DOCKET NO. 40-6940

Health Physics Report #1

to the

Kawecki Chemical Company
Boyertown, Pa.

RESULTS OF HEALTH PHYSICS SURVEYS DURING
THE FIRST SIX MONTHS OPERATION OF
KAWECKI CHEMICAL COMPANY PLANT
IN READING, PA.

April through September 1967

INTRODUCTION

In October of 1966, Mr. Robert A. Gustison, Manager of Chemical Processing for Kawecki Chemical Co., authorized Applied Health Physics, Inc. to serve as health physics consultants in connection with his firm's processing of tin slags containing trace amounts of thorium. The concentration of thorium ranges from 0.2 - 0.3% by weight in the tin slag as unwanted contaminates. Kawecki purchases these slags from various sources throughout the world for recovery of rare metals (e.g. tantalum and columbium.) The slags are shipped to a storage location in Baltimore, Maryland.

LICENSING

In January 1963 Kawecki Chemical Co. filed an application with the U. S. Atomic Energy Commission requesting issuance of a Source Materials License authorizing storage at the B-11 Yard, Canton Railroad Storage Yards in Baltimore. A.E.C. Source Materials License #STC-681 was issued January 21, 1963, which provided only for storage of the tin slags at Boyertown, Pa., rather than in Baltimore. This license was amended on June 21, 1963 to permit storage of 12,500 long tons in Baltimore; then it was amended again to permit 100 tons to be shipped to the Vanadium Corporation of America's (VCA) plant in Cambridge, Ohio for experimental processing as ordered by Kawecki.

Applied Health Physics was hired in August of 1965 to serve as health physics consultants to VCA. In September and December of 1965 Applied Health Physics (AHP) filed an application for renewal and an

amendment in the Source Materials license for VCA to increase the authorized amount of source material at their plant and to permit pilot-scale processing of the tin slags. VCA's license #STB-850 was amended as requested by Dr. R. J. Augustine of Applied Health Physics.

AHP conducted several radiological surveys during VCA's prototype plant operations for Kawecki in 1965 involving the processing of the tin slags in an electric arc furnace. The results of air sampling were all below permissible levels and the radioactive contamination levels were well within acceptable limits. The results of these health physics surveys for VCA were transmitted to Mr. Gustison as part of Kawecki's contract with VCA and served as a basis for the health physics program for the development of Kawecki's processing operations at Reading, Pa.

After thoroughly reviewing the results of the plant study at VCA, Kawecki Chemical decided to lease a large portion of a plant in Reading, Pa., formerly occupied by the American Chain and Cable Co. See Figures 1 and 2.

Prior to leasing these facilities, Mr. Gustison and R. Gallaghar made a thorough evaluation of this site and agreed that it was acceptable for processing of the tin slags. Thus, a change in the Source Materials License #STB-849 was requested on January 10, 1967 to permit metallurgical processing of the tin slags at the new location in Reading, Pa. The metallurgical operations were patterned after those at VCA and were to be monitored by Applied Health Physics to determine what additional safeguards, if any, were needed to comply with accepted health physics standards and applicable regulations.

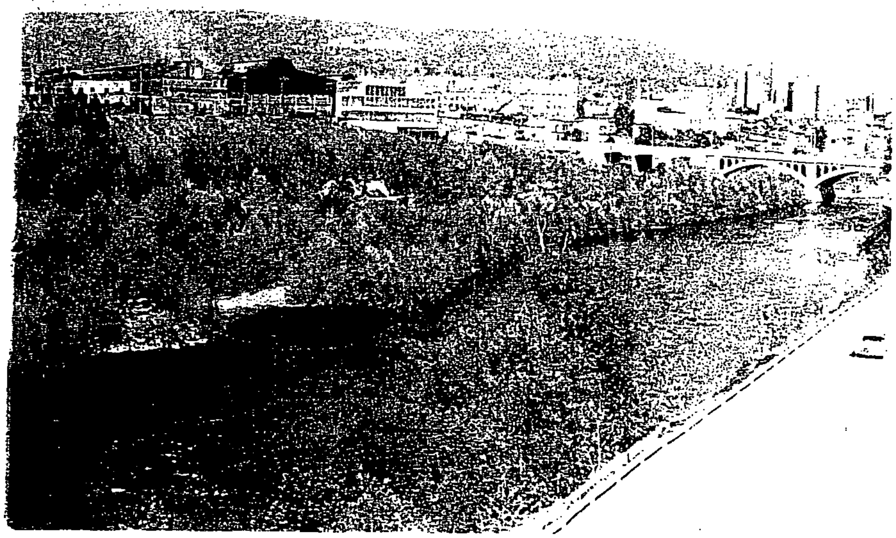

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FIGURE 1 Kawecki Chemical Company's Reading, Pennsylvania, plant looking east from the railroad bridge which spans the Schuylkill River. Kawecki occupies the first two buildings to the left of the large black building. Downtown Reading can be seen at the far right.

