

RDF — MATERIALS RECOVERY AND UTILIZATION: AN INTEGRATED APPROACH

G. L. BOLEY, R. M. HARTMAN, A. L. PLUMLEY, AND M. L. SMITH
ABB Resource Recovery Systems
Windsor, Connecticut

ABSTRACT

An on-going effort is described which is designed to meet three major national goals for the 1990s:

(a) Environmentally safe combustion of Municipal Solid Waste (MSW).

(b) Environmentally acceptable disposal of residue from waste-to-energy systems.

(c) Production of a revenue producing by-product meeting engineering specifications.

Optimizing the Refuse Derived Fuel (RDF) preparation process for materials recycling has been shown to allow potentially profitable recovery of ferrous metal, nonferrous metal, and other fractions of the raw municipal solid waste.

In turn, the preseparation of ferrous and nonferrous metals and process residue includes removal of heavy metal components, i.e., lead, cadmium, and mercury, and provides an even more optimum raw material (ash residue) for production of light-weight artificial gravel by the ABB ash stabilization process.

INTRODUCTION

Current solid waste management technologies can be tabulated in order of environmental and public policy preference:

- (a) Waste reduction.
- (b) Recycle/reuse.
- (c) Waste to energy.
- (d) Secured landfill.

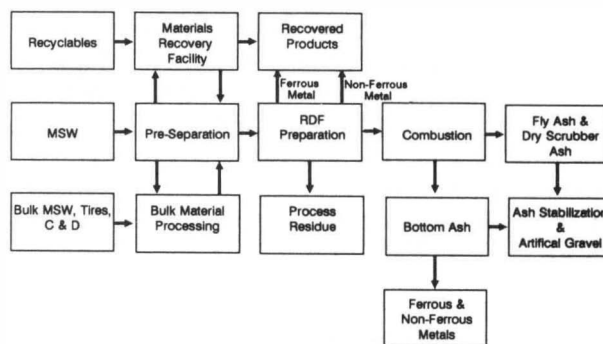


FIG. 1 ABB INTEGRATED MATERIALS RECOVERY AND ASH UTILIZATION

An integrated solid waste management program, developed by ABB, is designed to meet three major goals for the 1990s:

- (a) Environmentally safe combustion of MSW.
- (b) Environmentally safe disposal of MSW residue.
- (c) Production of revenue producing by-products meeting engineering specifications.

A conceptual flow diagram of the integrated ABB system is shown in Fig. 1. This discussion centers on the waste to energy and ash residue treatment portions of the program with the following principal components:

- (a) Separation of metals for reuse prior to combustion.

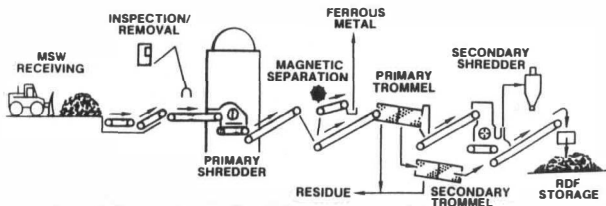


FIG. 2 MUNICIPAL SOLID WASTE PROCESSING SYSTEM — SINGLE LINE

(b) Combustion of organic material with high combustion efficiency followed by flue gas clean up with a state-of-the-art emission control system.

(c) Removal of metals from the bottom ash for reuse and processing/stabilization of the remaining combustion residue (bottom ash plus fly ash).

The ABB integrated solid waste management system uses proven technology.

Currently, ABB has three operating RDF facilities employing essentially identical front-end processing technology and boiler design features. These facilities are: the Mid-Connecticut facility (Mid-CT) in Hartford, Connecticut, with dry scrubber/fabric filter (DS/FF) technology; the Greater Detroit Resource Recovery Facility (GDRRF) facility in Detroit, Michigan, currently with lime addition and electrostatic precipitator (ESP) technology, but in the process of converting to DS/FF; and the Honolulu Resource Recovery Venture facility (H-Power) in Honolulu, Hawaii with dry scrubber/electrostatic precipitator (DS/ESP) technology.

