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Smelting of Arseniferous Copper Concentrate in an Electric-Arc Furnace

UNITED STATES DEPARTMENT OF THE INTERIOR

Report of Investigations 8144

Smelting of Arseniferous Copper Concentrate in an Electric-Arc Furnace

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SMELTING OF ARSENIFEROUS COPPER CONCENTRATE IN AN ELECTRIC-ARC FURNACE

by

D. L. Paulson,[1] W. Anable,[2] W. L. Hunter,[3] and R. S. McClain[4]

ABSTRACT

The Bureau of Mines studied the feasibility of producing copper matte in an electric furnace from blends of copper concentrate similar to those currently smelted in a gas-fired reverberatory system at an installation in Tacoma, Wash. A 800-kva electric-arc furnace was used to determine the distribution of constituents when arseniferous concentrates are being smelted in an electric-arc furnace.

Test results from smelting 40 tons of materials indicated that electric smelting is more like a conventional gas-fired system than originally expected. Although gas composition over the molten bath is much different in an electric furnace, the secondary constituents such as arsenic, lead, zinc, and antimony behaved the same as in a reverberatory furnace. The results established that an electric furnace would be compatible with sulfur and particulate recovery facilities that are being used.

INTRODUCTION

Copper smelting practice has not changed much over the last century. Little attention has been paid to the gas-fired reverberatory furnace because it has traditionally represented only about 10 percent of the total cost of producing copper from its ores. However, the emphasis on air pollution control, fuel shortages, and costs have generated interest in alternative smelting practices. Electric furnace smelting to produce copper matte is among the leading contenders.

The configuration and materials handling for an electric smelting furnace (fig. 1) is quite similar to a reverberatory smelting furnace (fig. 2). However, the production of sulfuric acid, liquid SO_2, or in some cases elemental sulfur as copper-smelting byproducts can be achieved at less expense due to

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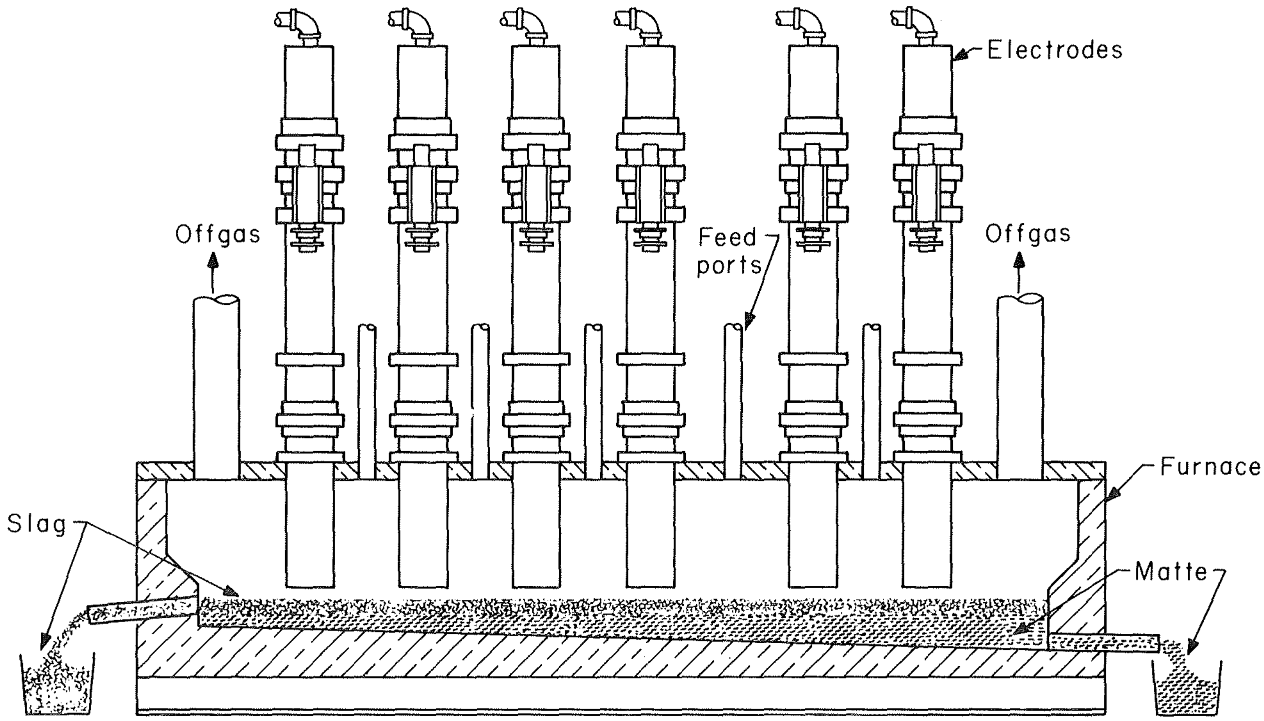

FIGURE 1. - Electric smelting furnace.