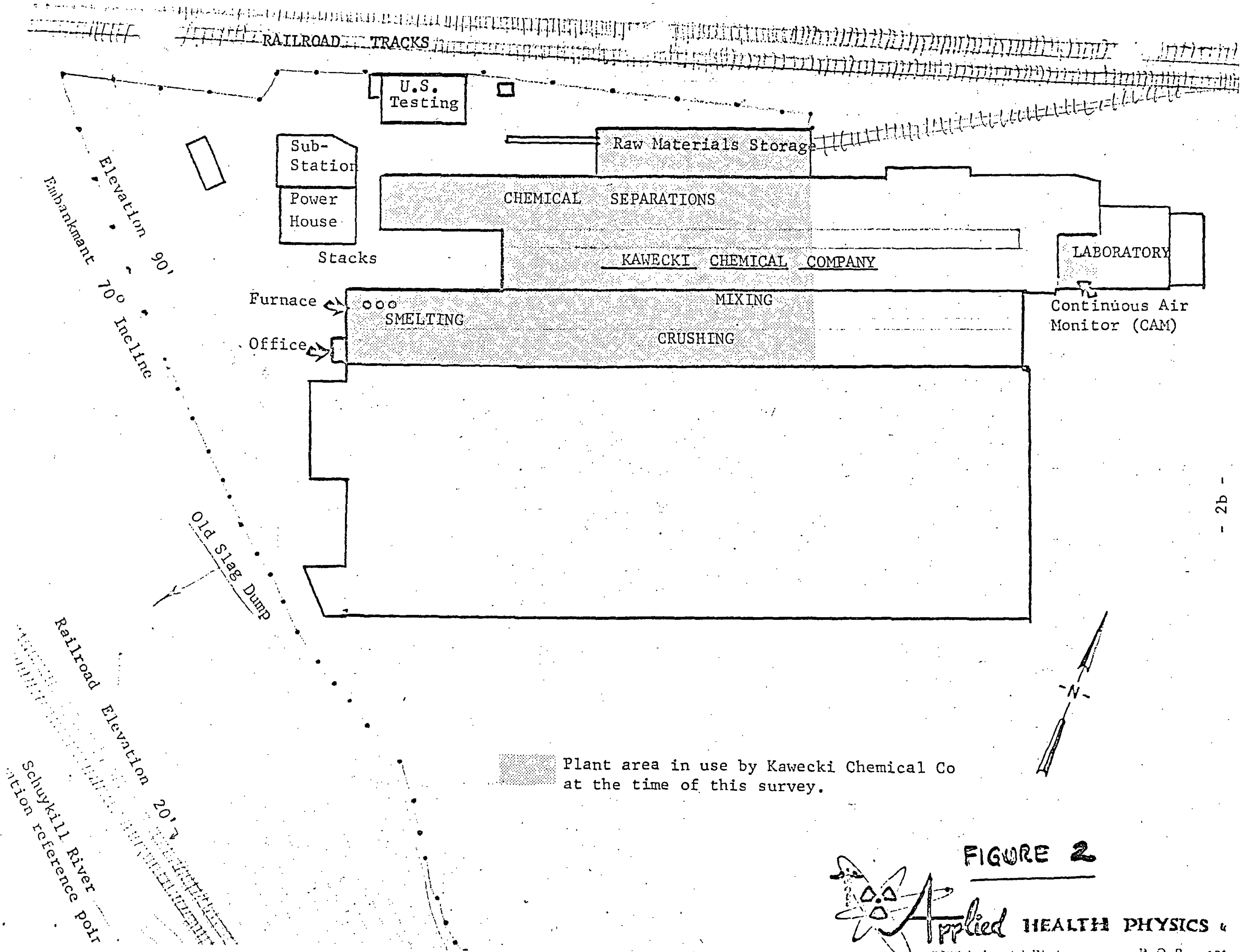

FIGURE 2

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A new Source Materials license - #SMB-920 - was issued March 17, 1967 authorizing up to 30,000 tons of tin slag containing up to 0.2% thorium and 0.05% natural uranium. This license expires September 30, 1967. Application for extension of this license was made by Mr. Gustison, and a 30 day extension has been received.

Upon receipt of the AEC license, orders were given for the transfer of the tin slags to Reading and in April we began our first sampling of the initial processing of the tin slags. Although the planning of the operations had been carefully conceived and thoroughly reviewed by competent technical personnel, there have been a number of unexpected difficulties that have delayed the construction and operation of the plant as planned. These delays have prevented the health physics surveys of certain phases of the operations.

DESCRIPTION OF PROCESSING OPERATIONS

The tin slags are shipped by rail from the storage location in Baltimore to Kawecki Chemical Company's plant in Reading, Pa. The railroad cars are unloaded inside the Raw Materials Storage Area shown in Figure 2. Vibrators are used to dislodge the tin slags from the gondola cars into large concrete storage bins and to assist in the flow of the fine slags into various conveyors that transfer the slag from the bins to the mixing area.

The tin slags consist of glassy flakes, 6 mesh by down, with less than 2% below 100 mesh. The slag contains 0.11-0.29% thorium as ThO_2 and about 0.02% uranium as U_3O_8. Table 1 and Figure 3 show the gamma spectra as obtained on a 4" NaI crystal low background 400 channel TMC analyzer.

REPORT OF

GAMMA RAY SPECTROMETRY ANALYSES

TABLE I

of Samples for

Kawecki Chemical Company
Reading, Pa.

Sample Number	Sample Description	Weight (gms.)	Counts Minus Background per 60 gms. Channels 20-199	20-159	120-159	% Thorium *
0	Thorium reference standard *	60	72,777	64,820	6,585	1.63 *
K-419-1	Non-magnetic slag	62.3	12,332	11,369	815	0.20-0.27
K-419-2	Tin slag	61.2	13,043	12,024	855	0.21-0.29
K-419-3	Slag	28.7	58	66	2	< 0.002
K-419-4	Slag	39.2	10,002	9,225	656	0.16-0.22

* Thorium concentration (% by weight) as determined chemically in this 60 gram sample was used as the basis for comparison of the gamma radioactivity of all samples using a 400 channel gamma ray spectrometer with a 4" Na I crystal. No corrections have been made for gamma ray absorption within the samples.

Collected : 4/18 - 20, 1967 by R. G. Gallaghar
Analyses : 5/14 - 16, 1967 by S. Yaniv
Reported : 5/31/67 by R. G. Gallaghar