SYSTEM DESCRIPTION

The flow of waste through the waste processing system at an ABB process facility is shown in Fig. 2. The process equipment is arranged to minimize changes in flow direction and material transfer points.

Incoming trucks are weighed and then directed to the MSW receiving area, where the waste is discharged on the receiving building floor. Front-end loaders are used to stockpile and feed process lines and inspect for the presence of nonprocessable items, which are separated for removal.

Studies by Franklin Associates [1] indicate that most of the lead in MSW enters the waste stream from household and lead-acid batteries, or consumer electronics (lead in paints and steel cans has decreased by 90–95% since 1970). Cadmium enters primarily in household batteries, plastics, and consumer electronics, while mercury enters in household batteries, electric lighting fixtures, thermometers, and thermostats.

On the basis of preliminary testing at the Mid-Connecticut facility in 1988–1989, [2] for every 1000 tons of MSW, there is approximately 40 tons of ferrous metal (iron), 780 lb of lead, 5 lb of cadmium, and 2.4 lb of mercury and about 130 tons of noncombustible materials such as glass, ceramics, aluminum, copper, or brass.

Preparation of Nonprocessable Items

MSW is loaded into a feed conveyor by front-end loaders and metered by the feed conveyor onto an inclined steel pan conveyor for leveling. The inclined conveyor carries the waste onto a horizontal, steel conveyor which feeds the primary shredder. Prior to the shredder, a picking station is located along side each horizontal feed conveyor to allow the operator to inspect the waste being transported to the primary shredder and to stop the conveyor and remove nonprocessable items. Nonprocessable items are removed using a hydraulic grapple controlled from a picking station control booth.

Processing of the Waste Stream into RDF

The primary shredder is a flail mill which performs coarse shredding of the waste stream. Closed bags are opened, ferrous metal is exposed, and glass containers are broken. Each primary shredder is enclosed in a reinforced concrete room equipped with a dedicated dust control system consisting of an exhaust fan and fabric filter.

After primary shredding, the waste is conveyed to the ferrous metal separation system consisting of a primary electromagnetic drum and a secondary drum type transfer magnet. The waste is then conveyed to the primary separation unit which is a totally enclosed trommel. Three discharge streams are conveyed from the trommel. One is a process residue stream which consists of small rocks, broken pieces of glass and other items which fall through small holes in the front section of the trommel. The second stream is a sized fraction consisting of small combustible products, aluminum cans, and medium sized noncombustibles. This stream is transported to the secondary trommel. The third stream is an oversized fraction consisting primarily of paper and plastic which is conveyed to the secondary shredder for size reduction.

The secondary trommel further separates the sized fraction received from the primary separation units. The discharge streams consist of:

(a) Process residue consisting of fine sand, glass, dirt, etc., which is conveyed directly to the residue

TABLE 1 MID-CONNECTICUT FACILITY* MATERIAL BALANCE
(July 10-14, 1989)

	MATERIAL BALANCE	ASH	MOISTURE	HHV	% OF BTU'S
MSW	100%	24%	29%	4,288	100%
FERROUS METAL	4%	91%	4%	424	0.4%
PROCESS RESIDUE	13%	35%	37%	2,800	8.1%
RDF	83%	18%	29%	4,706	91.5%

* As tested by the University of Wisconsin

load-out area where further recovery of combustibles may be provided.

(b) A sized fraction which is conveyed to the RDF collection conveyor.

The oversized fraction from the primary separation unit is conveyed to the secondary shredder. The secondary shredder is a high horsepower, horizontal shaft machine with hammers and grates arranged and sized to produce the desired RDF particle size. Hammer and grate shape and size are changeable to control top size and optimum particle size for boiler performance and to accommodate seasonal variations in waste composition. RDF is conveyed to the RDF storage building, where a front-end loader distributes and stockpiles the RDF.

On a weight basis, a material balance for normal operations at the Mid-CT facility is shown in Table 1.

Data from studies conducted at both the GDRRF and the Mid-CT facilities indicate that waste processing to produce RDF results in the removal of mercury, lead, and cadmium bearing components [3]. This, in turn, results in a reduction in potential mercury, lead, and cadmium air emissions generated by combustion, as compared to levels which would have occurred in the absence of processing. This pre-separation also reduces the potential load on the flue gas clean-up system.

