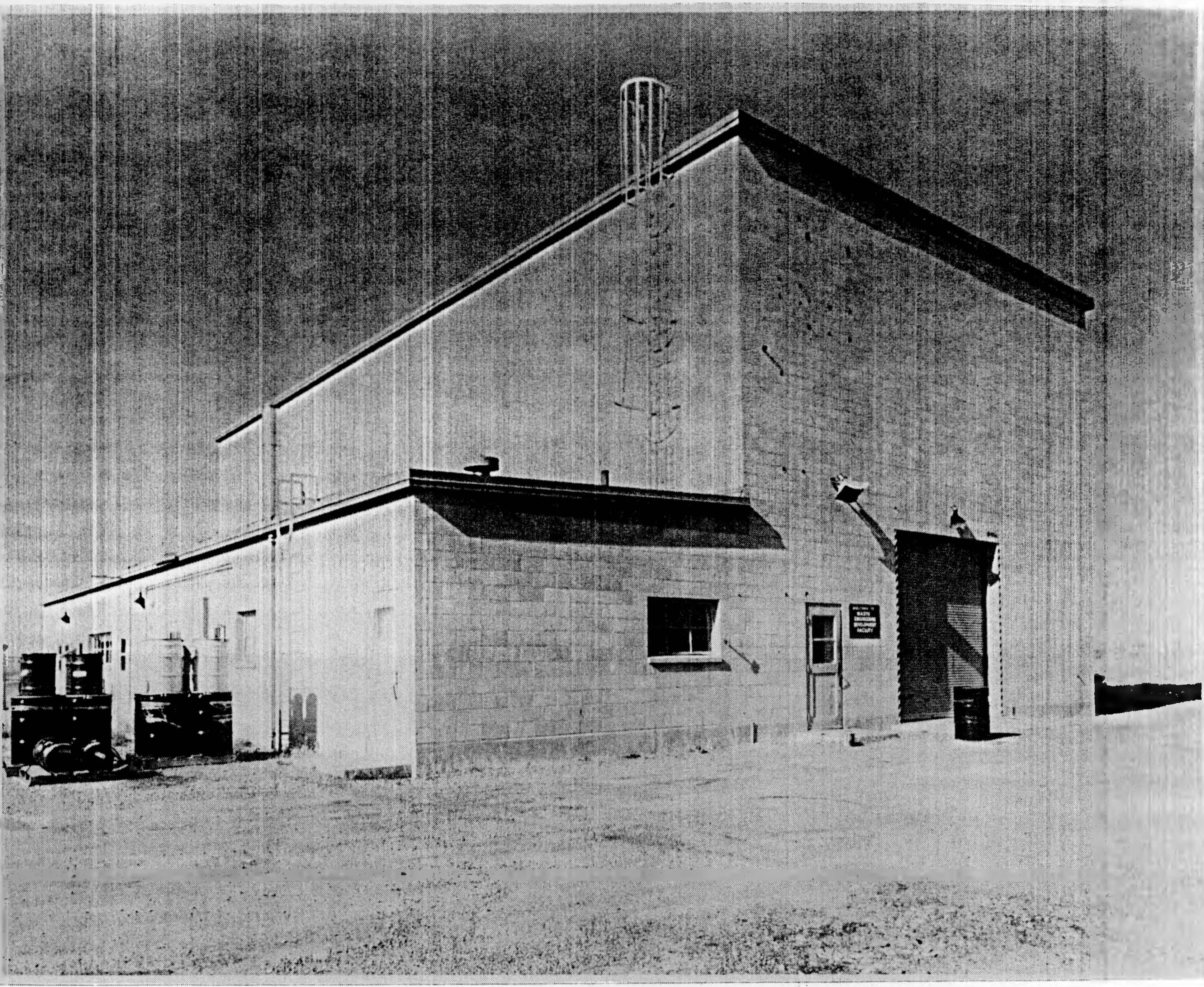

Figure 1. Waste Engineering Development Facility (WEDF)--formerly SPERT II.

Figure 2. WEDF solidification grout mixer and grout transfer pump.

- The air and water required for the grout mixer are provided from the utilities within the facility.

- A hose connected to the mixer on the upper level and to the probe in the solidification room for the injection of grout into the ash material (see description in Section 6.2).

- The ventilation system for the solidification room consists of an induced-draft fan (which is located on the building roof), a HEPA, filter, and ducting to provide air flow out of the room. The fan is rated at 1800 cfm and exhausts above the building. The system has been modified to provide a sliding damper with a connection for a flexible hose which attaches directly to the drum during solidification operations. The ventilation system removes any airborne material from the drum and room. Makeup air is supplied to the room through a dust filter installed in the wall of the room, next to the door (see Figure 3).

The WEDF system will continue to be used for solidification development work. Production operations for bottom ash will be conducted at the WERF solidification facility.

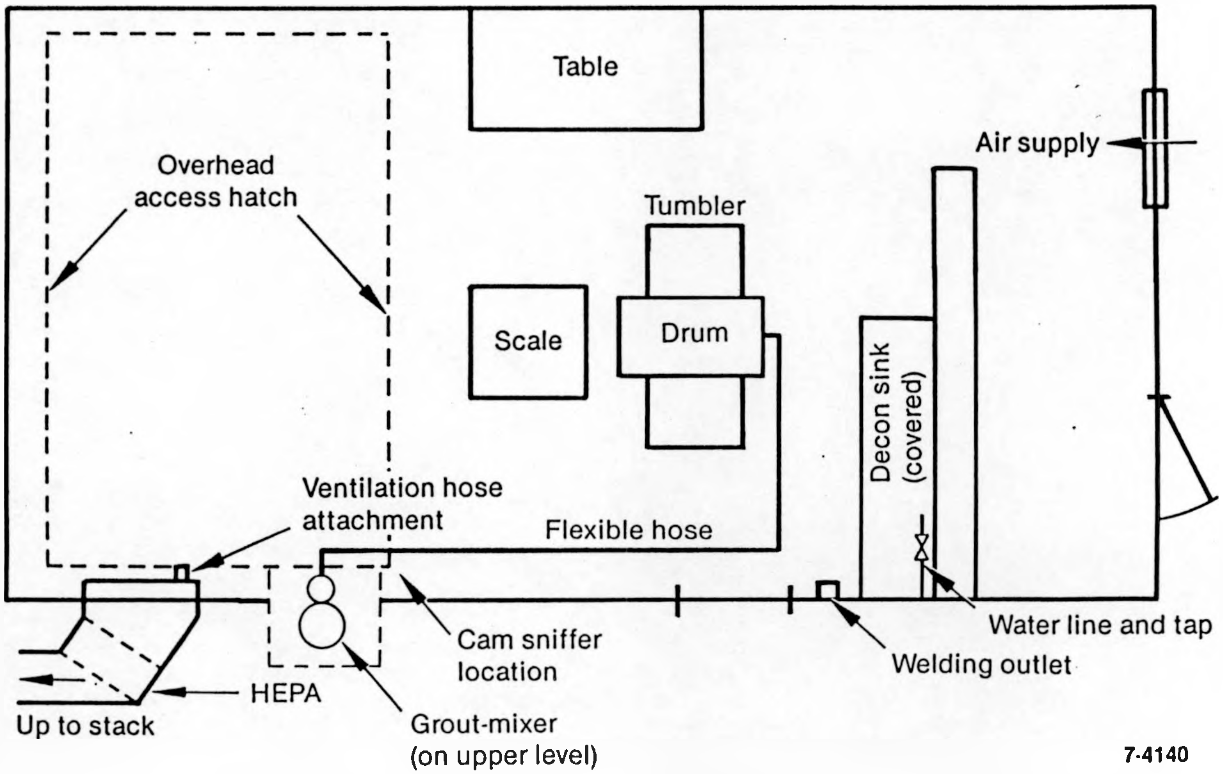

Figure 3. WEDF solidification system layout.