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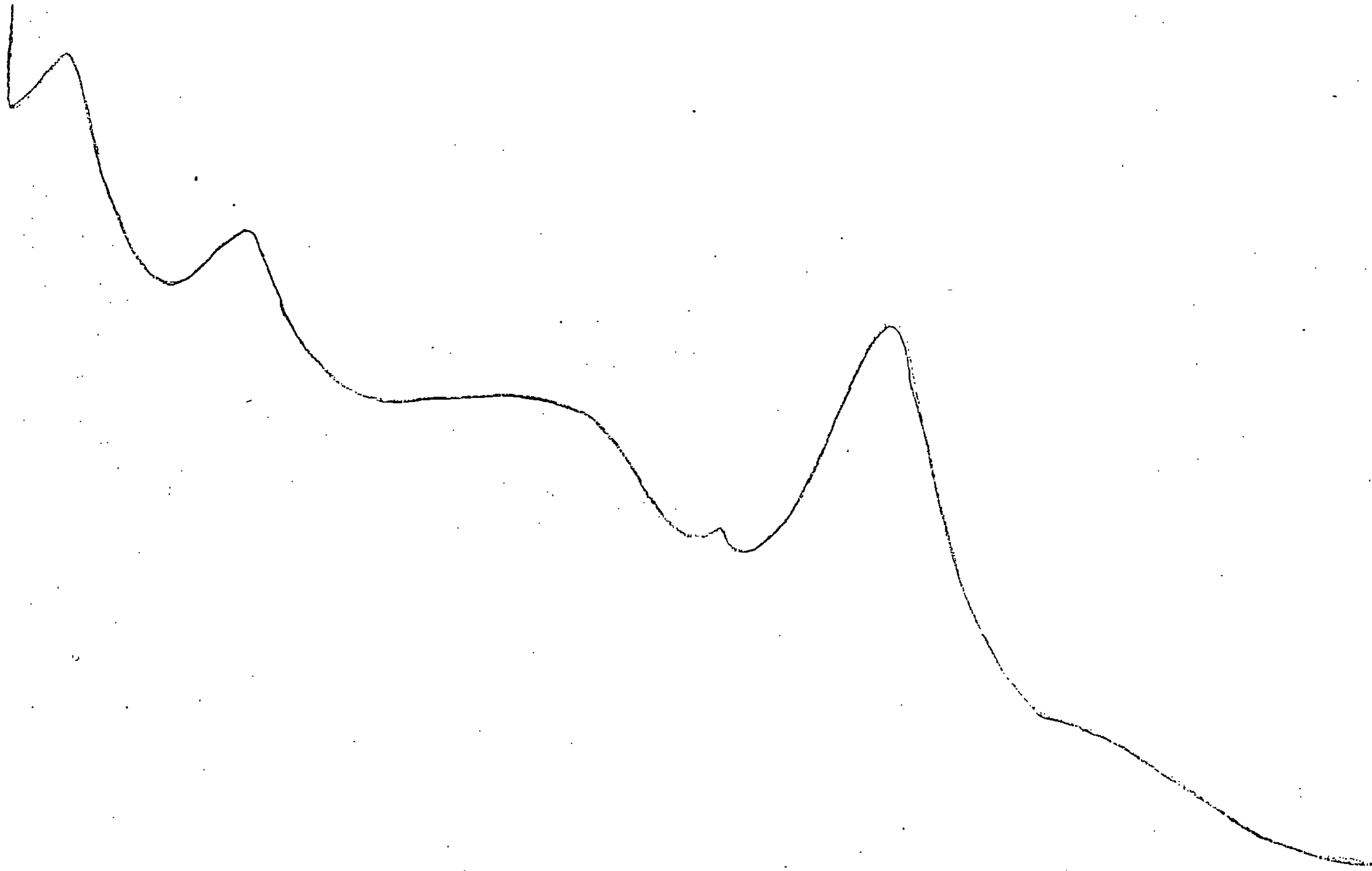


FIGURE 3 Gamma Spectra of Tin Slag

See Also Table 1.

The tin slags are fed into the mix system hoppers and are automatically weighed and mixed with coke and recycled non-magnetic alloys. After thorough mixing, the materials are discharged into hopper cars that transport the mixture into the furnace feed hoppers. The arc furnace is charged from the feed hoppers by means of two vibratory feeders.

The smelting operations are shown diagrammatically in Figure 4. The furnace is operated at about 2800°F for several hours. The slag is poured into a cast iron slag ladle and allowed to cool. See Figure 5. The product alloy is raked from the furnace into a large iron ladle and taken to the cooling area. When the product is sufficiently cool, the ladle is up-ended and the product alloy button is dropped on the floor where it is broken by drop balling. The product is further reduced by a jaw crusher, a hydro-cone crusher and magnetic separator. The magnetic portion is further reduced in a vibratory ball mill and sized on a gyratory screen. This material will be further processed chemically for the removal of tantalum and columbium. The non-magnetic portion is recycled to the furnace. The waste slag is dumped from the ladle when cool and broken up into 1-2 ft. chunks by use of the drop ball. It is then scooped up and deposited on the slag dump as shown in Figure 6. The size of the slag chunks can be seen in Figure 7.

The chemical separation of the rare metals was in the process of being completed in July-August; however, this phase of the operation is considered to be of little health physics significance. Each phase of the chemical processing will be monitored to verify this assumption.