The Mid-CT Resource Recovery facility was tested to study the partitioning of heavy metal elements in MSW to aid in improving the quality of the RDF [4]. This limited sampling program conducted by the University of Wisconsin for ABB-RRS resulted in a distribution analysis indicating the following quantities of heavy metals materials diverted from RDF to be combusted at the facility: mercury 53%; lead 59%; chromium 44%; and cadmium 35%. On the basis of these data, it can be seen that presorting and processing of the waste stream can significantly reduce the concentration of metals which must be controlled after the combustion process.

TABLE 2 COMBINED ASH COMPOSITION PER 100 TONS OF MSW

Component	Weight in Tons
Combustibles	2.5
Ash Inerts and Metals	12.0
Lime Added	0.8
Products Scrubbed by Lime	0.8
Moisture	<u>4.9</u>
Total	21.0 Tons

TABLE 3 COMBINED ASH DISTRIBUTION PER 100 TONS OF MSW

Component	Weight in Tons	% of Total
Fly ash	6.3	30
Bottom Ash	<u>14.7</u>	<u>60</u>
Total	21.0 Tons	100

Ash Disposal/Utilization

It has become increasingly difficult to site and obtain permits for waste-to-energy facilities due to issues such as concerns about the public health and environmental impacts of leachates resulting from ash residues. Detoxification, guaranteed stabilization, reuse if safe and practical, and controlled environmental management of ash residues are beginning to play a critical role in the current and future success and public acceptability of such facilities.

Based on Mid-CT and H-POWER performance tests, the average composition of combined ash per 100 tons of MSW is shown in Table 2.

Based on EPA and Environment Canada studies, the split between fly ash and bottom ash is shown in Table 3.

Based on RRS investigations over the past several years, the composition of MSW ash residue is approximately as shown in Table 4.

ABB Resource Recovery in Windsor, Connecticut has a license agreement with Aardelite Holding, BV, in Holland for exclusive use of a patented Aardelite technology in North America to produce light-weight, stabilized aggregate from the combined ash residue re-

TABLE 4 ASH COMPOSITION

65% Minus 3/4" mostly composed of ash fines -3/8" and glass

	% of Total
SiO ₂ Silica Oxide (glass)	57.9
Al ₂ O ₃ Aluminum Oxide	9.7
Fe ₂ O ₃ Iron Oxide	7.1
CaO Calcium Oxide	9.3
MgO Magnesium Oxide	2.2
Na ₂ O Sodium Oxide	6.1
Ignition Loss	2.7
Carbon	1.6
Other	3.4

35% Plus 3/4" mostly composed of friable ash with lesser quantities of metals, glass, and ceramics and unburned pieces of wood, rubber, textile, and paper in the approximate following percentages:

Friable ash, glass, and ceramics	77
Ferrous metal	15
Non-ferrous metal	6
Combustibles	2

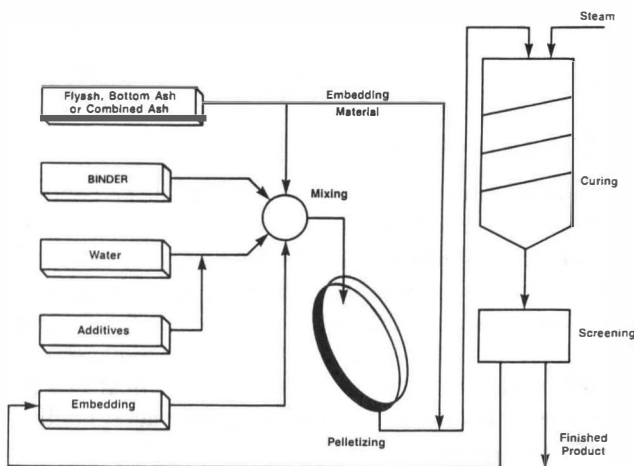


FIG. 3 DIAGRAM OF THE ABB ARTIFICIAL GRAVEL PROCESS FOR CONVERSION OF INCINERATOR RESIDUE TO LIGHTWEIGHT AGGREGATE

sulting from the combustion of municipal solid waste (MSW). The process (Fig. 3) blends the incinerator residue with binder and water (and possibly other constituents) in a mixer. The "green" mixture is then pelletized on a spinning disk pelletizer and dusted with an embedding material to prevent caking. The resulting product is cured in a steam-filled silo.