3. ANALYSIS OF INVENTORIED WERF ASH MATERIAL

Twenty-eight (28) drums of WERF bottom ash and sizing baghouse dust designated for solidification were used in this program. The contents of each drum were analyzed, using the Toxicity Characteristic Leaching Procedure (TCLP), to determine the hazardous constituents and whether the leachable levels of those constituents exceed toxicity criteria. The results of these tests on bottom ash clinkers determined the scope of the solidification program, as well as the extent of anticipated modifications to the existing WERF ash collection system.

While bottom ash was being collected from the incinerator into drums, five samples of clinkers and two of fine ash were taken from a single drum. The analytical results shown in Table 1 indicated that the ash was not hazardous. More importantly, the results indicated the hazardous constituents of the ash were evenly distributed throughout the drum. A composite sample was prepared and analyzed, with similar results.

Two samples were then taken from each of the 28 drums and sent to an independent laboratory for analysis. The results, shown in Table 2, indicated that, of the 28 drums sampled, 10 did not pass the EPA toxicity criteria using the TCLP. Based upon the results of the analysis, 18 drums of WERF ash material were classified as nonhazardous and disposed of as nonhazardous low-level waste. Eight of the ten drums of hazardous ash material were used in the development of the solidification procedure for bottom ash and in the evaluation of square drums.

The results of the laboratory analysis (see Table 2) showed that the bottom ash and clinkers were marginally hazardous. These low values are to be expected since the clinkers are the result of a molten process which tends to bind hazardous metals.

Experience with the stabilization of flyash indicated that hazardous constituents, such as those found in the bottom ash and clinkers, can be successfully treated by the solidification process.

TABLE 1. RESULTS OF LEACH TEST ANALYSIS OF RAW BOTTOM ASH AND CLINKER SAMPLES

Sample Number	Analyte Concentration Detected (mg/l)[a]		
	Cr	Cd	Pb
IC[b]1[c]	1.77	0.017	0.13
IC2	0.45	0.11	0.26
IAS1	2.6	0.68	0.01
IC3	0.29	0.05	0.15
IC4	1.4	0.12	0.83
IC5	1.93	0.36	0.71
IAS2	0.67	0.66	0.02

a. Maximum allowable concentrations (see Reference 4):
Cr--5 mg/L
Cd--1 mg/L
Pb--5 mg/L

b. IC = Incinerator clinkers
IAS = Incinerator bottom ash.

c. The order listed reflects the order (or level) in the drum where the sample was taken.

TABLE 2. RESULTS OF LEACH TEST ANALYSIS OF RAW ASH MATERIAL

Drum Number	Type Ash[a]	Ash Weight (lbs)	Analyte Concentration Detected (mg/L)			
			Cd[b]	Cr[b]	Pb[b]	Hazardous[c]
DSB1	SBHD	10	2.18	0.07	9.8	Yes
DSB2	SBHD	24	4.19	5.09	23.3	Yes
DSB3	SBHD	30	15.4	6.18	10.3	Yes
DIR1	Refractory	428	0.01	0.18	0.2	No
DIA1	BA	45	0.01	0.08	0.2	No
DIA2	BA	220	0.04	27.7	0.1	Yes
DIA3	BA	356	0.06	4.84	0.4	No
DIA4	BA	254	0.01	0.31	0.2	No
DIA5	BA	306	0.09	11.7	1.0	Yes
DIA6	FA	104	400.0	0.12	64.8	Yes
DIA7	BA	474	0.05	1.03	4.0	No
DIA8	BA	UK	0.46	2.82	3.3	No
DIA9	BA	433	0.33	0.59	29.0	Yes
DIAC1	BA	245	0.01	0.08	0.6	No
DIAC2	BA	297	0.01	1.06	3.3	No
DIAC3	BA	533	0.15	2.39	1.3	No
DIAC4	BA	445	0.47	2.22	0.5	No
DIAC5	BA	266	0.05	7.10	0.4	Yes
DIC1	BA	128	0.01	1.1	2.7	No
DIC2	BA	210	0.02	1.62	0.3	No
DIC3	BA	UK	0.01	0.04	0.1	No
DIC4	BA	UK	0.02	5.73	5.2	Yes
DIC5	BA	UK	0.33	3.64	0.1	No
DIC6	BA	223	0.01	0.39	0.2	No
DIC7	BA	UK	0.02	0.34	2.6	No
DIC8	BA	UK	0.3	0.96	0.2	No
DIC9	BA	UK	0.05	7.00	0.9	Yes
DIC10	BA	UK	0.06	2.2	1.1	No

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a. SBHD = Sizing Baghouse Dust
FA = Flyash
BA = Bottom Ash
UK = Unknown

b. Two samples were taken from each drum and analyzed for silver, arsenic, barium, mercury, selenium, cadmium, chromium and lead. The cadmium, chromium, and lead were the only constituents which approached the maximum values. Therefore, only the highest values detected of these constituents are reported here.

c. Maximum allowable values: Cd < 1.0 mg/L
(Reference 4) Cr < 5.0 mg/L
Pb < 5.0 mg/L

4. LAB-SCALE TESTING OF BOTTOM ASH

The methods used to develop binder-to-waste ratios for the solidification of flyash (reported in Reference 2 and verified by the drum-scale testing reported in Reference 3) were also used to develop the formula for solidification of incinerator bottom ash. Samples taken from each drum were used in the development of binder-to-waste ratios.

One-hundred-gram ash samples were combined with several combinations of water-cement slurries. The samples were allowed to cure for 24 hours, and then examined. The combinations that set up with no standing water were sent to the laboratory for TCLP analysis. Results of leach test analysis of the lab-scale samples are shown in Table 3. As indicated, the laboratory tests verified that the solidification process, using a cement slurry to stabilize the hazardous constituents, was effective and that the binder-to-ash ratios were adequate to continue with the drum-scale solidification process.

Lab-scale tests were conducted only on the drums of hazardous bottom ash. No lab-scale testing was conducted on the drums of sizing baghouse dust or flyash since the grout formula had already been developed in previous testing.

TABLE 3. RESULTS OF LEACH TEST ANALYSIS OF LAB-SCALE SAMPLES

	Analyte Concentration Detected (mg/L)							
Drum Number	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
DIA2	0.01	0.01	2.2	0.001	2.9	0.0004	0.01	0.02
DIA5	0.01	0.01	1.1	0.001	4.3	0.0004	0.01	0.02
DIC4	0.01	0.01	2.4	0.001	0.07	0.0004	0.01	0.01
EPA Limits (see Reference 4)	5.0	5.0	100	1.0	5.0	0.2	5.0	1.0

5. ASH TRANSFER

The in-drum mixing technique developed for the solidification of WERF flyash (see Reference 3) showed that the optimum weight of flyash for successful tumble mixing in a 55-gal drum is 100 pounds.

As indicated in Table 1, the weights of the inventoried hazardous ash varied from 10 to 533 pounds per drum. Based upon the calculated weights and fill levels required for successful tumble mixing of each drum, it was obvious that the ash had to be redistributed prior to processing. To support the evaluation of square drums, the ash material was transferred to square drums at this time (see Section 6).

The amounts of sizing baghouse dust contained in the drums were below the optimum amount for solidification; therefore, the ash material in these drums was consolidated. However, the weights of bottom ash ranged from below, to well above, the optimum amount, so the ash material in these drums was redistributed throughout a number of drums. The consolidation and redistribution of the ash material was a one-time effort involving a relatively few number of drums; therefore, it was not cost effective to develop an engineered, contained transfer system.