HEALTH PHYSICS SURVEYS

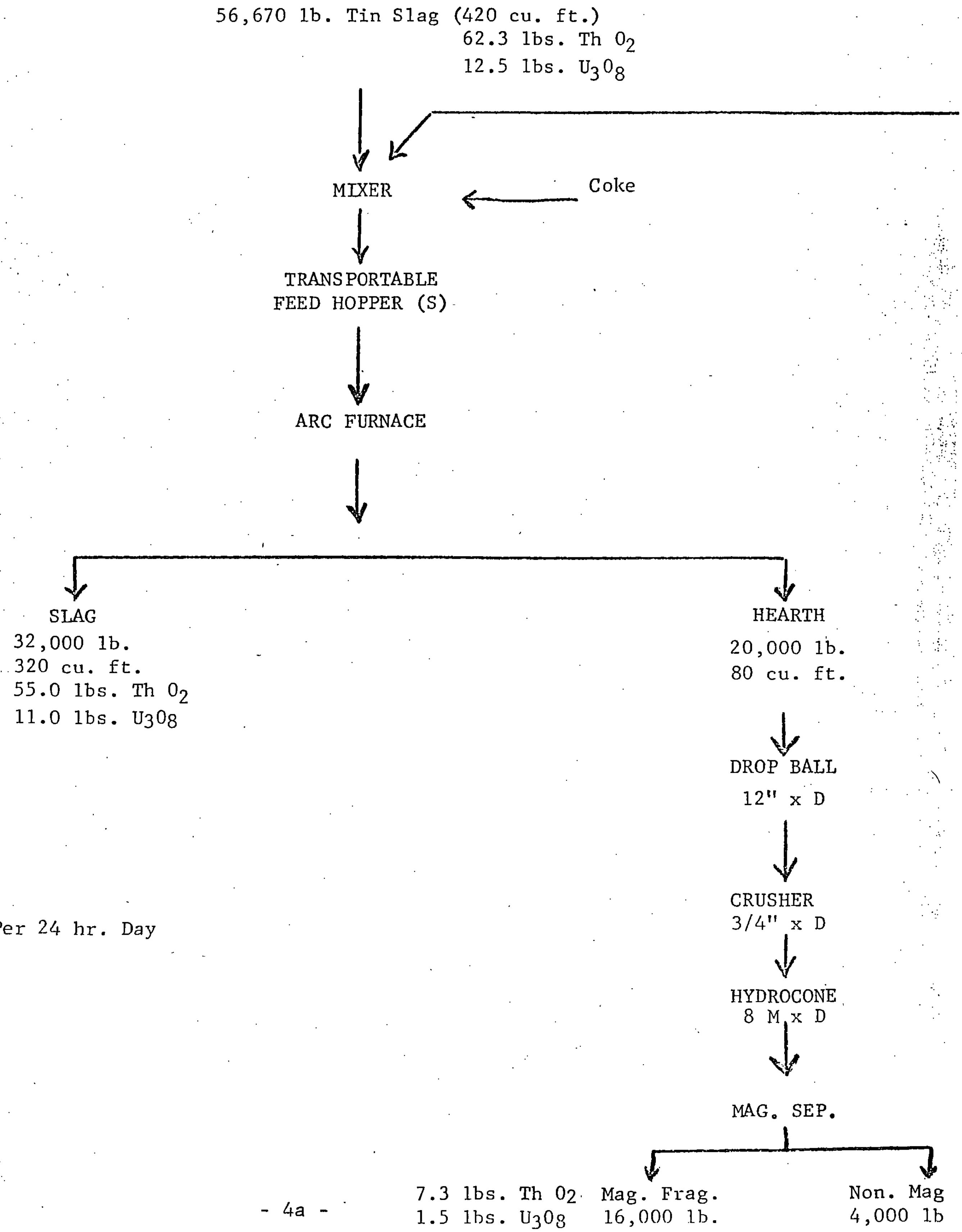
Every phase of the planned metallurgical operations was thoroughly reviewed by certified health physicists from Applied Health Physics several

KAWECKI CHEMICAL COMPANY

Reading, Pennsylvania

Smelting Operation

FIGURE 4



BASIS: Per 24 hr. Day

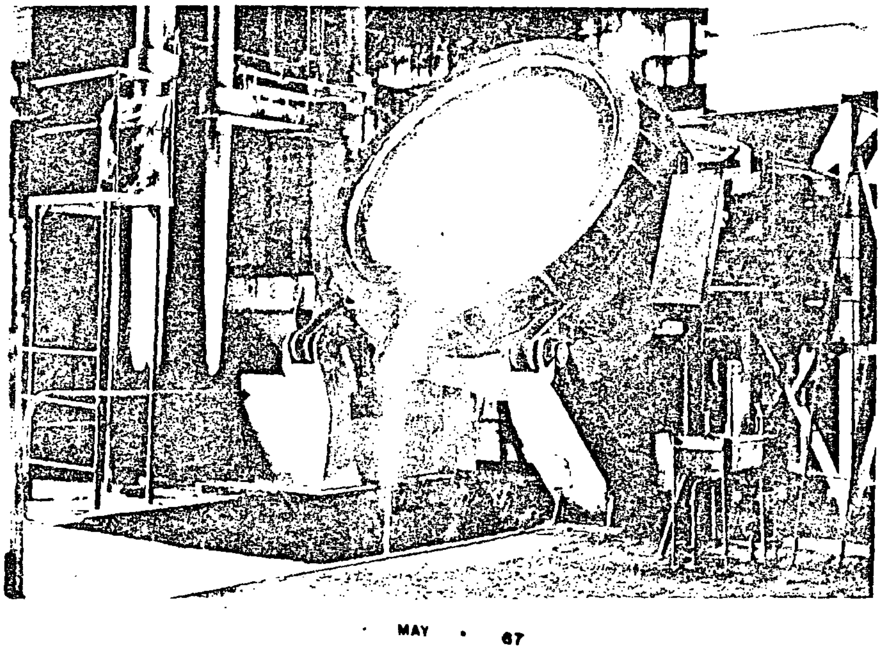


FIGURE 5 Photograph showing the waste slag being poured into the cast iron slag ladle which is located in a pit below the arc furnace.

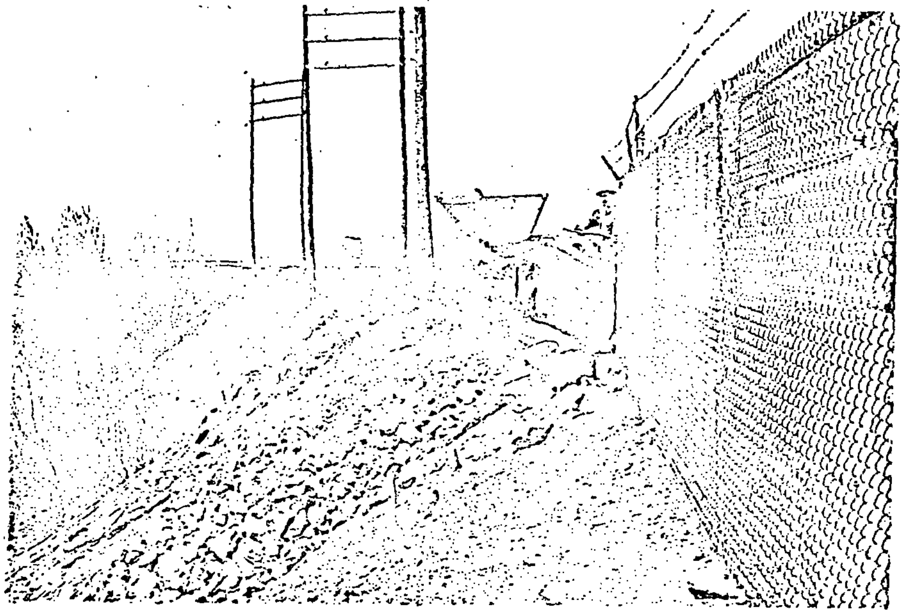


FIGURE 6   Waste slag as it is deposited on the old slag dump which borders the southern edge of the Kawecki plant site.

