

INDUSTRIAL HYGIENE SURVEY REPORT

at

Aluminum Company of America (ALCOA)  
Wenatchee Works  
P.O. Box 221  
Wenatchee, Washington 98801

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## ABSTRACT

An industrial hygiene evaluation was conducted at the Aluminum Company of America (ALCOA), Wenatchee, Washington to ascertain worker exposure to air-borne concentrations of selected polynuclear aromatic hydrocarbons (PAH). Several PAH compounds identified in air pollution studies in selected major cities and in studies of coke oven workers have been shown to induce skin cancer and lung cancer in laboratory test animals. Coal tar pitch, used in fabricating anodes and cathodes, when heated, is the primary source of generation of PAH compounds. At ALCOA, measurement of five selected PAH compounds were made in the carbon plant and the potroom. Results of measurements made for the five PAH compounds and for the benzene soluble fraction of coal tar pitch volatiles are reported.

PURPOSE OF SURVEY: To conduct industrial hygiene survey of employees working in selected aluminum reduction operations to ascertain exposure to selected polynuclear aromatic hydrocarbons.

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## INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is engaged in a study of worker exposure to airborne concentrations of selected polynuclear aromatic hydrocarbons (PAH) in the aluminum reduction industry. Organic materials used in fabricating anodes and cathodes, when heated, are sources of generation of PAH compounds. Several PAH compounds identified in air pollution studies in selected major cities and in studies of coke oven workers have been shown to induce skin cancer and lung cancer in laboratory test animals.

The study is divided into two parts--epidemiology and industrial hygiene. The epidemiologic evaluation is a case-control study of lung cancer mortality using personnel records from 13 aluminum reduction facilities, while the industrial hygiene evaluation will characterize worker exposure to several PAH compounds at four of the 13 plants. A composite report for each part as well as individual industrial hygiene reports for each plant will be written.

This paper is a report of the industrial hygiene evaluation at one of the four facilities--Aluminum Company of America (ALCOA), Wenatchee, Washington. Results of measurements made for five PAH compounds and for the benzene soluble fraction of coal tar pitch volatiles are reported.

## DESCRIPTION OF FACILITY AND WORKFORCE

The ALCOA-Wenatchee Works has been in operation since 1952. Ready access to hydroelectric power was a major consideration in the decision to locate here. Molten aluminum is produced electrolytically in reduction cells--more commonly referred to as pots--which are located in the potroom. Supporting the potroom operation is the carbon plant where the main electrolysis process components (anodes and cathodes) are prepared. The metal castings department casts molten aluminum (obtained from the potroom) into ingots for various applications.

As of the date of this report, approximately 905 people are employed at the Wenatchee Works of which about 727 are production employees. Of these 727, approximately 299 are employed in the potroom and 56 are employed in the carbon plant.

## DESCRIPTION OF OPERATIONS

### General Process Description

ALCOA-Wenatchee uses the prebake electrolytic process as the aluminum reduction method to extract aluminum (Al) from alumina ( $Al_2O_3$ ). In this process, the alumina is dissolved in a molten bath of cryolite ( $AlF_3 \cdot 3NaF$ ) along with other additives, then electrolytically reduced to aluminum by passing electric current from the carbon anode to the carbon cathode which constitutes the inner lining of the pot. (See Figure 1)

The prebake pot is composed of two sections: A substructure which contains the carbon cathode (a bed of carbon blocks with a metal rod inserted through the bed to conduct electricity) material; and a superstructure which contains the prebaked carbon anodes--cured blocks of carbon, with a metal rod inserted into each anode to provide support and conduct electricity. Also considered part of the superstructure are the pot covers, exhaust hooding, material bins, and buss bar. See Figure 1. The electric current--60,000-225,000 amperes at a 5 volt potential--separates the aluminum and oxygen ions. The oxygen liberated combines with carbon contained in the anode to form carbon dioxide. Lesser amounts of carbon monoxide are also formed. The aluminum settles to the bottom of the pot. The molten metal is then periodically syphoned off into a crucible.

### Carbon Plant Operations

Production of the carbon anode blocks and preparation of the carbon cathode for use in the pots constitute major operations at a prebake plant. These activities are performed in the carbon plant. There are three areas of interest in the carbon plant: The anode/cathode preparation areas, the furnace room, and the rodding room.