ABB recently completed a test program, [5] comprised of three phases, in which bottom ash (BA) and baghouse ash (BHA) were collected separately at an RDF fired resource recovery facility. These residues were blended and processed in Holland to make light-weight aggregate pellets and subjected to testing to confirm both their environmental and structural integrity. Specific program objectives were:

(a) Determine the viability of the process for producing pellets from MSW residue.

(b) Determine structural and leaching potential of a range of residue mixtures.

(c) Evaluate the effects of various admixtures.

In addition to bench-scale testing, the test program included a series of four demonstration runs using Aardelite's 3 tons/hr pilot facility.

Results of Bench and Pilot Test Runs

The following discussion compares leaching test results from bench-scale treated artificial gravel production in Holland during November 1988 (Series I), February 1990 (Series II), and April/May 1990 (Series III) and untreated ash samples. More comprehensive leaching test results are also available from four large-scale pilot production runs in April/May 1990 when 3-9 tons of light-weight aggregate pellets were produced in each run.

(a) Leaching studies show that samples of untreated RDF incinerator bottom ash tend to produce leachate which exceeds EPA limits for lead and occasionally may exceed those limits for cadmium. Baghouse ash tends to produce leachate which is above EPA limits for cadmium and may occasionally be above those limits for lead, arsenic, selenium, and mercury (see Table 5).

(b) ABB light-weight aggregate (artificial gravel) prepared from combined ash resulted in reduction of the leachability of heavy metals on the basis of analysis of some 216 test mixtures from three different composite Mid-Connecticut ash collections. Although even lower leachate levels would be desirable, EPA limits were exceeded in only one case when tested by the TCLP procedure. Figures 4-7 show typical fixation of lead, cadmium, and mercury.

(c) Completion of four extended pilot test runs utilizing RDF ash provided sufficient operating data that a viable commercial plant can be designed.

The resulting pellets are suitable for utilization in various products or processes which incorporate gravel. These products weigh only about 60% of their natural gravel counterparts. A second phase of field utilization studies is planned.

TABLE 5 BENCH TEST SERIES I, EP TOX PROGRAM, NOVEMBER 1988
(All Values in ppm)

UNTREATED MATERIALS					ABB ARTIFICIAL GRAVEL (PROCESSED)			
	Baghse Ash (BHA)	Bottom Ash (BA)	BHA/BA Combined 50:50	Dutch Coal Fly Ash (CFA)	EPA Limits	BHA (Avg)	BHA/BA Comb 50:50	BHA/CFA Comb 50:50
Arsenic	2.0 (81)	<0.2 (16)	0.3 (30)	0.5 (290)	5.0 [100]	2.0	2.0	1.0
Barium	6.6 (45)	1.2 (390)	1.6 (315)	0.7 (720)	100.0 [2000]	0.5	0.3	0.4
Cadmium	2.2 (73)	0.1 (8)	0.4 (15)	0.01 (7)	1.0 [20]	0.13	0.08	0.6
Chromium	<0.02 (160)	0.6 (1080)	0.4 (610)	<0.02 (120)	5.0 [100]	0.07	0.05	0.07
Lead	1.5 (5100)	49 (5600)	29 (5800)	0.7 (80)	5.0 [100]	2.0	2.0	2.0
Mercury	0.79 (38)	0.01 (0.8)	0.01 (4.8)	<0.001 (0.2)	0.20 [4]	<0.0 03	<0.003	<0.003
Selenium	0.4 (20)	0.4 (20)	0.7 (20)	0.2 (230)	1.0 [20]	0.8	0.8	0.9
Silver	0.1 (130)	0.1 (230)	0.6 (180)	0.02 (3)	5.0 [100]	0.09	0.1	0.1

() = Concentration available in base material (ppm)

[] = Concentration required in base material to exceed EPA limits if all of the element were extracted