FIGURE 7   View of slag dump from rim of steep embankment. Note the large 2-3' chunks of waste slag.

months before the smelting began at the Reading plant. The results of the health physics surveys at VCA's plant in Cambridge, Ohio were reviewed since the same tin slags were processed in a manner practically identical to the methods selected for Kawecki's Reading facility. Applied Health Physics had analyzed samples of the materials on each step in the metallurgical process and found that most of the thorium remained in the waste slag. The results of our radiological surveys at VCA during the processing of Kawecki's tin slags are contained in Appendix I. These data showed there was no airborne radioactive concentrations in excess of currently accepted limits for natural thorium as shown in Table 2.

TABLE 2

MAXIMUM PERMISSIBLE CONCENTRATIONS IN AIR AND WATER *

Average concentration Natural Thorium in working atmosphere based upon 40 hr/wk $3x10^{-11}$ uc/ml

Average concentration Natural Thorium in environment at point of discharge - 168 hrs/wk $1x10^{-12}$ uc/ml

Average concentration of insoluble Th in water at point of discharge $1x10^{-6}$ uc/ml

Average concentration of soluble Th in water at point of discharge $1x10^{-5}$ uc/ml

* Based upon Pennsylvania Health Department Regulations, Chapter 4, Article 433 "Regulations for Radiation Protection" and U.S. Atomic Energy Commission Regulations, Title 10, Part 20 "Standards for Protection Against Radiation" - (NOTE: Per 10CFR 20.5c - "A curie of natural thorium means the sum of 3.7×10^{10} dis/sec. from Th-232 plus 3.7×10^{10} dis/sec from Th-228." One curie of natural thorium is equivalent to 9,000 kilograms or 19,850 pounds of natural thorium.)

From our previous radiological surveys involving processing of identical materials containing thorium, we considered the principal health physics objective to be one of evaluating and controlling airborne radioactivity. Air samples were collected at occupied areas during various phases of the metallurgical operations as shown in Figure 8. Breathing zone and general room air samples were collected on Gelman HV 70 filter paper using calibrated low volume air samplers. The air particulate samples were analyzed for net alpha radiation in low background gas proportional counters (Nuclear Measurements Corp. Model PC-3A). All alpha activity present after seventy-two hours has been assumed to be from thorium and/or its decay products. This assumption is based upon multi-channel gamma spectra analyses of the raw materials (see Appendix II) used in the smelting operations and chemical analyses.

The results of the air sampling are given in Table 3 and indicated that the highest airborne concentrations occurred during drop-balling, crushing operations. Samples ranged from 0.15 to $9x10^{-11}$ μc/ml. The highest concentration was obtained at the shaker. Dust control equipment has been received for the crusher and shaker. This is not an area that is occupied except for a few minutes per hour and is located in a very large high bay area of the plant; thus, dilution occurs before reaching occupied areas. The management of Kawecki plan further steps to reduce and to control atmospheric contamination by means of dust collectors and modification of the operations. These steps have already been partially accomplished.

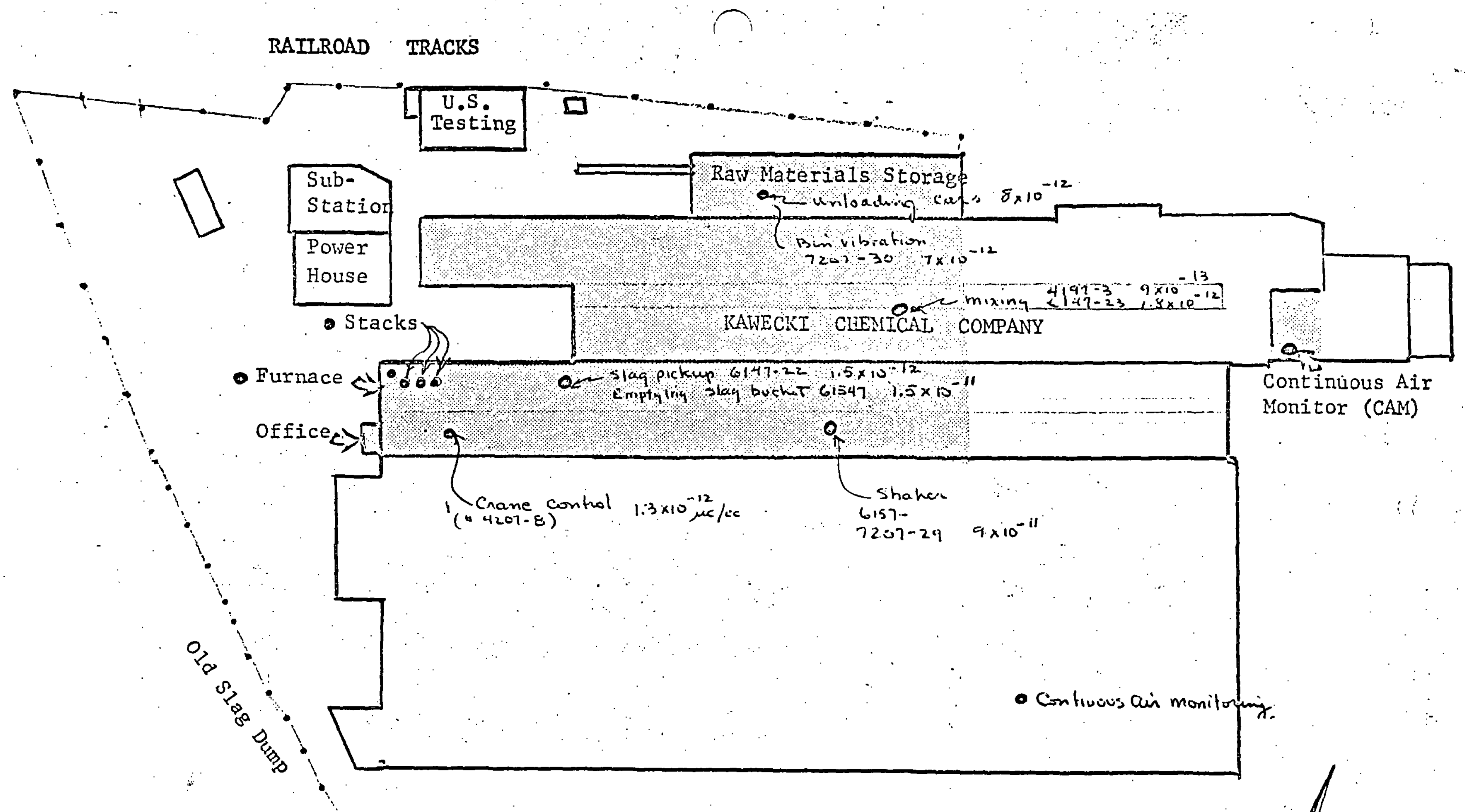


FIGURE 8 Location of Air Sampling

All values are microcuries per ml air (µc/ml)