For the anode preparation, calcined petroleum coke and pelletized coal tar pitch are crushed and discharged into a steam heated mixer where the mix is heated to about 300° F to form a viscous carbon mixture. (In the prebake process, this mixture is referred to as "green mix"). The warm green mix is then conveyed to anode formers where the mix is formed into the shape of the anode block. The anode blocks are then transferred to the furnace room where they are put into a below ground natural gas-fired pit furnace and baked--a 30 day baking and cooling cycle. During baking, the block's mechanical strength and electrical conductivity are improved and, at the same time, the pitch volatiles are driven off and exhausted to a furnace collection system. After the required baking cycle, the now hardened anode blocks are removed from the furnace, inspected and cleaned, and then brought to the rodding room. Here a copper rod is inserted (to provide support and to conduct electricity). Molten cast iron is used to join the rod to the anode block. The anode blocks with copper rods inserted are then brought to the potroom.

Rodding room operations, besides insertion of a copper rod into a newly fabricated and cured anode block include rod straightening, welding, and removing carbon "butts" (unused anode material left on the rod after removal of a consumed anode from the pot) and cast iron from the consumed anode/rod.

For cathode preparation, pre-baked cathode blocks (cured blocks made up of coal tar pitch, petroleum coke, and anthracite coal) which are obtained commercially are placed in the steel shell and cemented together using a coal tar pitch containing cement. The steel shell with cathode blocks (and electrical conducting bar) is then brought to the potroom for installation.

## Potroom Operations

In the potroom the baked carbon anodes are inserted into the pot superstructure. As the carbon anodes are consumed by the electrolytic process, the old anodes are removed and new ones are inserted. (See Figure 1). Replacement of the anodes is "staggered" so that all of the anodes for a given pot do not have to be replaced at the same time--thus allowing for a continuous process. The pots have a limited lifespan and they too must be periodically replaced. This is done, however, much less frequently than is replacement of anodes. The usual procedure is for the new cathode to be installed following entire pot disassembly for refurbishment. (The life of an entire cathode is quite variable ranging from 1000-2000 days. The actual life of a given pot is dependent upon such factors as pot design and pot operations.)

### GENERATION OF PAH COMPOUNDS

The primary source of airborne PAHs in the prebake aluminum reduction process is the coal tar pitch, a constituent of the green mix used in making the anode. Coal tar pitch is also contained in a seam mix used to cement the prebaked cathode blocks together. Coal tar pitch, used as a binder for the aggregates making up the anode, contains a high concentration of PAHs. When heated during preparation of the green mix some of these PAHs will volatilize. When heated during the baking of a new pot (which follows installation of a new cathode), PAHs will be volatilized from the seam mix which contains coal tar pitch. Once airborne, these PAHs may form small particles themselves or may cool and condense onto particulate matter.

### SURVEY OF PLANT

#### A. Description of Exposed Work Groups

There are two production areas of the facility where potential worker exposure to PAH compounds is most likely to occur: the potroom, in which are located the aluminum reduction cells, or pots, and the carbon plant where the anode blocks and cathode are prepared (for subsequent transfer to the potroom).

##### 1. Potroom

Potential exposure to PAH compounds would, under normal pot operating conditions, be minimal. This is because most, if not all, of the PAHs will have been driven from the anode (which were fabricated from coal tar pitch) during its 30 day baking period in the pit furnace. (Furnace baking temperatures are higher than pot operating temperatures.) PAHs volatilizing from the coal tar pitch containing seam cement (joining the cathode blocks) during the initial baking of a new pot will, under normal operating conditions, be captured by the fume hoods contained in the pot superstructure (see later discussion pertaining to exposure control methods). Also, acting to reduce long-term PAH exposure possibly emanating from the seam cement is the period of the initial "burn-in" for a new pot, which ranges from 8 to 24 hours, after which few, if any, PAHs would emanate from the cathode seam cement. The main potential for exposure to PAHs in the potroom would occur as a result of fugitive

PAH emissions from the carbon plant (see following discussion) which may find their way into the potroom.

Exposure groups evaluated in this survey and a brief description of their duties are:

Pot Tender: inspects assigned pots for proper functioning, adjust electrode position above molten bath, and adds bath materials.

Tapper-Carbon Changer: taps measured amounts of aluminum from pots, changes carbon anodes according to schedule, cleans crucibles and siphons.

Craneman - Potroom: operates overhead crane used in transportation of raw materials, carbon anodes, and tapping equipment in the potroom.

## 2. Carbon Plant

Potential exposure to PAH compounds can occur during several activities associated with the carbon plant operations: Paste Mixing--paste constituents are weighed and charged into a steam heated mixer and then dumped into a conveyor (the paste compound is heated to approximately 150°C so as to be homogenized); anode forming--paste mix is emptied into a forming machine which forms anode blocks by vibration; anode baking--anodes are baked in below ground pit furnaces.