Manually transferring ash of any type generates some airborne contamination. Therefore, the consolidation of the sizing baghouse dust was conducted in the WERF sizing room, where the dust was originally generated. The sizing room provided a contained area, with ventilation and radioactivity monitoring equipment, in which to transfer the sizing baghouse dust without the risk of airborne contamination escaping to the environment.

The bottom ash material, which consists of both ash and clinkers, was easier to handle than the sizing baghouse dust. Therefore, transfer of the bottom ash was conducted under close supervision in the solidification room at the WEDF. The transfer of ash at both locations was conducted by trained personnel wearing proper protective clothing.

A drum-handling and -tilting mechanism was used to aid in the lifting and tilting of the ash drum while transferring the ash. Experiments with this mechanism have proved successful in minimizing the amount of dust generated during ash transfer. To further contain the dust, a temporary plastic shroud was taped around the two drums and the room carefully monitored for airborne contamination. The room ventilation and filter system contained the dust and prevented its escape from the room. The room was decontaminated after the ash transfer operation was completed.

At this time, the drums were filled with a variety of combinations of ash and clinkers. Drum SD3 was filled with 157 pounds of baghouse dust and clinkers. Drum SD10 consisted mostly of clinkers, with only a little ash. Additional samples of the dry ash were taken at this time to assist in lab-scale testing. Table 4 shows which drums were combined for the final solidification. Some drums were left for future solidification after the mixing formula has been established (e.g., Drum DIC9).

TABLE 4. DRUM TRANSFER COMBINATIONS

Round Drum Number[a]	Square Drum Number	Ash Type[b]	Ash Weight (Pounds)
DSB1 DFA2 DSB3	SD1	BHD	120
DSB2 DFA2	SD2	BHD	110
DFA1	SD3	BHD	152
DIA6	SD4	FA	130
DIA2	SD5	BA	175
DIA2 DIA5	SD6	BA	174
DIA5	SD7	BA	175
DIA9	SD8	BA	177
DIA9 DIA6	SD9	BA	178
DIA9 DIC4	SD10	BA	178
DIC4	SD11	BA	107

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a. D = Drum
SB = Sizing baghouse
FA = Flyash
IA = Incinerator flyash
IC = Incinerator bottom ash with clinkers

b. BHD = Baghouse Dust
FA = Flyash
BA = Bottom Ash

6. EVALUATION OF SQUARE DRUMS

6.1 Test Plan

A major concern of all waste storage facilities is the efficient use of space. In keeping with this concern, several sites have been investigating the use of more efficient waste containers. Several facilities are presently investigating a 71-gallon square drum (See Figure 4). The square drum allows 71 gallons of waste to be contained in the same base area as a standard 55-gallon drum. Radioactive Waste Management Complex (RWMC) personnel at the INEL have also made preliminary evaluations and have included square drums in their acceptance criteria. The added capacity of the square drum makes it an ideal container for the solidification process. However, as with the round drum, the use of square drums is primarily dependent upon whether an in-drum mixing technique can be developed.

Successful solidification of WERF flyash was also dependent upon the development of an in-drum mixing method that would ensure a homogeneous mixture. As reported in Reference 3, it was determined that drum tumbling alone was not an effective mixing method. A motorized paddle mixer was therefore used to ensure that a homogeneous mixture was obtained. The physical nature of the incinerator bottom ash with clinkers precludes the use of the rotary paddle. Because of the design of the WERF ash collection system, in-drum mixing is the most desirable method for solidification of ash material; therefore, the capability of effective mixing in a square drum was a major concern. To develop an in-drum mixing technique, 10 square drums (with a variety of top openings) were purchased, and the drum tumbler in the WEDF solidification room was modified to accommodate square drums. The tumbler can be easily re-adapted to accommodate round drums.

Following this modification, noncontaminated/nonhazardous flyash, obtained from a commercial incinerator, was placed in a square drum. Using drum tumbling and the in-drum paddle mixer, the drum contents were solidified. The binder-to-waste formula for solidification of this

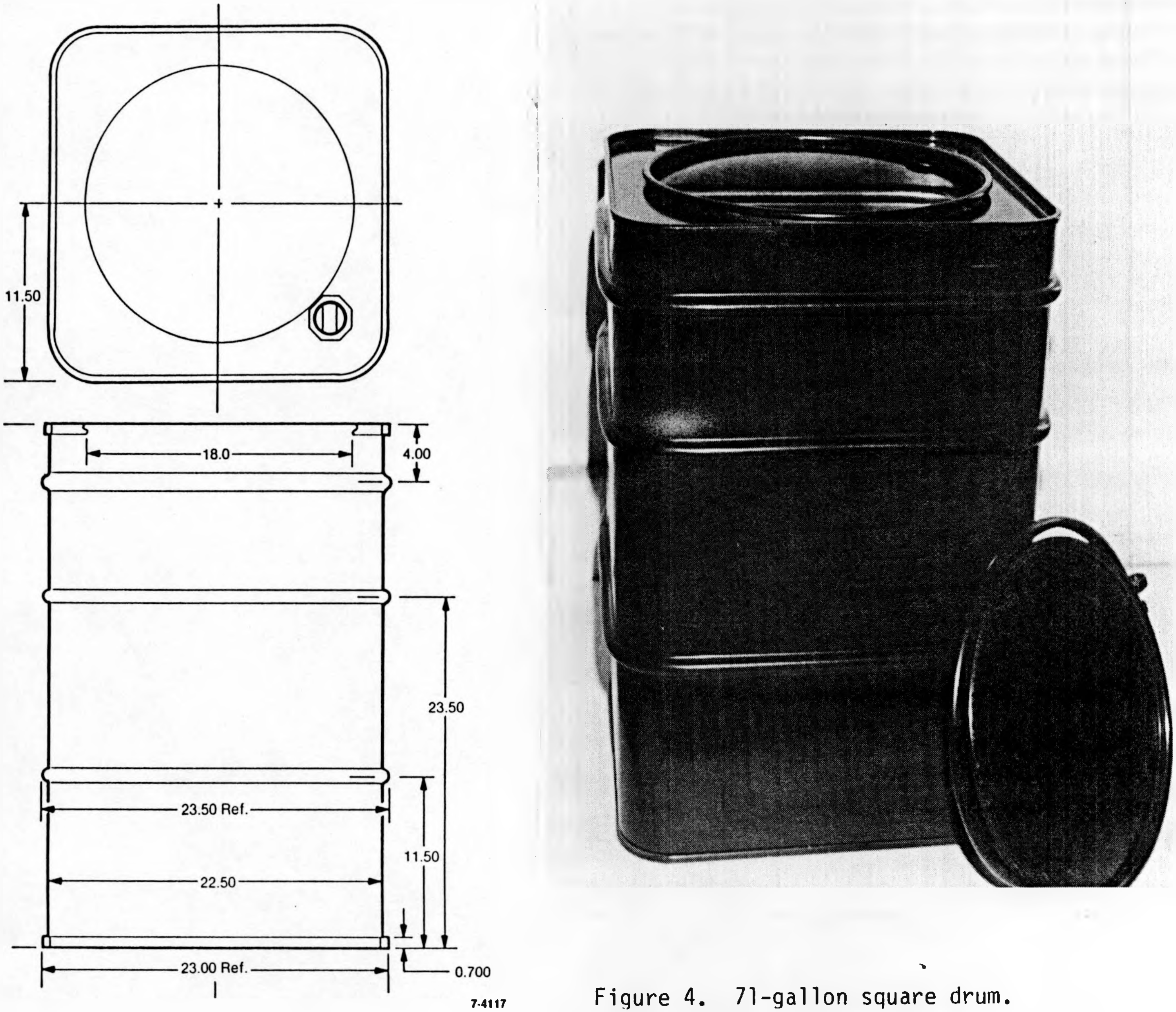

Figure 4. 71-gallon square drum.

commercial flyash was determined using the same lab-scale techniques as those used in previous development work (see Reference 2).