CONCLUSIONS

Review of the analytical data shows that without treatment, incinerator combustion residue may exceed the EPA limits for lead or cadmium and less often be above limits for arsenic, selenium, and mercury. Analyses of the product produced in pilot runs 1, 2, and 4 show that the tendency for leaching of heavy metals on the EPA toxicity list is reduced significantly below the limits. However, in run 3, when no binder was added to the mixture, the product did not meet strength requirements and exceeded limits for several heavy metals. In general, total availability (TA) leaching indicated that excess metals were present, but were stabilized by the Aardelite process. The less aggressive column leaching test procedure resulted in even lower leachate levels for processed pellets as compared to EP or TCLP toxicity test levels in all cases.

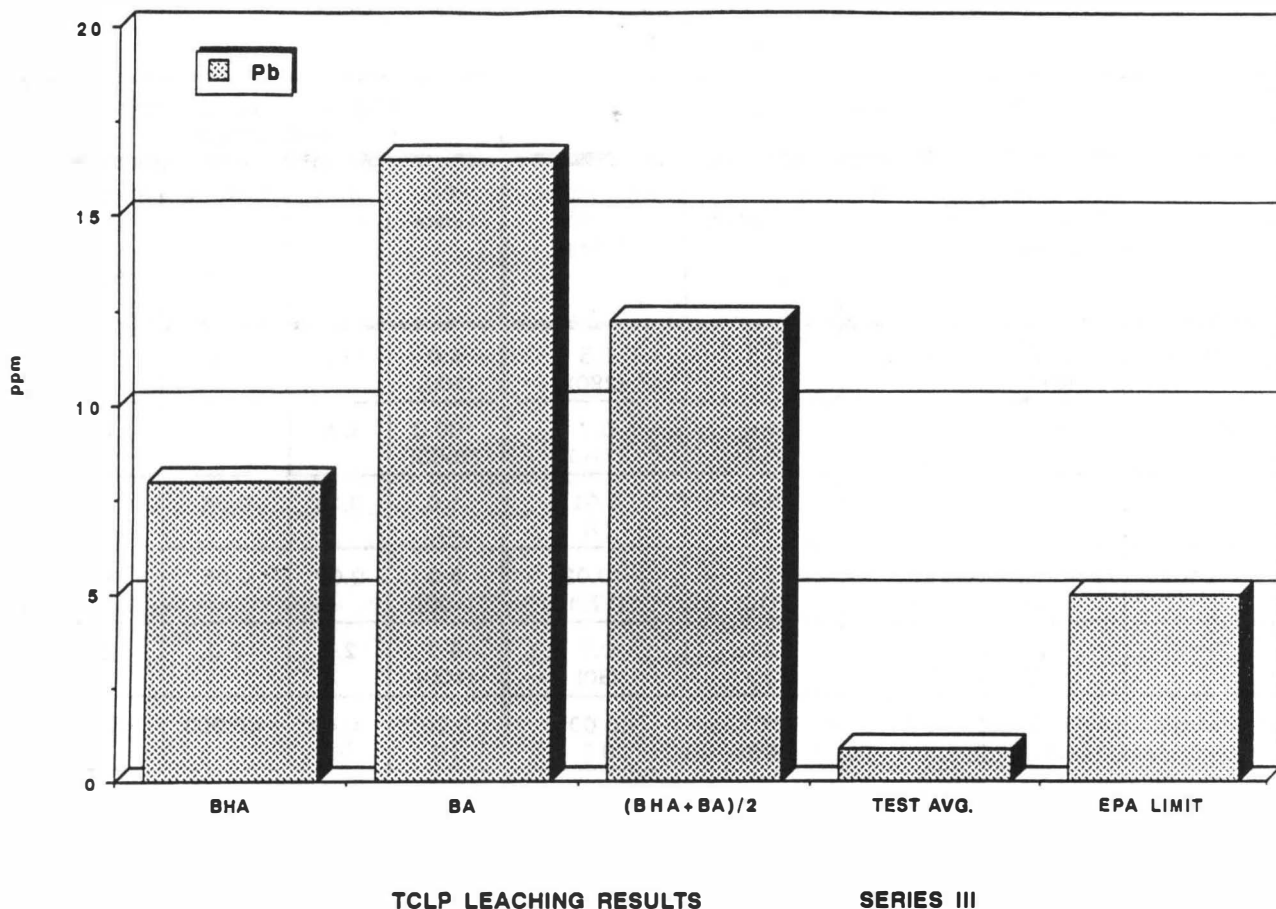
Based on the results of EPA leaching tests on some 216 formulations of artificial gravel produced by the