Millman - 1st Class: operates grinding, classifying, weighing and mixing equipment to obtain properly sized carbon materials; operated forming equipment which fabricates carbon anodes.

Mixer Operator: operates paste mixer (This job is normally considered as one of the major duties of the Millman - 1st Class. During this evaluation, exposure measurements were made of individuals (classified as Millman - 1st Class) who were performing only mixer operator duties during the sampling period. For information purposes, therefore, a separate job grouping was used and measurements reported separately).

Vibrator Operator: operates anode forming machine. (This job is also normally considered as one of the duties of the Millman - 1st Class. See parenthetical note for Mixer Operator).

Equipment Operator - Potlining: operates mechanized equipment associated with relining electrolytic cells. This would include industrial tractor, overhead bridge type crane, paving breaker, and rock drills.

Furnace Repairman: repairs below ground ring furnaces. Also repairs crucibles and flues.

Furnace Operator: attends and operates ring furnace firing system; monitors and makes corrections to operation of waste gas and regenerator systems.

Packer - Unpacker: loads and unloads carbon electrode (anodes), pot-lining side blocks, and other carbon materials in the furnace.

Carbon Cleaner: operates and monitors baked anode cleaning machines and equipment to convey and store baked anodes.

Craneman - Baked Anode: operates overhead, long span, bridge crane to service the baking furnaces.

Furnace Operator - Rodding Room: operates electromelt furnaces, and is working leader of crew which bonds anode rod assemblies to carbon anodes with molten metal.

Pourer - Rodding Room: pours cast iron into stub hole in anode.

Butt Stripper - Rodding Room: removes unconsumed anode material (carbon butts) from anode rod.

## B. Description of Exposure Control Methods/Use of Personal Protective Equipment

### 1. Potroom

At the time of this evaluation all pots in two potlines were locally exhausted to a dry scrubbing system (The dry scrubbing system uses alumina to absorb fluoride emissions from the pots. This alumina is then recycled--to be used in some of the potlines). All pots in three potlines were locally exhausted to an electrostatic precipitator followed in line by a wet scrubber. When the pot covers were in place over the pot, visual observation indicated that the effectiveness of emissions capture was satisfactory. Capture effectiveness is also enhanced by the crust formation around the edges of the pot (see Figure 1). The crust essentially seals the pot. (The crust, however, must be broken at various times throughout the day to facilitate various pot servicing operations--tapping/carbon changing, and/or addition of raw materials).

Personal protective equipment used in the potroom included coveralls, head covering, safety glasses, safety shoes, and protective gloves.

### 2. Carbon Plant

Paste Mixing: This process is enclosed except during charging and emptying. General ventilation is in operation in the paste mixing area to remove emissions from the mixing operation.

Anode Forming: General ventilation is in operation in the area of the process to remove emissions.

Anode Baking: The underground ring furnaces are locally exhausted to a dry scrubbing system. General ventilation is also in operation in the furnace room.

Personal protective equipment used in the carbon plant--for most operations--included coveralls, head covering, safety glasses, safety shoes, and protective gloves.

PRESENT APPLICABLE OCCUPATIONAL HEALTH STANDARDS/  
THRESHOLD LIMIT VALUES

At the time of this report, there are no occupational health standards for those PAHs addressed in this report--Chrysene, Pyrene, Fluoranthene, Benz(a)Anthracene (BaA), Benzo(a)Pyrene (BaP). These substances are presently classified as a portion of those compounds contained in coal tar pitch volatiles (CTPV).<sup>2</sup> Generally speaking, CTPV refers to volatile matter emitted into the air when coal tar, coal tar pitch, or their products are heated.<sup>2</sup> Besides containing a large quantity of lower molecular weight polycyclic hydrocarbons, CTPV also contain higher weight polycyclic hydrocarbons, the aforementioned PAHs of which are in this group. Polycyclic hydrocarbons known to be carcinogenic are of this larger molecular type.<sup>3</sup> At the time of this report, three of the five PAHs evaluated have been shown to have varying degrees of carcinogenic activity in animals: BaP, strongly carcinogenic; BaA, carcinogenic; Chrysene, uncertain or weakly carcinogenic.<sup>1</sup> In 1967, the American Conference of Governmental Industrial Hygienists (ACGIH), through its Threshold Limits Value (TLV) Committee, recommended an exposure limit for CTPV of 0.2 milligrams of benzene soluble components of CTPV per cubic meter of air ( $\text{mg}/\text{M}^3$ ). This limit applies to a time-weighted average (TWA) concentration for a normal 8 hour work day or 40 hour work week. Only particulate volatiles which are soluble in benzene are included in this level. The Committee stated that since no safe limit of exposure could be established for carcinogens, and due to the instability in the composition of volatiles from coal tar pitch, this exposure limit should minimize exposure to carcinogenic substances contained in the volatiles. The Occupational Safety and Health Administration (OSHA), at its creation in 1970, adopted this 1967 ACGIH recommendation as an occupational health standard. The current standard is 0.2  $\text{mg}/\text{M}^3$ .<sup>3,5</sup>