When the drum contents were thoroughly cured, the drum was cut into sections and examined to determine if proper mixing had taken place. This examination indicated that the mixing was complete and the mixture was homogeneous throughout the monolith, including the corners, which were the areas of greatest concern. The results of this test verified that square drums can be successfully used in the solidification of flyash.

6.2 Test Procedure

The flyash mixing procedure consisted of two stages. The first was drum tumbling, with water added on top of the ash prior to tumbling. The purpose of this stage was to dampen the ash, thereby eliminating dust when the lid was removed. The second stage consisted of removing the lid, inserting the paddle, and mixing while a cement-water slurry was added to the dampened ash. This two-stage mixing technique proved effective with both round and square drums. However, because of the clinkers in the bottom ash, it was concluded that the use of the in-drum paddle mixer would not be possible.

To facilitate ash mixing, a special grout probe was designed. The probe (see Figure 5) consists of a section of one-inch pipe with three sets of five 3/8-inch-diameter holes drilled on 120° centers. The probe is designed to be inserted through the 2-inch-diameter bung in the top of the drum.

The grout transfer pump, located below the mixing tank, provides the pressure required to force the grout (after it leaves the mixing tank) through the hose which connects to the probe. The transfer pump forces the grout through the probe directly on and into the ash material within the drum. The probe's discharge ports are first positioned above the ash to dampen the surface and settle the dust. As the probe is inserted into the material, the high-pressure transfer pump (200 psi) creates jets of cement slurry to penetrate the ash material, lifting and hydro-mixing the slurry

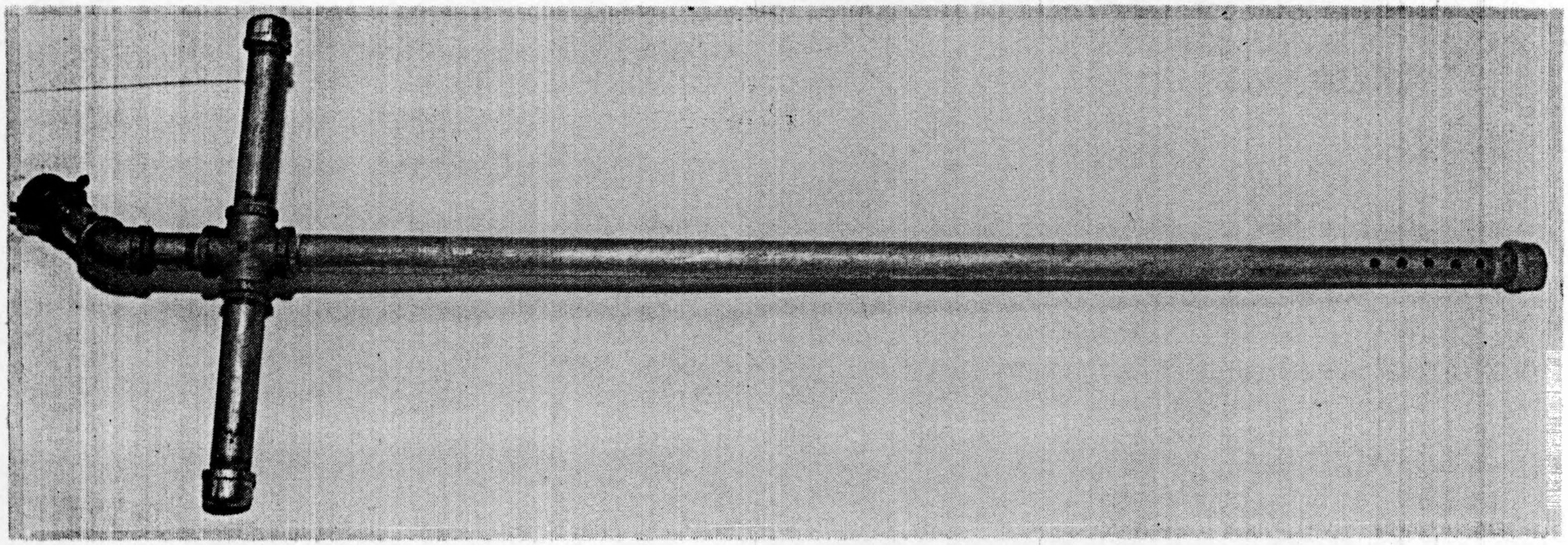

Figure 5. Grout probe.

with the ash. The probe is inserted deeper into the material (to the bottom of the drum), forcing the slurry to the bottom, thereby lifting the ash material and preventing it from sticking in the corners of the drum. Repeated removal and reinsertion of the probe into each corner and throughout the drum during grout injection distributes the cement slurry throughout the drum, partially mixing the contents. When the appropriate amount of grout has been inserted into the drum, the probe is removed, the bung cover replaced and tightened, and drum tumbling started.

Noncontaminated commercial incinerator bottom ash with clinkers was obtained and placed into a square drum. The commercial bottom ash was not identical to the WERF bottom ash; the clinkers were not as large nor of the same hardness. However, the material was adequate for this type of test. A mixing formula, using the lab-scale procedure, was developed for the commercial bottom ash. Using this formula, the grout was mixed in the mixing tank. The transfer pump was then used to inject the grout through the probe into the ash material. After filling the drum with the appropriate amount of grout, the drum was placed on the drum tumbler, sealed, and tumble-mixed. At the conclusion of the tumble mixing stage, the drum was allowed to thoroughly cure, after which it was cut into sections and examined. The results of the examination indicated that the mixing formula was not correct, as there was some standing water after curing. However, the mixture did set up, and proper mixing did take place, as evidenced by the fact that the contents were homogeneous throughout.

A second drum of commercial bottom ash was solidified using a formula that used less water. This drum was also cut into sections. Examination revealed that the use of the transfer pump and probe for grout injection, along with drum tumbling, was sufficient to produce a homogeneous mixture throughout the drum.

The results of these tests were sufficiently successful to warrant drum-scale testing of radioactive WERF incinerator bottom ash in square drums.

7. DRUM-SCALE SOLIDIFICATION OF WERF BOTTOM ASH

Square drums with various types of top openings, 6 1/2-inch-diameter and full open lids, were purchased for evaluation. Ash material was placed into each type of drum. The square drum with the 6 1/2-in.-diameter opening was considered to be a good choice for flyash, but possibly not for bottom ash as the opening was too small to allow clinkers to be inserted. In order to determine the acceptability of the 6 1/2-in. opening, bottom ash was placed in a square drum (Drum SD6). This drum was selected as the first drum to be solidified.

7.1 Processing the First Drum

Drum SD6 was a combination of bottom ash and small clinkers (no large clinkers were present) with a total ash weight of 174 pounds (see Table 5). The drum was positioned on the scale, its weight verified, and then moved to the drum tumbler and clamped into place.

Twenty-nine (29) gallons of water were metered into the grout mixing tank, filling the mixing tank to within seven (7) inches of the top. The mixing motor was started on slow speed and 366 pounds of dry cement added. The mixing tank was just barely able to contain the mixture (some spillage did occur). It was determined that, for future drums, the grout should be mixed in two batches so as not to fill the mixer too full.