Aardelite pelletizing process, in which EPA limits were exceeded in only one case, it is concluded that residue from combustion of municipal solid wastes treated by ABB's licensed process with certain admixtures will produce a stable artificial gravel. The process requires initial screening of the bottom ash to remove large noncombustible ceramic and metal components, followed by crushing of the remaining bottom ash residue.

Artificial gravel, produced by this process, is a stable material, with potential for utilization as light weight aggregate in road construction and in formed concrete products. Efforts to apply this technology in certain large scale demonstrations are underway.

REFERENCES

- [1] Artz, N. S. and Franklin, M. A. "Effects of Arranging Municipal Waste characteristics on Combustion Fuel Quality," EPA/



The five columns of data in figures 4 and 5 are identified as:

1. BHA - Raw/Untreated baghouse ash
2. BA - Raw/Untreated bottom ash
3. $\frac{(BHA + BA)}{2}$ - Mathematical averages of 1 and 2
4. Average Test Series III Results
5. EPA Limits

FIGURE 4

AWMA Conference on Municipal Waste Combustion, Tampa, Florida, April 1991.

[2] Boley, G. L. "Partitioning of Elements by Refuse Processing," EPA/AWMA Conference Municipal Waste Combustion, Tampa, Florida, April 1991.

[3] Pierce, G. G. "Controlling Mercury Emissions from RDF Facilities," EPA/AWMA Conference on Municipal Waste Combustion, Tampa, Florida, April 1991.

[4] Ham, R. K. and Hammer, V. A. "Elemental Composition and Partitioning of Metals at Madison and Mid-Connecticut Resource Recovery Plants," University of Wisconsin-Madison, July 1991.

[5] Plumley, A. L. and Boley, G. L. "ABB Ash Treatment Technologies," In *Proceedings of the Third International Conference on Ash Utilization and Solidization*, Arlington, Virginia, November 1990.