The application of the standard for coal tar pitch volatiles to the aluminum reduction prebake process for the purpose of determining the degree of hazard to exposed workers must, however, be done with discretion. Certain processes in the prebake operations give rise to generation of benzene soluble substances other than those benzene soluble substances associated with CTPV. Most evident are the activities in the carbon plant--paste mixing, anode forming, and rodding room processes, the mechanical operations of which can generate oil mist--from the oil used to lubricate moving parts. Additionally, decomposition products of lubricating oil--from oil contact with heat generating processes/parts--can be present. Sources include compressed air used for automatic pot feeders and siphoning metal from pots (compressor lubricating oil is volatilized during compression), hot anode clamps that are regularly oiled, and cranes and vehicles which require lubrication of heated parts. Also, in the furnace room, employees may be exposed to the products of combustion of natural gas which is used to fire the ring furnaces. Oil mist, decomposition products of lubricating oil, and products of combus-

tion of natural gas contain, among other constituents, benzene soluble aliphatic compounds. These aliphatic compounds are not considered to present the same type of hazard as do the volatiles. Therefore, inclusion (usually unavoidable) of aliphatic contaminants in the determination of the benzene soluble fraction would tend to overstate the hazard potential arising from benzene soluble volatiles. Therefore, interpretation of benzene soluble data for this pre-bake process should be made with the aforementioned consideration in mind.

#### SAMPLING AND ANALYTICAL METHODS

Personal breathing zone samples were collected in the potroom and carbon plant for measurement of exposure to the benzene soluble fraction (BSF) of total particulate material (BSFTPM), to the BSF of vapor material (BSFVM), and to five PAHs--Chrysene, Pyrene, Fluoranthene, BaA, and BaP. Measurements were made for both particulate (PPAH) and vapor (VPAH) forms of these five PAHs.

##### 1. Benzene Soluble Fraction (BSF), PAH Compounds

The sampling train consisted of a filter cassette housing a glass fiber filter and a 0.8 um pore size silver membrane filter to capture the particulate phase, followed by a glass tube containing porous polymer sorbent to capture the vapor phase. Sample flow rate was 1.5 liters per minute (lpm). The glass fiber and silver membrane filters and porous polymer sorbent were analyzed separately for BSF according to NIOSH P&CAM 217.<sup>6</sup> The portion of the sample extract remaining after the solubles analysis was analyzed for the five PAH compounds using reverse-phase high performance liquid chromatography according to NIOSH P&CAM 206. (Addendum: Primarily as a result of the NIOSH evaluations conducted in the aluminum reduction industry--to characterize employee exposure to PAHs--the analysis of the porous polymer sorbent for the BSF--which would be indicative of exposure to BSFVM--has been discontinued by NIOSH. This was because porous polymer was found to have an inherently high and variable "background" content of benzene soluble material. (Average background for porous polymer: 0.05 milligrams of benzene soluble material per sample.) This made it difficult to determine the quantity of benzene soluble material--present on the porous polymer--which could be attributed solely to conditions of the work environment. Analyses of porous polymer for specific PAHs does continue. Excessive and variable "background" content on the porous polymer of the five PAHs have not been uncovered. (Background content on the porous polymer of the five PAHs, with few exceptions: less than the limit of detection of the analytical instrument)).

#### RESULTS AND DISCUSSION

Table 1 shows the individual sample results for exposure to the BSF and to five specific PAH compounds. The upper value in each cell shows the value for the particulate analysis (BSFTPM, PPAH), while the lower value shows the value for the vapor analysis (BSFVM, VPAH). Table 2 is the summary of exposure to the BSF by job title. (Addendum: For reasons indicated previously

the analysis of the porous polymer sorbent for the BSF is no longer conducted. Values for this analysis are, nevertheless, reported (BSFVM) in the interest of depicting exposures--to BSFVM--determined by state of the art analytical methods which existed at the time of this evaluation. Values listed for the BSFVM may not, however, be indicative of employee exposure).