When the grout had been thoroughly mixed, the drum bung cover was removed and the opening monitored for airborne contamination. The probe was inserted, with the discharge ports just above the surface. The transfer pump was started and the probe manipulated so that the grout played onto the surface of the ash. The probe was then maneuvered deeper into the ash until it reached the bottom of the drum and into a corner (see Figure 6). It was manipulated into all four corners of the drum and throughout the ash material. When all the grout had been dispensed, the probe was removed, wiped clean, and inserted into a plastic bag to contain any potentially contaminated material. The bung cover was replaced and

TABLE 5. SOLIDIFICATION PROCESSING FORMULAS

Square Drum Number	Date Processed	Ash Type	Ash Weight (Pounds)	Water (Gallons)	Cement (Pounds)	Drum Level (Inches)	Volume (Gallons)	Fill (%)	Final Gross Weight[a]
SD1[b]	3/12	BHD	120	32.4	240	23.5	50.5	71	725
SD2	3/13	BHD	110	29.7	220	14.7	31.7	44.6	650
SD3	3/19	BHD	152	40	314	26	55.8	79	865
SD4	3/13	FA	130	35	260	28	60.8	86	760
SD5[c]	3/11	BA	175	26.2	350	23.5	50.5	71	821
SD6[d]	3/5	BA	174	29.2	366	24.5	52.5	74	935
SD7	3/11	BA	175	26.2	350	23	48.5	68	821
SD8[e]	3/12	BA	177	25.2	350	21.5	46.1	65	811
SD9	3/12	BA	178	25.2	350	22.5	48.4	68	844
SD10	3.11	BA	178	25.2	351	27.5	59.2	83	916
SD11	3/12	BA	107	15.1	211	14.5	31.1	44	530

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a. Empty drum weight = 76 pounds.

b. Flyash mixing formula; water/ash = 2.25; cement/ash = 2.0.

c. Mixing formula for drums SD5 and SD7; water/ash = 1.25 cement/ash = 2.0; water/cement = 0.625.

d. Mixing formula for drum SD6; water/ash = 1.4; cement/ash = 2.0; water/cement = 0.645.

e. Mixing formula for drums SD8 - SD11; water/ash = 1.18 cement/ash = 2.0; water/cement = 0.6.

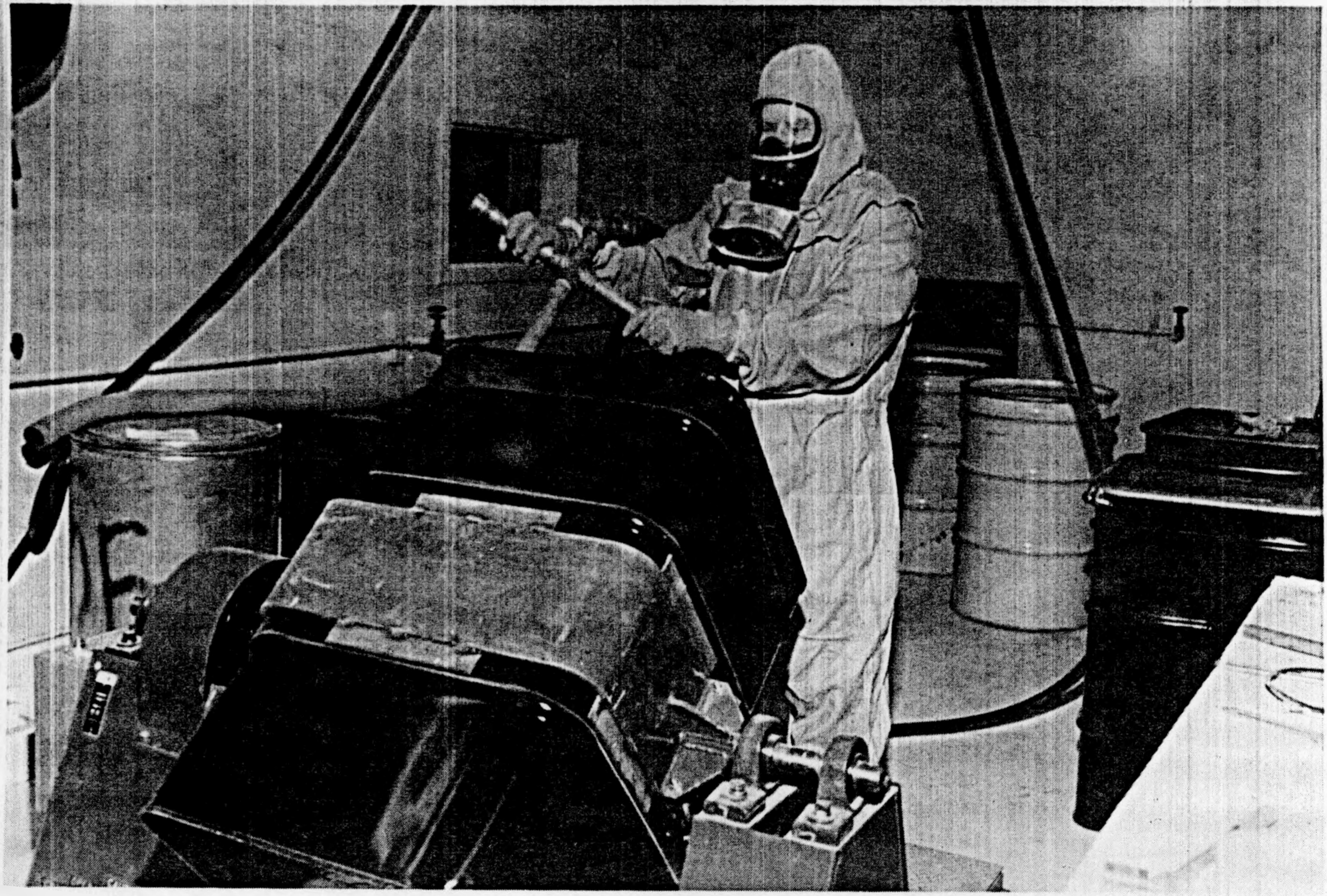

Figure 6. Drum of bottom ash, shown on WEDF square drum tumbler.

tightened and the drum was rotated (on the drum tumbler) to an inverted position and checked for leaks. The drum did not leak and was then tumbled end over end for 5 minutes at 18 rpm.

After removal from the drum, the probe was transferred to a 30-gallon drum lined with plastic. The plastic bag was removed from the end and ten (10) gallons of fresh water were metered into the mixing tank, thus washing the tank. The water was then pumped through the transfer pump to the probe and into the 30-gallon drum, thereby washing both the line and probe. This amount of washwater later proved to be insufficient for proper cleaning. In subsequent solidification procedures, 15 gallons of water were used to wash the tank and probe. The transfer pump was disassembled and cleaned prior to the mixing of other batches, and the probe was cleaned of small bits of bottom ash. The wash water was allowed to settle, the solids were removed, and the water was eventually used in the solidification of other drums, so as not to generate additional waste.

7.2 Sampling the Solidified Drum

At the conclusion of the drum tumbling phase, the drum was positioned in an upright position and the 6 1/2-in.-diameter cover removed. A section of 1-in.-diameter plastic pipe was inserted into the mixture and manipulated throughout the drum to obtain a representative sample. Two full-length samples were taken in this manner. The mixture appeared to be excessively liquid; therefore, 25 pounds of dry cement were added and mixed in using the sample tube. Two additional full-length samples were taken.

The four samples were placed in sample jars and their lids tightly sealed. After sampling, the top cover of the drum was replaced and resealed. The drum was then removed from the tumbler, placed on the scale for weighing, and maneuvered to a remote area of the room to cure.

After 24 hours, the drum cover was removed and the contents visually examined. It was discovered that the mixture had set up, but there was approximately one (1) inch of standing water on top of the monolith.