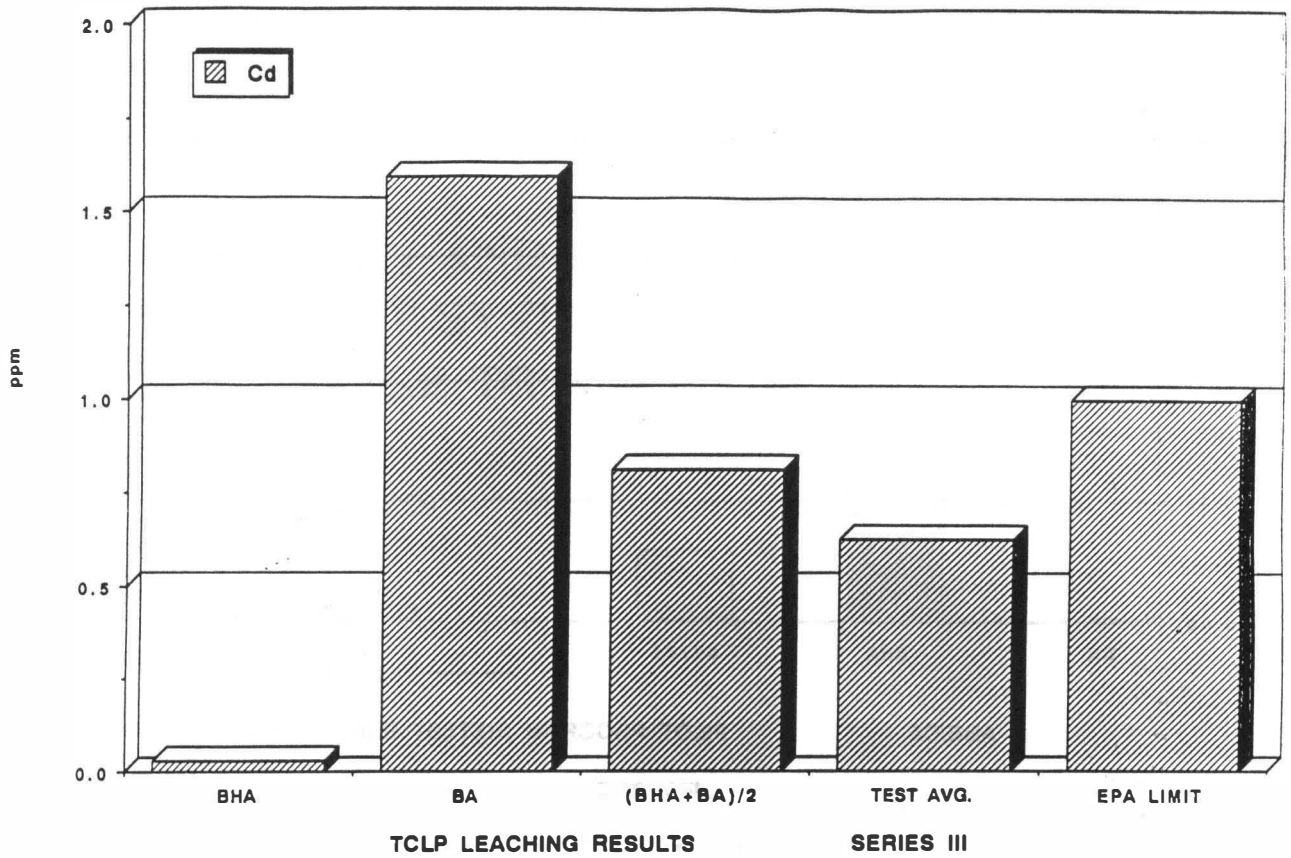


FIGURE 5

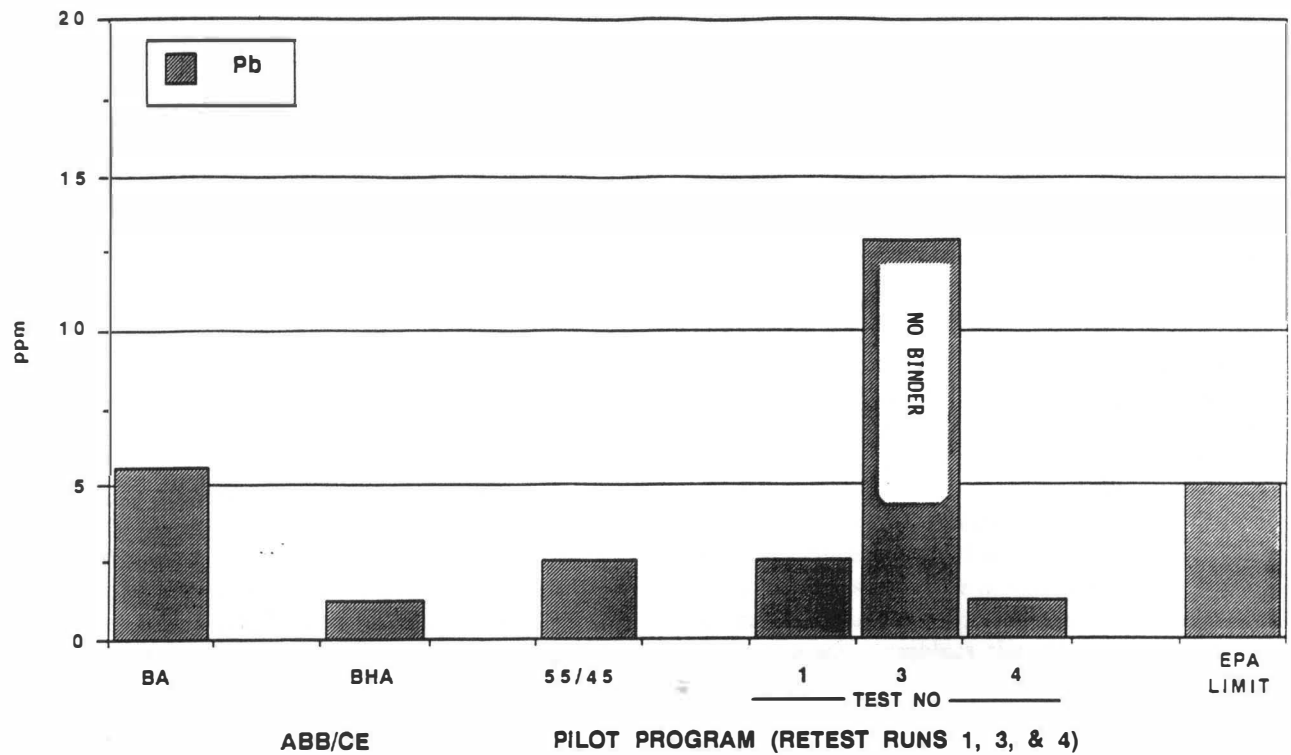