Referring to Table 2, geometric mean\* of potroom workgroups to BSF of particulate material (BSF TPM) ranged from 0.06 mg/M<sup>3</sup> for the Pot Tender and Potroom Craneman to 0.13 mg/M<sup>3</sup> for Tapper/Carbon Changer. For carbon plant workgroups, geometric mean exposure to BSF TPM ranged from 0.08 mg/M<sup>3</sup> for the Bake Craneman to 0.18 mg/M<sup>3</sup> for the Millman - 1st Class group. As noted previously, those carbon plant workgroups which were evaluated may be exposed to benzene soluble substances other than benzene soluble substances associated with CTPV, which depending upon the specific workgroup, would include certain components of the oil mist, decomposition products of lubricating oils, and certain products of combustion of natural gas. Assuming this to be the case to some degree, exposure of these groups to the hazardous components of the BSF is probably less than the reported value. For those potroom workgroups evaluated exposure values for BSF should reflect actual exposure to the hazardous components, since operation using or generating non-CTPV benzene soluble substances were not observed to be, at the time of the survey, in the immediate area.

Analysis of the BSF TPM extract for the five PAH substances (PPAH) indicated that for most workgroups (with the exception of several employees of the Millman - 1st Class workgroup and several employees in the Bake Carbon workgroup), are near or below the limit of detection of the analytical instrument. Because of the vast majority of values (greater than 50%) were below the limit of detection, a valid statistical workup of the data could not be performed.

Analysis of the BSFVM extract for the vapor phase of the five PAHs (VPAH) indicated that exposure values for all measured VPAHs (with exception of pyrene and fluoranthene) for most workgroups (with the exception of several employees in the Millman - 1st Class workgroup) are near or below the limit of detection of the analytical instrument. Detectable levels of VPAHs pyrene and fluoranthene (compared to the other three VPAHs) were found for several employees in the Millman - 1st Class workgroup and for several employees in the Pot Tender workgroup. From an occupational health viewpoint, however, the significance of values from vapor analyses has yet to be determined. (In animal studies conducted by several investigators, purified PNA compounds, one such compound being BaP, have produced tumors of the tracheobronchiolar tree or lung parenchyma only when absorbed onto particulates and injected below the larynx.<sup>1</sup>) At this time, vapor values are not incorporated in the CTPV standard. Measurements of the vaporous phase were made and results were obtained to provide an indication of worker exposure to presumably vapor volatiles and vaporous PAHs--both of which are not accounted for under the present CTPV standard.

\*Occupational environmental data has been shown by several investigators to follow a log-normal distribution. For this distribution, the measure of central tendency is the geometric mean.

## CONCLUSIONS

Measurement of exposure of most work groups in the potroom and carbon plant to five PAH compounds indicated, with few exceptions concentrations of the particulate phase of all five PAHs were near or below the limit of detection of the analytical instrument. Detectable concentrations of the vapor phase of two of the five PAHs--pyrene and fluoranthene--were found for several workgroups.

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ELEVATION VIEW: PREBAKE REDUCTION CELL