As curing was still taking place, it was decided to let the drum cure for an additional three days. At the end of this time, the drum was opened and re-examined. The standing water was still evident. The water was then syphoned off and measured (20 pounds) and samples taken for analyses. The water (minus the samples for analysis) was returned to the drum and fifty (50) pounds of dry cement were added to absorb the excess water. The ash samples that were sealed into jars did set up, but all four had standing water. The water was drained off and the jars resealed. Analytical results from the sample of standing water indicated that it was slightly hazardous (7.83 mg/L of leachable chromium, 5 mg/L being the maximum allowable). When dry cement was mixed into the water, the leachable level was reduced below the maximum allowable level.

The height of the solidified monolith was 24.5 inches. The monolith had a volume of 52.5 gallons of stabilized ash, or 74% of the drum capacity.

7.3 Solidifying the Remaining Drums of Bottom Ash

Drums SD5 and SD7 were selected next for solidification. SD5 had a 6 1/2-in.-diameter top opening, and SD7 had a full-square cover without a bung. Both were filled with bottom ash and clinkers. Drum SD7 had more and larger clinkers. Each drum contained 175 pounds of ash material.

Based on experience with Drum SD6, which contained standing water after solidification, the binder-to-waste ratio was changed to: water-to-ash 1.25 to 1 and cement-to-ash 2 to 1.

The grout was mixed in two batches. The first contained 21 gallons of water and 282 pounds of cement; the second, 5.2 gallons of water and 68 pounds of cement. During the curing time of Drum SD6, several different grout mixing ratios were experimented with to determine the limitations of the mixer and the transfer pump. At this time, it was determined that a water-to-cement ratio of less than 0.4 to 1 resulted in too stiff a mixture, which loaded the transfer pump, and the probe did not function as designed. A water-to-cement ratio of 0.5 to 1 was marginal; 0.6 to 1 was ideal, providing the pump was clean. The quick-disassemble feature of the pump facilitates cleaning.

The same in-drum mixing technique used on Drum SD6 was used on Drum SD5. After tumbling, a full core sample was taken from each of the four corners of the drum. The drum was then set aside to cure.

Drum SD7, which had a full-square cover without a bung, was positioned, on the tumbler and the cover carefully removed. A CAM sniffer hose was positioned near the cover as it was removed to detect any airborne contamination. The bottom ash material is not as light as flyash and, therefore, generated very little dust.

After the drum cover was removed, a large plastic bag was slipped over the drum and secured in place with tape. A small hole was cut in the plastic and the grout probe inserted through it to a position where the probe discharge ports were just above the ash material. The transfer pump was started and grout injected to wet the surface. The probe was then manipulated to inject the grout into the bottom corners and throughout the ash. Using the plastic cover allowed ready observation of the interaction between the jets of cement slurry and the ash material, particularly the lifting of the ash as the slurry was injected at the bottom of the drum.

The probe was removed and transferred to the 30-gallon drum. The full cover was replaced with some difficulty, as it was discovered that, either the drum became distorted during clamping into the drum tumbler saddle or the cover was not square, as had been assumed. After several attempts, the drum passed the inverted leak test and was then tumbled for 5 minutes. The cover was removed after tumbling, and the mixture was visually inspected. A sample tube was used to stir the mixture to detect any lumps of unmixed ash. The drum was resealed and tumbled for an additional 5 minutes before being sampled. A full-length sample was taken from each of the four corners of the drum. The full-open cover allowed easy access to the drum contents for sampling. The drum was resealed and set aside to cure.

After being allowed to cure for 24 hours, both drums were opened and the contents examined. Both drums had set up, but each had some standing water (about 1/4 inch for SD7 and 1/8 inch for SD5) on the surface. Dry cement was added to both drums to absorb the water.

The samples from SD5 and SD7 showed a film of water on the cured sample. This water was drained off before the sample jar was resealed. The ash types in the two drums were different; Drum SD5 had mostly ash material, while SD7 had more clinkers. The amount of water on the surface of SD5 was so little that it was thought that, had the cover been left off during curing, and the jar let stand for longer than 24 hours, the water would have evaporated. The standing water in Drum SD7 might also have evaporated with time, but the objective was to develop a mixing formula for all types of bottom ash combinations. Therefore, the binder-to-ash ratio was adjusted for future drums.

The difficulty experienced with the full-drum cover was somewhat discouraging, but, since ash material had already been transferred to these drums, solidification of drums of bottom ash continued using this type of cover.

Drums SD8, SD9, SD10, and SD11 were solidified using the same in-drum mixing technique as used for SD7. A mixing ratio of water-to-ash of 1.18 to 1 and cement-to-ash of 1.97 to 1 was used on the last four drums with good results. All drums set up with no standing water. Refer to Table 4 for actual amounts of binder used.

After sampling Drum SD10, it was decided to take advantage of the accessibility of the full-open drum and add accumulated lab-scale samples to the void space remaining in the drum. One hundred pounds (100) of samples that were no longer needed were added to the mixture. After curing, the cover was removed and the contents observed. The addition of the samples had not altered the mixture, which had firmly set up.

At the conclusion of solidifying Drum SD11, samples from all the solidified drums were collected and sent to an independent laboratory for analysis. It was concluded that the in-drum mixing technique developed for commercial bottom ash was also successful for WERF bottom ash in square drums. However, it was concluded that the full-drum cover should not be used; the 6 1/2-in.-diameter cover had functioned much better for bottom ash. However, since the optimum cover size should be still larger, the packaging vendor was contacted, and a square drum with an 18 1/2-in.-diameter opening was sent to the INEL for evaluation. The top of the drum also had a 2-inch bung. This type of drum meets all the design requirements of the WERF ash collection system, minimizing modifications and allowing interchangeability between round and square drums.

7.4 Solidifying WERF Sizing Baghouse Dust

The in-drum mixing technique used with commercial noncontaminated/nonhazardous flyash in square drums was used to solidify the sizing baghouse dust (see Section 6.1).

Drums SD1 and SD2 contained 120 and 110 pounds respectively, of sizing baghouse dust and flyash. Each of these two square drums had a 6 1/2-in.-diameter top opening. The grout mixing formula developed for drum-scale WERF flyash was used for this ash, and no lab-scale tests were conducted.

Eighteen (18) gallons of water were metered into the grout mixing tank. The probe was inserted through the 2-in.-diameter bung. The transfer pump forced water through the probe, which directed water onto the surface of the ash. The probe was then removed, three mixing bars inserted, the bung cover reinstalled, and the drum sealed. The drum was then tumbled for five (5) minutes. The grout probe was reinserted through the 2-inch bung into the dampened ash completely to the bottom. Grout was mixed in the mixing tank (14.4 gallons of water and 240 pounds of cement) and pumped through the probe into the ash. When the grout had been injected, the probe was removed, the bung cover resealed, and the drum tumbled for an additional 5 minutes.

At the end of this phase, the drum tumbling was stopped, the 6 1/2-in.-diameter cover removed, the motorized mixing paddle inserted into the drum, and the contents thoroughly mixed. Four full-length core samples were taken from each drum and sealed in sample jars. The drums were resealed and set aside to cure.

Drum SD4 was a square drum with a 6 1/2-in.-diameter top opening and contained 130 pounds of WERF incinerator flyash. During the solidification of Drums SD1 and SD2, it was observed that, when the probe was maneuvered throughout the drum, the ash appeared thoroughly dampened. It was decided to attempt solidification of Drum SD4 without tumbling, using the probe to dampen the ash and the paddle to complete the required mixing. The probe was inserted through the bung and positioned to dampen the surface ash, then worked into the ash and maneuvered throughout the drum to dampen the drum contents.

After injecting the appropriate amount of water, the cover was removed, the paddle inserted and connected to the mixing motor, and the mixing started. Following mixing, the probe was reinserted and grout injected through it into the ash. At the conclusion of grout injection, additional paddle mixing was completed, and four full-length samples taken from the drum. Both the probe and mixing paddle were removed and the drum resealed and set aside to cure.