Plant area in use by Kawecki Chemical Co at the time of this survey.

FIGURE 7

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TABLE 3

REPORT TO KAWECKI CHEMICAL COMPANY

RESULTS OF AIR SAMPLE ANALYSES

Operation or Location	Number of Samples	Sample No.	Results (μc/ml)
Unloading R.R. Cars	1	27	$8x10^{-12}$
Bin Vibration	1	30	$7x15^{-12}$
Mixing Furnace Charge	2	3	$9x10^{-13}$
		23	$1.8x10^{-12}$
Arc Melting - at furnace control	13	1	$1.8x10^{-12}$
		4	$< 10^{-13}$
		6	$3x10^{-12}$
		7	$1x10^{-13}$
		9	$6x10^{-13}$
		10	$2x10^{-13}$
		11	$9x10^{-13}$
		12	$1.8x10^{-12}$
		14	$2x10^{-13}$
		15	$1x10^{-12}$
		17	$7.2x10^{-12}$
		18	$1x10^{-12}$
		26	$3.8x10^{-12}$
Transformer Vault Roof	2	2	$1.6x10^{-12}$
		5	$2x10^{-12}$
Crane Operator's Cab	1	8	$1.3x10^{-12}$

Table 3

Operation or Location	Number of Samples	Sample No.	Results (μc/ml)
Stack	6	13	$9x10^{-13}$
		16	Lost
		19	$2x10^{-12}$
		20	$3x10^{-11}$
		21	$4x10^{-12}$
		28	$2.7x10^{-11}$
Slag Crushing	3	22	$1.5x10^{-12}$
drop ball		25	$4.4x10^{-11}$
emptying bucket		24	$1.5x10^{-11}$
Hearth			
drop ball			
crushing			
shaker	1	29	$9x10^{-11}$

Environmental (CAM) Continuous Air Monitoring Data

Dates	Radioactivity (d/m) Alpha	Beta
9:00 A.M. 6/14 - 9:10 A.M. 7/20/67	25.0	103.0
9:10 A.M. 7/20 - 11:30 A.M.	1.8	27.6
11:30 A.M. 7/28 -		
6:00 P.M. 8/17 - 11:00 A.M. 8/25	0	13.6
11:00 A.M. 8/25 - 11:00 A.M. 9/8	1.8	0

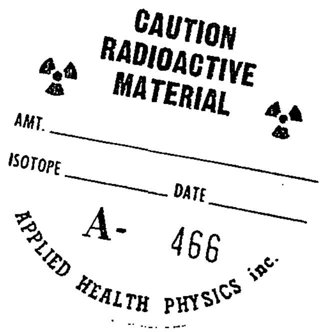
Stack samples were taken at the point of discharge some 80 to 100 feet above the ground. Considerable difficulty was encountered in the collection of these samples because of the heat from the arc furnace, precarious positioning of sampling equipment and heavy dust burden. Two of our air samplers burned out during sampling and several samples were lost as a result of heat, malfunction and/or loss of equipment. However, we were able to obtain five (5) representative stack samples which ranged from $9x10^{-13}$ to $3x10^{-11}$ µc/ml. with an average of $8.7x10^{-12}$. Considering that the furnace operated approximately 18 hours per week during the first six months, concentrations of thorium discharged over 168 hours per week would average well below $1x10^{-12}$ uc/ml as averaged over a 13 week period.

However, in view of these concentrations, steps have been taken to adjust the smelting operations to control the flow of raw materials into the furnace, thereby reducing the possible discharge of unreacted materials which results when the furnace is fed at too high a rate.

Future stack sampling will be greatly facilitated by the installation of sampling ducts in the discharge stacks which connect to sampling equipment located on the floor of the smelting area. Thus, we will be able to collect more stack samples at less risk to personnel and equipment.

It was noted during our initial survey in April that the furnace discharged some large particulates, especially when the reaction rate was too high. To sample and evaluate these materials as discharged, we located a number of fallout samplers over a wide area inside the plant and at various distances downwind from the stacks. These fallout samplers consisted of steel discs 3" - 4" in diameter with a 1" hole that contained

a special adhesive paper disc, adhesive on one side and printed on the other side with a serial number and other information as shown on the sample below.



These fallout samplers were positioned before the furnace started up and were collected after 1 - 18 days of exposure. The results of alpha analyses of 143 samples is given in Table 4-A. The alpha activity ranged from 0 to 70 d/m.

TABLE 4-A

ALPHA ANALYSES OF FALLOUT SAMPLES

Date	Total Number	Serial Numbers	Range Alpha dpm
4/18	67	501-567	0-30
5/4	41	568-590	0-66
5/5-23	15	66-75 717-731	0-42
6/14	20	783-803	0-70

The results of gamma analyses of three samples is given in Table 4-B. The gamma activity ranged from < 0.005 to < 0.15 percent.