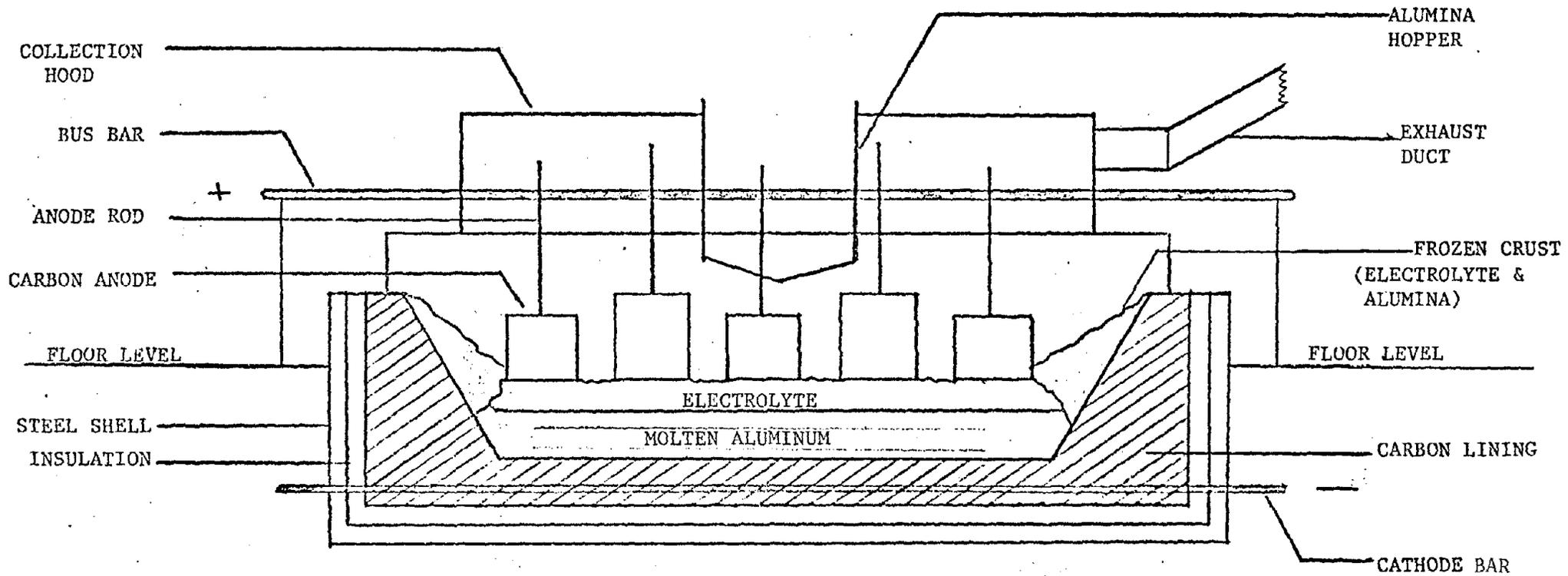


FIGURE I

TABLE 1

Sampling/Exposure Data for Benzene Soluble Fraction,  
Polynuclear Aromatic Hydrocarbon

Filter #	Date (1978)	Sample Time Min.	Air Volume M <sup>3</sup>	Job #	Description	Benzene Soluble Fraction mg/M <sup>3</sup>	Chrysene ug/M <sup>3</sup>	Pyrene ug/M <sup>3</sup>	Fluoranthene ug/M <sup>3</sup>	Benz (a) Anthracene ug/M <sup>3</sup>	Benzo(a) Pyrene ug/M <sup>3</sup>
AC-14	8-22	286	0.40	11	Pot Tender	0.25	<0.37	<0.73	0.29	<0.29	<0.15
						<0.07	<0.23	0.67	0.79	0.20	<0.14
AC-6	"	386	0.58	"	" "	0.03	<0.17	<0.35	<0.13	<0.092	0.06
						0.04	<0.18	<0.63	<0.23	<0.15	<0.10
P2-15	8-23	395	0.59	"	" "	0.12	<0.17	<0.34	<0.07	<0.08	<0.02
						0.13	<0.18	<0.63	0.64	<0.15	<0.10
P2-16	"	398	0.60	"	" "	0.15	<0.17	<0.34	<0.07	<0.08	<0.02
						0.16	<0.18	<0.62	0.65	<0.14	<0.10
P2-12	"	426	0.64	"	" "	0.15	0.38+	<0.31	<0.06	0.41	0.44+
						0.18	<0.16	1.30	1.00	<0.14	<0.09
P3-9	8-24	379	0.57	"	" "	<0.04	<0.20	<0.42	<0.09	<0.17	<0.09
						0.13	<0.32	<0.63	0.36	<0.31	<0.19
P3-8	"	362	0.54	"	" "	<0.04	<0.21	<0.43	<0.09	<0.17	<0.09
						0.11	<0.33	<0.65	<0.25	<0.32	<0.20
P3-6	"	425	0.64	"	" "	0.03	<0.19	0.58	0.23	<0.16	<0.08
						0.06	<0.16	<0.32	0.29	<0.14	<0.09
P3-5	"	431	0.65	"	" "	0.06	<0.19	<0.38	<0.08	<0.15	<0.08
						0.04	<0.16	<0.32	0.21	<0.13	<0.09
AC-11	8-22	370	0.56	14	Tapper/ Carbon Changer	1.23	<0.18	<0.36	<0.07	<0.08	<0.07
						0.11	<0.18	<0.64	<0.25	<0.15	<0.11

Notes: Upper value in each cell represents particulate analysis  
Lower value in each cell represents vapor analysis

+ Non-resolved interferences possibly present

## Limits of Detection:

Benzene soluble: 0.02 mg/sample

Chrysene: 5.0 ug/sample (1 ul injection)