After Drums SD1, SD2, and SD4 had set up, (with no standing water), Drum SD3 was readied for solidification. SD3 was a square drum with a full-drum cover without a bung and contained 157 pounds of sizing baghouse dust and bottom ash clinkers.

The drum was positioned on the tumbler, the cover carefully removed, and a large plastic bag taped in place over the opening. A slit was cut into the plastic and the probe inserted and positioned with the discharge ports just above the surface of the ash.

Forty-one (41) gallons of water and 314 pounds of cement were mixed in two (2) batches and pumped through the probe to wet the top surface and then injected into the ash. The plastic bag covering the top of the drum allowed observation of this process. Pressure of the grout flowing through the probe lifted the ash, as expected, to the point of almost overflowing the drum, until the probe was vigorously manipulated throughout the drum to allow the jets to facilitate more mixing. As this happened, the mixture level dropped to a more manageable height in the drum.

After injecting all the grout into the drum, the probe was removed, the cover was replaced, and the drum sealed. The drum was then tumbled for ten (10) minutes, with the clinkers acting as mixing bars. After mixing, the drum was stopped, the cover removed, the mixing paddle connected to the mixing motor, and an attempt made to paddle mix the mixture. The presence of the clinkers made paddle mixing hazardous to both the paddle blades and the operator. After a few minutes, this effort was abandoned. Four (4) samples were taken, one (1) full-length sample in each of the four corners. A fifth sample was taken by scraping the sample tube along the bottom corner, probing for lumps of unmixed ash, and lifting large clinkers to the surface. This was done to observe how much (if any) unmixed ash had adhered to the clinkers. Where the sample tube could not be used to raise the clinkers to the surface for examination, fireplace-type tongs were used. The clinkers were found to be clean of unmixed ash and replaced in the mixture. The cover was replaced, the drum resealed, and set aside to cure.

8. SOLIDIFIED BOTTOM ASH ANALYTICAL RESULTS

The results of the TCLP testing of samples from the solidified drums (shown in Table 6) indicate that the solidification process was successful in all drums. The values listed in the table are the highest values obtained from the four samples taken from each drum as it was solidified. These were full-length samples taken near each corner of the drum. The results indicate that the in-drum mixing technique used produced a homogeneous mixture.

The conclusion drawn from the analysis is that both the in-drum mixing techniques and mixing formulas were sufficiently correct to produce a homogeneous monolith which can be disposed of as nonhazardous low-level radioactive waste material. It was also concluded that square drums can be efficiently used for both flyash and bottom ash solidification.

The square drums are only partly full and will be capped with either sand or cement grout. The reason for filling the drums is to minimize subsidence when disposed of at the RWMC.

TABLE 6. RESULTS OF LEACH TEST ANALYSIS OF STABILIZED ASH SAMPLES

Drum Number	Analyte Concentration Detected (mg/L) In Dry Ash Material[a] Cd	Cr	Pb	In Stabilized Ash[b] Cd	Cr	Pb	Ash[c] Type
SD1	15.4	6.20	9.80	0.01	0.56	0.80	BHD
SD2	2.64	5.75	23.3	0.01	0.65	0.60	BHD
SD3	2.64	5.75	15.9	0.01	0.73	0.51	BHD
SD4	400	0.12	64.8	0.01	0.17	0.80	FA
SD5	0.04	27.7	0.10	0.01	0.72	0.10	BA
SD6	0.04	27.7	0.10	0.01	0.36	0.10	BA
SD7	0.09	11.7	0.10	0.01	0.42	0.10	BA
SD8	0.33	0.59	29.0	0.01	0.09	0.10	BA
SD9	0.33	0.59	29.0	0.01	0.18	0.10	BA
SD10	0.33	5.73	29.0	0.01	0.22	0.10	BA
SD11	0.01	5.73	0.10	0.01	0.31	0.10	BA

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a. Highest value of dry ash samples (2 per drum) from all drums making up composite ash drum.

b. Highest value of solidified ash samples (4 per drum).

c. BHD = Baghouse Dust
FA = Flyash
BA = Bottom Ash
Acceptable values (see Reference 4): Chromium (Cr) less than 5 mg/L
Cadmium (Cd) less than 1 mg/L
Lead (Pb) less than 5 mg/L.

9. QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance/Quality Control (QA/QC) of the sample gathering and analysis were considered important to ensure that the methods used would provide valid, reliable, consistent, and representative analytical results. The procedure used for leaching the samples, to provide the extract for metals analysis, was the TCLP.

The laboratory used for sample analysis has its own QA/QC plan, which includes procedural controls, specifications, and standard methods for performing analysis, verifying results, performing instrument calibration, instrument maintenance procedures and internal quality control. All analyte concentration analyses were performed using EPA-approved or laboratory standard procedures. The laboratory used for analysis uses blanks periodically in analytical procedures for background data and quality control.

The data in Table 7 are the results of the standards and blanks submitted to the laboratories for analysis. These samples were submitted blind to provide a check of lab accuracy, and were analyzed simultaneously with the samples of ash material and stabilized ash material.

Samples labeled WEDSSL were a standard solution, purchased from a chemical supply company, which contained 1000 mg/L lead. As shown by the analytical results, the laboratory performance was acceptable.

The samples labeled SPC consisted of solidified blanks, which contained only cement and demineralized water. These samples were used to determine if any bias existed in the lab procedures for specific metals, or if any tramp metals were present in the cement used in the solidification tests. The data obtained are consistent, and indicate no bias for any metal, nor the presence of any tramp metals in the cement used. These data were also compared with earlier analysis of the same type of blank; the results are consistent.

TABLE 7. QA/QC SAMPLE ANALYTICAL RESULTS

	Analyte Concentration Detected (mg/L)							
Sample Number	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
WEDSSLA	--[a]	--[a]	--[a]	--[a]	1028	--[a]	--[a]	--[a]
WEDSSLB	--[a]	--[a]	--[a]	--[a]	1075	--[a]	--[a]	--[a]
WEDSSLC	--[a]	--[a]	--[a]	--[a]	974	--[a]	--[a]	--[a]
WEDSSLD	--[a]	--[a]	--[a]	--[a]	984	--[a]	--[a]	--[a]
SPC12A	<0.01	1.1	<0.01	0.03	<0.1	<0.0004	<0.01	<0.01
SPC12B	<0.01	1.7	<0.01	0.01	<0.1	<0.0004	<0.01	<0.01
SPC13A	<0.01	1.3	<0.01	0.03	<0.1	<0.0004	<0.01	<0.01
SPC13B	<0.01	1.5	<0.01	0.01	<0.1	<0.0004	<0.01	<0.01

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a. Standard solution of 1000 mg/L lead only; therefore this sample was not analyzed for this element.

In addition to the standards and blanks used as quality control samples, solidified bottom ash samples also contained quality control samples. The solidified samples were collocated samples, drawn in the same method at the same time from the drum; these gave an indication of the homogeneity of the solidified mixture. The results from all these samples were very consistent and indicate good homogeneity within the drums.

The data obtained for this program have been shown to be valid, reliable, consistent, and representative of the sample population by the consistency and accuracy of the analysis results.

10. FUTURE ACTIVITIES

Stabilization of waste at the INEL will be an ongoing activity. Each waste, as it is identified and available, will be subjected to waste characterization, lab-scale testing for development of binder-to-waste ratios, drum-scale testing, and toxicity testing of solidified samples before implementation of production solidification treatment. The next waste scheduled for development is the sludge that resulted from the decommissioning of the Initial Engine Test (IET) Facility.

The EPA requires facilities that treat hazardous wastes to have an approved RCRA Part B permit. The INEL has submitted an application for this permit, which includes the solidification process. The results of the development activity for WERF incinerator flyash have been presented to the EPA and the INEL has received agreement from that agency that the flyash stabilization meets the RCRA regulations. Any further support activities will be conducted as required.