TABLE 4-B

GAMMA ANALYSES OF FALLOUT SAMPLES

Sample Number	Location	Percent Thorium
A 973	Settled dust from floor of mixing area	< 0.005
A 974	Settled dust from roof of transformer vault	< 0.005
A 975	Settled dust from stacks collected on roof	< 0.15

A continuous air monitor (Nuclear Measurements Corp. Model WJ-1) was installed in April to collect air particulate samples. This equipment consists of a vacuum pump which pulls air from the atmosphere through a Gelman HV-70 filter paper which is located in a shielded beta-gamma end window G-M counting chamber, connected to a countrate meter that measures and records the beta-gamma activity of the filter paper. The filter paper is changed each week and sent to Applied Health Physics for net alpha and beta measurement. Figure 9 is a photograph of the continuous air monitoring equipment, which is located in Kawecki's laboratory (see Figure 2) and samples environmental airborne radioactivity collected through a hose which extends for a distance outside of the building.

Samples were taken at various phases of the extraction process and the gamma activity has been analyzed in a low background 400-channel gamma spectrometer using a 4" NaI Crystal. These results have been compared to a thorium reference standard of the same physical size as the samples and the thorium concentration determined. Further work is being done to establish a rapid and reliable analytical technique for thorium analyses based upon gamma spectrometry. These data are shown in Table 5 and indicate that 86 percent of the thorium originally present in the tin slag is removed by smelting and is discarded in the waste slag.

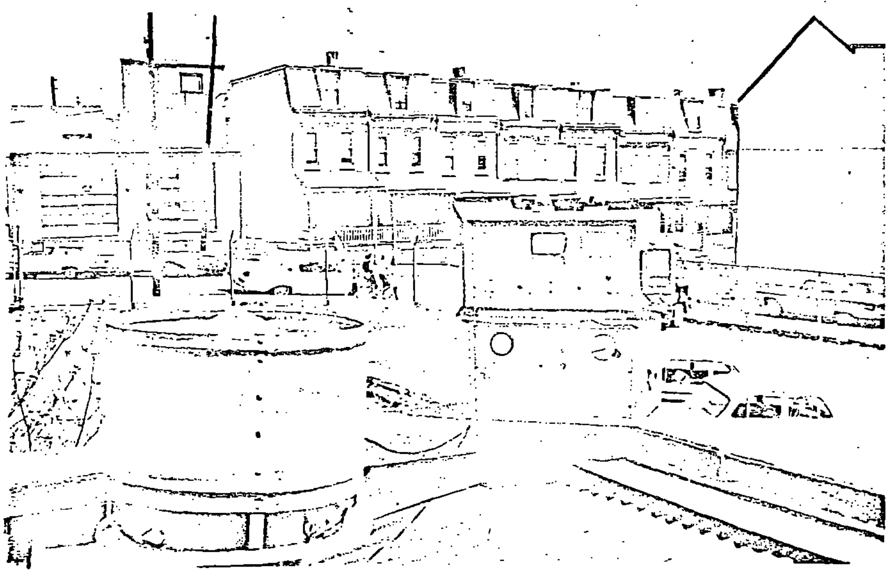


FIGURE 9 Continuous air monitoring equipment (Nuclear Measurements Co. Model WJ-1) which is located in Kawecki's Chem. Lab. at the far northeastern edge of the plant site. This equipment has been operated continuously since 6/14/67 to collect, analyze and record atmospheric radioactivity in the environment.

TABLE 5

SUMMARY OF RADIOLOGICAL ANALYSES
OF SAMPLES FROM METALLURGICAL OPERATIONS

Sample Number		Description	RESULTS Alpha	Gamma	% Th.
A-133	1a.	Tin Slag	0.032 pc/mg	450 c/m/gm	
134			.044		
135	1b.	Tin Slag	.076	440	
K-4192		Tin Slag		216	0.21-0.29
A-970		Tin Slag			0.2 -0.3
K-419-3	2	Periclase Ladle Lining Material (yellow)			
K-419-4		Waste Slag (black)		166 c/m/gm	0.16-0.22
A-969		" " composite Lot 9			0.3 -0.4
A-972		" " from silica fusion			0.23-0.35
K-419-1		Non Magnetic Slag		198 c/m/g	0.2 -0.27
136	3	Magnetic Fraction	0.26 pc	210 c/m/gm	
137	3	Magnetic Fraction	0.25 pc/mc		
A-966		Blend #1			0.10
A-967		Lot 10			0.12
138	4	Non-Magnetic Fraction	0.96 pc/mg	426 c/m/g	
139	4		0.45		
A-971		" " from crusher			0.2 -0.3
140	5a.	Scrap Alloy	0.00	0.036	
141		" "	0.015		
142	5b.	" "	0.00	0.012	
143		" "	0.022		
144		" "	0.004		
145	6	HF Filter Cake	0.05 pc/mg	230 c/m/gm	
146			0.13		
K-8192		" "			0.02
147	7	Product Slag	0.1	246 c/m/g	
148		" "	0.004		
A-968		Caustic slag from Hammer Mill			0.05-0.07

Our first radiological safety surveys at the Reading plant were performed April 18 - 20 followed by additional surveys May 4, 5 and 23; June 14 - 16; July 18, 19; August 17 and September 8. During these surveys radiation measurements were made using calibrated alpha gas proportional survey meters (Eberline, Model PAC-3G), beta-gamma survey meters (Nuclear Measurements Corp., Model GS-3 with end-window G-M having a 1.4 mg/cm^2 window) and gamma scintillation survey meters (Precision, Model 111 c).

During one of the initial beta-gamma surveys of the plant we were surprised to find radiation levels of 10 - 15 mr/hr around the railroad cars loaded with the tin slags. This was far in excess of what could be expected from 0.2 - 0.3 percent thorium and was soon determined to be originating from a 2 Mev. x-ray unit operating at U. S. Testing Company's radiography facility. The radiation levels extended over a wide area of the plant, as shown in Figure 10. Apparently the radiation results from "sky-shine", stray radiation which, having undergone multiple deflections within the radiography room, scatters off the steel roof beams and down into the adjacent plant area occupied by Kawecki.