Pyrene: 10.0 ug/sample (1 ul injection)

Fluoranthene: 2.0 ug/sample (1 ul injection)

Benz(a)Anthracene: 2.0 ug/sample (1 ul injection)

Benzo(a)Pyrene: 1.0 ug/sample (1 ul injection)

TABLE 1

Filter #	Date (1978)	Sample Time Min.	Air Volume M <sup>3</sup>	Job #	Description	Benzene Soluble Fraction mg/M <sup>3</sup>	Chrysene ug/M <sup>3</sup>	Pyrene ug/M <sup>3</sup>	Fluor-anthene ug/M <sup>3</sup>	Benz (a) Anthracene ug/M <sup>3</sup>	Benzo(a) Pyrene ug/M <sup>3</sup>
P2-10	8-23	432	0.65	14	Head Tapper/ Carbon Changer	0.08	<0.15	<0.31	<0.06	<0.07	0.08+
						0.21	<0.16	<0.60	<0.31	<0.13	<0.09
P2-13	"	335	0.50	"	Tapper/ Carbon Changer	0.096	<0.19	<0.38	<0.08	<0.09	<0.06
						0.25	<0.20	<0.68	0.50	<0.17	<0.12
X-2	8-24	460	0.69	"	" "	0.03	<0.17	<0.36	<0.07	<0.14	<0.07
						0.06	<0.29	<0.57	<0.21	<0.29	<0.17
P3-1	"	460	0.69	"	" "	0.03	<0.17	<0.36	0.15	<0.14	<0.07
						0.03	<0.14	<0.29	0.70	<0.12	<0.09
AC-15	8-22	434	0.48	15	Craneman-Potroom	0.21	<0.33	<0.67	<0.14	0.24	<0.14
						0.11	<0.21	<0.40	<0.19	<0.17	<0.12
AC-12	"	346	0.52	"	" "	0.04	<0.18	<0.38	<0.08	<0.09	<0.08
						0.11	<0.19	<0.66	0.39	<0.16	<0.12
P2-11	8-23	424	0.64	"	" "	0.03	<0.16	<0.31	<0.06	<0.07	<0.03
						0.12	<0.16	<0.60	1.40	<0.13	<0.09
AC-1	8-22	419	0.63	21	Millman-1st Class	0.22	3.00	5.30	5.10	4.40	2.50
						0.13	<0.17	<0.61	0.77	<0.14	<0.10
AC-2	"	417	0.63	"	" " "	0.17	2.00	5.30	5.40	2.90	1.60
						0.10	<0.17	1.30	2.00	<0.14	<0.10
P2-1	8-23	251	0.38	"	" " (Mixer Operator)	0.21	0.86+	<0.44	0.35	1.20	0.50+
						0.35	<0.24	<0.76	0.63	<0.20	<0.14
P2-2	"	438	0.57	"	" " (Vibrator Operator)	0.20	0.96	0.48	0.77	1.70	1.23
						0.10	<0.18	1.60	4.70	<0.14	<0.10

## Notes:

\*\*Parallel Samples. The sample designated as 'x' was not included in the preparation of the Table 2 Exposure Summary.

TABLE 1

Filter #	Date (1978)	Sample Time Min.	Air Volume M <sup>3</sup>	Job #	Description	Benzene Soluble Fraction mg/M <sup>3</sup>	Chrysene ug/M <sup>3</sup>	Pyrene ug/M <sup>3</sup>	Fluor-anthene ug/M <sup>3</sup>	Benz (a) Anthracene ug/M <sup>3</sup>	Benzo(a) Pyrene ug/M <sup>3</sup>
* X-1	8-24	443	0.66	21	Millman-1st Class (Vibrator Operator)	0.14	1.10	<0.30	0.24	1.20	0.47
						0.06	<0.15	3.10	2.70	<0.12	<0.09
* P3-16	"	443	0.66	"	" "	0.11	1.10	<0.30	0.22	1.10	0.52
						0.15	<0.15	1.40	0.46	<0.12	<0.09
* X-3	"	394	0.61	22	Potliner (Equip. Operator)	<0.03	<0.19	<0.40	<0.08	<0.15	<0.08
						0.04	<0.31	<0.60	<0.22	<0.30	<0.19
* P3-4	"	394	0.59	"	" "	0.03	<0.19	<0.41	<0.08	<0.16	<0.08
						0.08	<0.18	<0.35	0.18	<0.15	<0.10
AC-7	8-22	380	0.57	23	Furnace Repair	0.12	0.31	2.90	0.55	0.27	0.13
						0.19	<0.18	<0.64	<0.24	<0.15	<0.11
P2-6	"	399	0.52	"	Furnace Operator-Bake Carbon	2.12	<0.19	<0.38	<0.17	0.33	0.13
						0.14	<0.19	<0.71	<0.38	<0.16	<0.12
P2-3	8-23	416	0.62	"	Packer-Unpacker	0.06	<0.16+	<0.32	0.16	0.20	0.10+
						0.10	<0.17	<0.61	<0.32	<0.14	<0.10
AC-5	8-22	390	0.58	"	" "	0.12	<0.17	0.81	0.27	0.12	<0.07
						0.08	<0.18	<0.63	<0.23	<0.15	<0.10
P3-17	8-24	424	0.64	"	" "	0.06	0.57	0.78	0.85	0.71	0.07
						0.04	<0.16	<0.60	0.30	<0.14	<0.09
P3-19	8-24	420	0.63	"	Carbon Cleaner	0.06	0.39	0.80	0.48	0.47	0.12
						0.10	<0.16	<0.60	0.22	<0.14	<0.10