The next activity to be conducted under this development program will be the preparation of the production solidification facility at WERF. This will include stabilization of a backlog of incinerator flyash and, pending EPA concurrence, incinerator bottom ash and sizing baghouse dust. The status of this activity is shown in Table 8.

TABLE 8. STATUS OF WERF FLYASH AND BOTTOM ASH DISPOSITION

Drum Number	Contents	Leach Test Results	Solidified	Disposition	Status
DN1	Flyash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DN2	Flyash	Hazardous	Yes-Failed	Storage at RMWSF	Stored at RMWSF
DN3	Flyash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DN4	Flyash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DN5	Flyash	Hazardous	Yes-Failed	Storage at RMWSF	Stored at RWMSF
DN6	Flyash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DN7	Flyash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DN8	Flyash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DN9	Flyash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DSB1	Sizing Baghouse Dust	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DSB2	Sizing Baghouse Dust	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DSB3	Sizing Baghouse Dust	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DSB4	Sizing Baghouse Dust	--[a]	No	Solidify at WERF	Date TBD
DIR1	Incinerator Refractory	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIA1	Bottom Ash	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIA2	Bottom Ash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DIA3	Bottom Ash	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIA4	Bottom Ash	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIA5	Bottom Ash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DIA6	Flyash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DIA7	Bottom Ash	Nonhazardous	No	Disposal at RWMC	Awaiting shipment
DIA8	Bottom Ash	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIA9	Bottom Ash	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DIAC1	Ash and Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIAC2	Ash and Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIAC3	Ash and Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIAC4	Ash and Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIAC5	Ash and Clinkers	Hazardous	No	Solidify at WERF	Date TBD
DIC1	Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIC2	Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIC3	Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIC4	Clinkers	Hazardous	Yes-Passed	Disposal at RWMC	Awaiting shipment
DIC5	Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIC6	Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIC7	Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIC8	Clinkers	Nonhazardous	No	Disposal at RWMC	Disposed at RWMC
DIC9	Clinkers	Hazardous	No	Solidify at WERF	Date TBD
DIC10	Clinkers	Nonhazardous	No	Disposal at RWMC	Awaiting shipment
DIC11	Clinkers	--[b]	No	Solidify at WERF	Date TBD
DIC12	Clinkers	--[b]	No	Solidify at WERF	Date TBD
DIC13	Clinkers	--[b]	No	Solidify at WERF	Date TBD

TABLE 8. (continued)

Drum Number	Contents	Leach Test Results	Solidified	Disposition	Status
DIC14	Clinkers	--[b]	No	Solidify at WERF	Date TBD
DIC15	Clinkers	--[b]	No	Solidify at WERF	Date TBD
DIC16	Clinkers	--[b]	No	Solidify at WERF	Date TBD
DIC17	Clinkers	--[b]	No	Solidify at WERF	Date TBD
DFA1	Flyash	--[a]	Yes-Passed	Disposal at RWMC	Awaiting shipment
DFA2	Flyash	--[a]	Yes-Passed	Disposal at RWMC	Awaiting shipment
DFA3	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA4	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA5	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA6	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA7	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA8	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA9	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA10	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA11	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA12	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA13	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA14	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA15	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA16	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA17	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA18	Flyash	--[a]	No	Solidify at WERF	Date TBD
DFA19	Flyash	--[a]	No	Solidify at WERF	Date TBD

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a. Flyash and sizing baghouse dust, based on previous testing which showed hazardous constituents to be well over EPA limits, are assumed to be mixed waste. As mixed waste, all flyash and sizing baghouse dust will be stabilized before disposal.

b. All incinerator bottom ash and clinkers will be stabilized prior to disposal. Testing has shown that some of the bottom ash and clinkers are marginally hazardous. Therefore, the decision has been made to solidify all the waste to ensure that no hazardous waste is sent to the RWMC, and to minimize subsidence of the waste form after disposal.

11. CONCLUSIONS

The primary goal of the stabilization program for incinerator bottom ash and sizing baghouse dust was to verify that the successful methods developed in the lab-scale program could be adapted into a production-scale process which produces a stable waste monolith that contains no free liquids, no leachable metal levels in excess of EPA limits, and can therefore be disposed of as low-level radioactive waste.

The objectives defined to meet this goal were as follows:

- Verification that the lab-scale methods developed for flyash could be used to determine binder-to-waste ratios (a cement grout mixing formula) for drum-scale solidification of incinerator bottom ash
- Development of an in-drum mixing technique which ensures that a homogeneous monolith is produced
- Verification that the monolith leachable metal levels are below the limits set in the EPA toxicity leaching criteria
- Development of procedures for production-scale solidification of bottom ash.

Two additional and associated goals were: to analyze the inventoried ash material being stored at the Radioactive Mixed Waste Storage Facility (RMWSF), and to evaluate 71-gallon square drums as a more efficient container for solidified waste.

As discussed in the text, lab-scale grout mixing formulas were not completely successful when used as drum-scale formulas. For drums which contained mostly ash with few clinkers, the lab-scale mixing formula was adequate; however, as clinkers were added, increasing the weight, the mixing formula needed adjustment. It was determined that the clinkers did not absorb the water, leaving standing water on top of the monolith. In all cases, the mixture did set up hard and addition of dry cement to absorb the excess water was more of an inconvenience than a process problem. The final mixing formula, however, eliminated the need to add dry cement.

Using the probe to inject cement grout directly into and throughout the ash material facilitated mixing and allowed the elimination of the ash-dampening stage used in the original method of solidifying flyash. The use of the probe in injecting grout into bottom ash, combined with the weight of the clinkers, made drum tumbling a successful mixing technique.

The homogeneity of the drum is initially determined by visual inspection of full-length samples taken from the drum after the mixing stage, and just prior to curing. Homogeneity is verified by analyzing the samples. Visual inspection of sectioned drums of noncontaminated ash (which had used a similar mixing technique to that used for contaminated ash), and the analytical results of samples taken from all the stabilized contaminated ash drums, verified that the mixing techniques used produced a homogeneous monolith.

The analytical results obtained from all the drums processed show, through both analytical and statistical evaluation, that the monolith resulting from the solidification process of bottom ash material does not contain leachable toxic metal levels in excess of EPA limits and can therefore be disposed of as a low-level radioactive waste.

It was also verified that the 71-gallon square drum can be used successfully in the solidification process, and the WERF ash collection system has been modified so that either square or round drums can be used. The solidification room equipment at WERF (mainly the drum tumbler) will be modified to accommodate square drums. Facility modifications have been completed to allow the use of the grout mixer and transfer pump. The solidification procedures will be changed to include the use of this equipment as well as the grout probe.

The results of the analysis of the inventoried ash material substantiated the assumption that WERF flyash and sizing baghouse dust are hazardous and will therefore always be subjected to the solidification process before disposal.

WERF bottom ash, although not always hazardous, will be considered as such and, to satisfy subsidence requirements, will also be solidified.

Although there is a substantial weight increase associated with the solidification process, there is no relative volume increase. The weight increase is approximately 4 times the original weight for flyash and sizing baghouse dust, and 3.4 times for bottom ash and clinkers.

The use of 71-gallon square drums allowed six drums of flyash and sizing baghouse dust to be consolidated into four drums of waste material, a decrease of two drums. Five drums of bottom ash with clinkers were redistributed into seven drums, an increase of two drums. The net change in number of drums was zero.

From a hazardous waste volume standpoint, the impact of the solidification process is a volume reduction of 100%, as all eleven drums were initially hazardous waste but, following solidification, the material in all eleven was rendered nonhazardous.

12. REFERENCES

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