Mr. R. Gustison and R. Gallaghar reviewed these findings with the manager of U. S. Testing Company and with Mr. McDonald of the Pennsylvania Health Department. Even though these radiation levels may exist only under certain operating conditions and beam orientation of the 2 Mev Van de Graaf machine, it is obvious that additional precautions should be taken by U. S. Testing to comply with Pennsylvania Health Department Regulations

X-RADIATION SURVEY

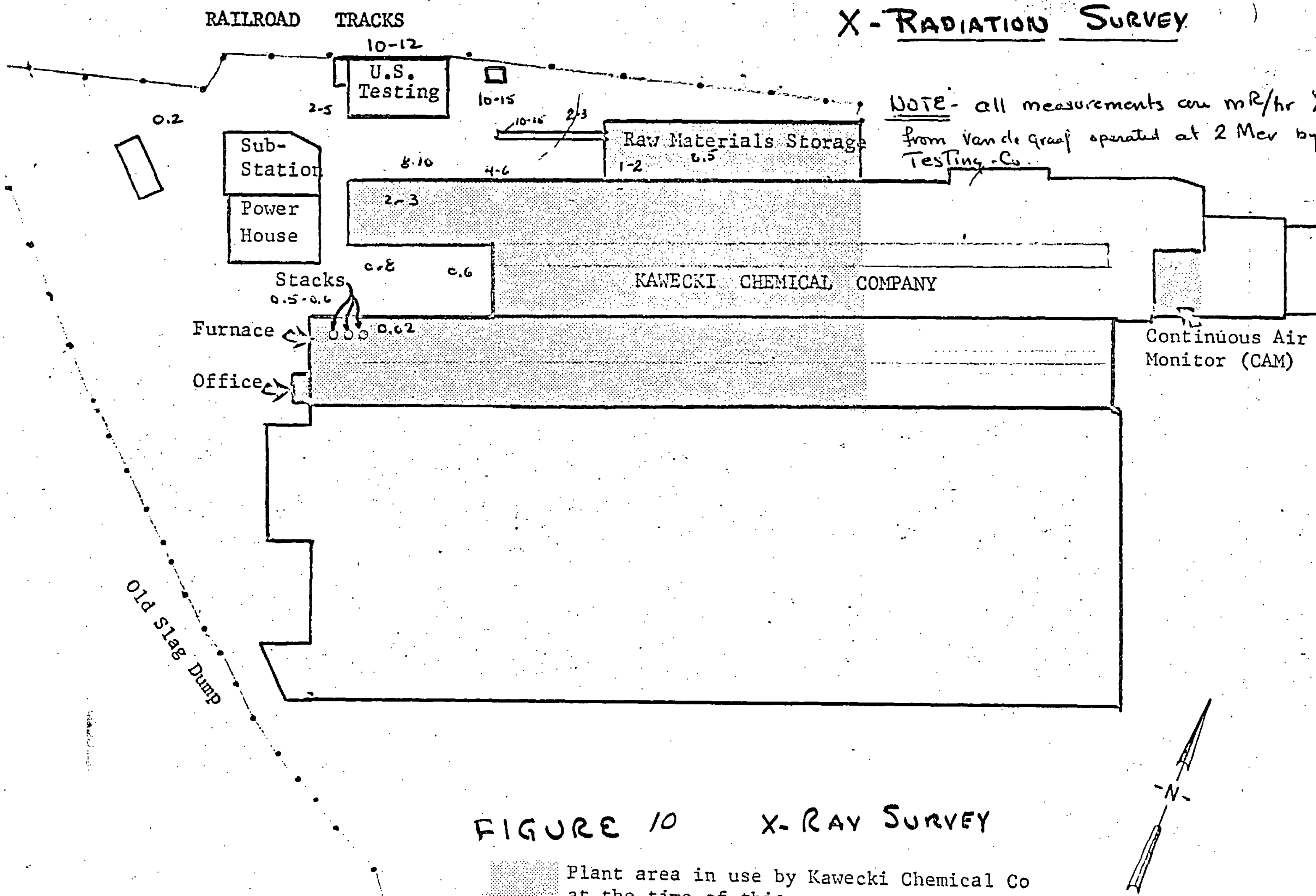


FIGURE 10 X-RAY SURVEY

Plant area in use by Kawecki Chemical Co at the time of this survey.

NOTE: In 1966. U.S Testing Co. operated this x-ray unit at 2 Mev. for 196 hours.

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Article 433 which governs the safe use of x-ray equipment. For the protection of our client's personnel we have installed dosimetric devices at various locations to further monitor stray radiation in areas occupied by Kawecki personnel.

No significant alpha contamination was detected during our surveys. The gamma radiation levels measured from the railroad cars loaded with the tin slag were 0.5 to 0.7 mr/hr. No measurable beta-gamma activity was present after unloading but cars had up to 52 d/m/100 cms. Tin slags in the raw material storage bins showed beta-gamma levels of 0.8 to 1.2 mrads/hr. The slag measured 0.07 - 0.5 mrads/hr at contact. The slag dump contained 1.0 - 1.5 mr/hr.

The gamma radiation levels at the exterior of the loaded gondola cars (0.5 - 0.7 mr/hr) necessitates labeling as required in Title 49 CFR 74.553 on each car. The exemptions from labeling (Title 49 CFR, Part 73.392 (a)(3) do not appear to apply to these shipments. The AEC regulations Title 10 CFR Part 20.203 require labeling of "each area or room in which natural thorium is used or stored in an amount exceeding 5000 uc, or 99.5 lbs. must be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words "CAUTION - RADIOACTIVE MATERIALS". Each container in which natural thorium is transported, stored or used in a quantity greater than 9.9 pounds must have the same label.

WASTE DISPOSAL

The waste slag contains 0.2 to 0.29 percent thorium in the form of a black glass-like material which is broken into large pieces. This material is in a form that is ideal for the retention of radioactive

materials as an inert glass. The owners of the plant site have granted permission in the lease for the use of the slag dump for the disposal of wastes from Kawecki's operations and the company has formally requested a permit from the Pennsylvania Health Department for disposal of these materials. Previous requests for disposal of the waste slag were made to the U. S. Atomic Energy Commission. See Appendix III.

SUMMARY

The results of the radiological safety surveys at Kawecki Chemical Company's plant in Reading, Pennsylvania are reviewed and discussed in this report. Unexpected delays and difficulties with the installation and operation of metallurgical processing equipment and procedures necessitates further surveys of those portions of these processes which could not be included in this report. The data obtained from surveys made during the period April through September indicate that the metallurgical operations have been conducted in compliance with accepted radiological safety standards and applicable Federal and State regulations.

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