FIGURE 6

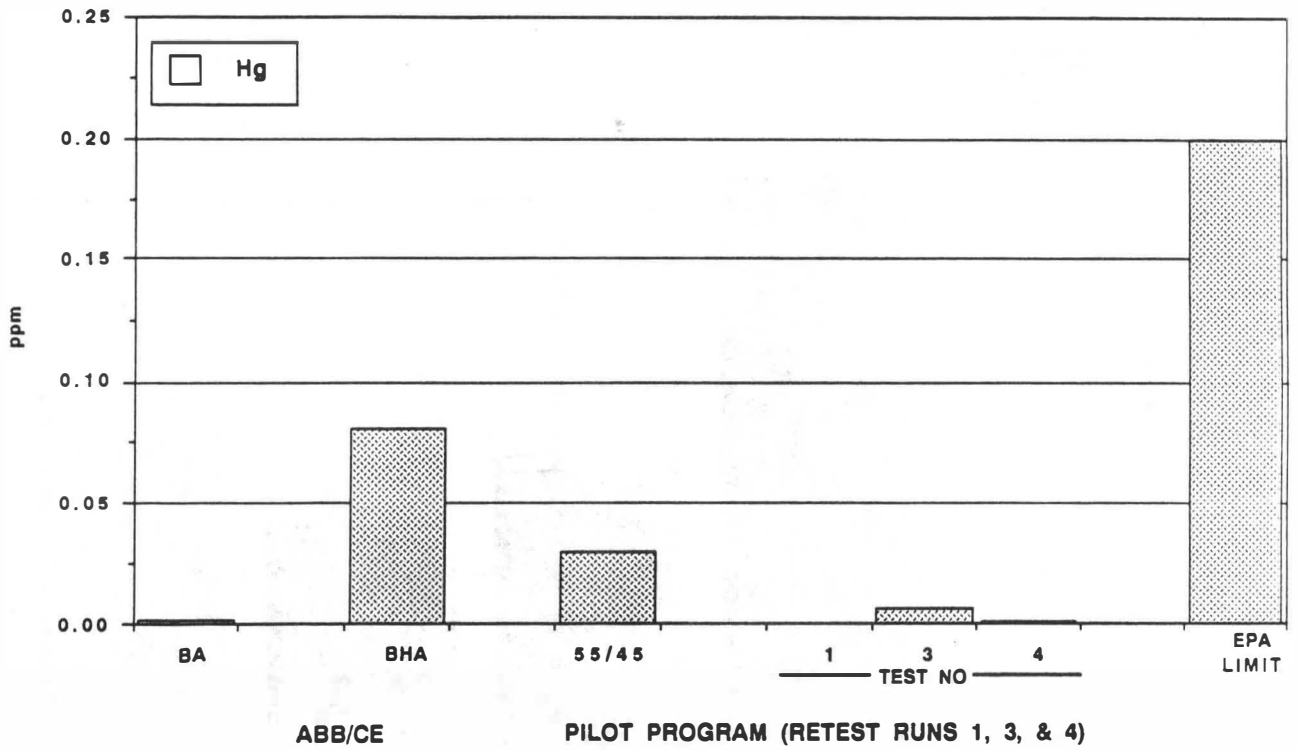


FIGURE 7