## Notes:

\*\*Parallel Samples. The samples designated as "X" were not included in the preparation of the Table 2 Exposure Summary.

TABLE 1

Filter #	Date (1978)	Sample Time Min.	Air Volume M <sup>3</sup>	Job #	Description	Benzene Soluble Fraction mg/M <sup>3</sup>	Chrysene ug/M <sup>3</sup>	Pyrene ug/M <sup>3</sup>	Fluor-anthene ug/M <sup>3</sup>	Benz (a) Anthracene ug/M <sup>3</sup>	Benzo(a) Pyrene ug/M <sup>3</sup>
AC-4	8-22	393	0.59	23	Craneman-Bake	0.06	0.29	<0.62	0.35	0.31	0.09
						0.10	<0.18	0.75	0.32	<0.15	<0.10
AC-8	"	377	0.57	"	" "	0.06	<0.18	<0.35	0.12	0.11	<0.07
						0.11	<0.18	<0.64	<0.24	<0.15	<0.11
P3-21	8-24	402	0.60	"	" "	0.17	0.50	<0.33	0.22	0.69	0.30
						0.10	<0.17	<0.62	0.30	<0.14	<0.10
P2-4	8-23	395	0.51	"	" "	0.07	0.25+	<0.38	0.18	0.27	0.15+
						0.05	<0.19	<0.72	0.28	<0.16	<0.12
P2-7	"	285	0.43	24	Furnace Operator-Rodding Room	0.15	<0.21	<0.42	<0.08	<0.01	0.04+
						0.09	<0.22	<0.72	<0.41	<0.19	<0.13
P2-8	"	387	0.52	"	Pourer-Rodding Room	0.096	<0.19	<0.38	<0.13	0.12+	0.07+
						0.12	<0.19	<0.70	<0.38	<0.16	<0.12
P3-20	8-24	361	0.54	"	Butt Stripper-Rodding Room	0.09	<0.18	<0.36	<0.07	<0.08	<0.07
						0.14	<0.18	<0.65	<0.25	<0.16	<0.11

TABLE 2

## EXPOSURE SUMMARY: Benzene Soluble Fraction

Job Description	Benzene Solubles		
	No. Sam.	Geo. Mean mg/M <sup>3</sup>	Range mg/M <sup>3</sup>
Pot Tender	9	0.06	0.02-0.25
	9	0.08	0.03-0.18
Tapper/Carbon Changer	4	0.13	0.03-1.23
	4	0.11	0.03-0.25
Craneman Potroom	3	0.06	0.03-0.21
	3	0.11	0.11-0.12
Millman - 1st class	5	0.18	0.11-0.22
	5	0.15	0.10-0.35
Bake 1 Carbon	6	0.14	0.06-2.12
	6	0.10	0.04-0.19
Craneman - Bake	4	0.08	0.06-0.17
	4	0.09	0.05-0.11
Anode 2 Assembly	3	0.11	0.09-0.15
	3	0.11	0.09-0.14

Notes: Upper value in each cell represents particulate analysis  
Lower value in each cell represents vapor analysis

1 Group includes Furnace Repair, Furnace Operator, Packer-Unpacker, Carbon Cleaner

2 Group includes Furnace Operator-Rodding Room, Pourer-Rodding Room, Butt Stripper-Rodding Room