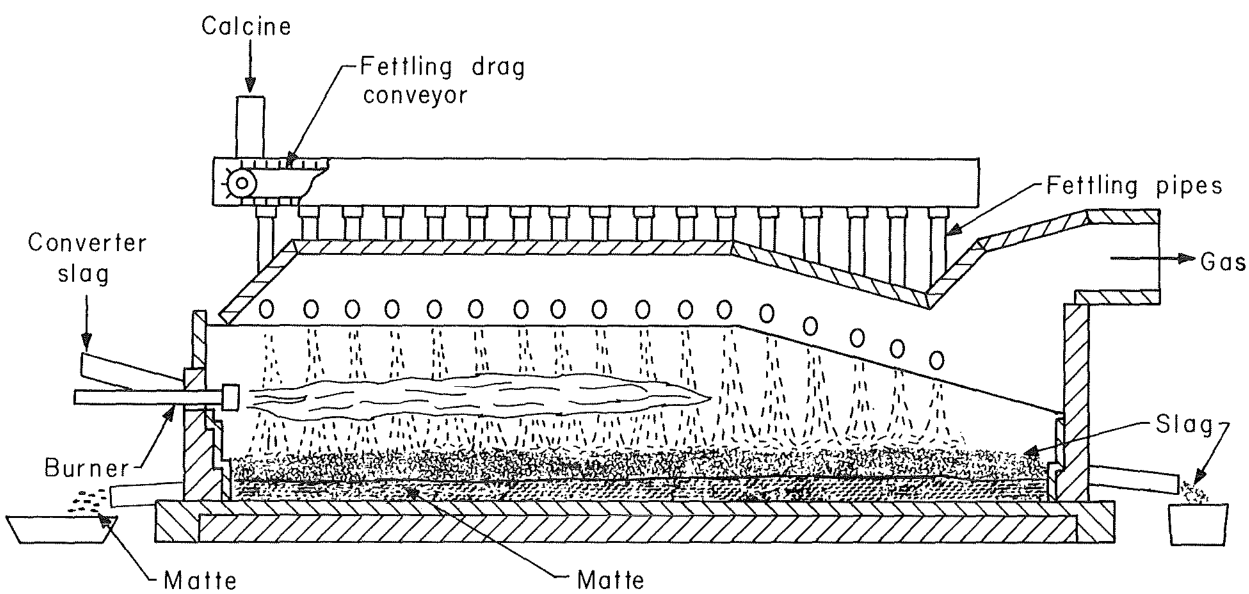

FIGURE 2. - Gas-fired reverberatory furnace.

lower gas volumes and higher SO_2 concentrations in the gases from an electric smelting furnace.

ASARCO Incorporated was interested in evaluating electric furnace smelting as a possible alternative for their custom smelter in Tacoma, Wash. The company entered a cooperative agreement with the Bureau of Mines to perform a series of smelting tests in an 800-kva electric furnace at the Bureau's Albany Metallurgy Research Center (AMRC).

The investigation was designed to determine the feasibility of producing copper matte in an electric furnace from a feed similar to charge materials being smelted at ASARCO's Tacoma smelter. The raw concentrates that are being processed at the Tacoma smelter come from many sources and present a wide variety of unique compositions. Consequently, several of the test plans emphasized procedures to determine the effects of charge composition, gas sweep, and furnace operating parameters on matte grade and the distribution of impurity elements in the furnace products.

SMELTING COPPER CONCENTRATES IN AN 800-kva ELECTRIC FURNACE

Several combinations of chalcopyrite concentrates and smelter byproducts were blended by ASARCO to be processed in an electric arc furnace. The furnace charges were calculated to simulate the present and anticipated material flow through the cooperator's smelter in Tacoma, Wash. Smelting parameters were changed during the test series to determine the effect of various electric-furnace smelting conditions on the compositions of the smelting products.

Materials Used for Smelting in the Electric Furnace

One concentrate from a single source and three blended concentrates were shipped to AMRC from the Tacoma smelter for the first seven smelting tests. The uncombined concentrate was particularly significant because it contained 11.4 wt-pct arsenic. The blended materials consisted of seven or eight different concentrates that are received by the custom smelter.

The concentrates and blends as they were received at AMRC were mixed with the appropriate amounts of converter slag and flux; furnace charges were calculated on the basis of individual concentrate and furnace byproduct analyses. The chemical analyses shown in table 1 were used for the material balances in smelting tests 1 through 6.

Additional furnace charges were blended at the Tacoma smelter for the last six smelting tests and some additions were made at AMRC. Feed compositions for the last six tests were based on chemical analyses of samples that were taken from the feeder belt during each smelting test.

The feed materials for all tests included amounts of pulverized converter slag equivalent to the amounts of molten slag that return to ASARCO's reverberatory furnaces. Therefore, the predicted amount of iron reporting to the matte was equal to the iron in the converter slag that was being added. That parameter is necessary to maintain a balanced flow through the entire smelter and was adhered to throughout the investigation. Fourteen tests were made to smelt furnace charges containing the following components:

Component	Range of compositions, wt-pct
Cu	19.7 -22.5
As	.94- 6.3
Fe	15.7 -26.7
Pb	1.5 - 3.3
Zn	.80- 1.5
Sb	.24- .78
Ni	.15- .34
SiO_3	11.0 -18.9
CaO	.32- 2.3
Al_2O_3	.25- 1.7
S	17.6 -24.4

TABLE 1. - Chemical analyses of the copper furnace feed materials

(Component, wt-pct)

Material	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Arseniferous concentrate........	31.4	11.4	14.6	NA	NA	NA	NA	4.0	1.3	0.9	35.3
Herreshoff calcine..	28.4	3.2	21.5	1.3	1.23	0.78	0.05	5.6	2.4	1.8	26.8
High-As green charge	25.2	4.13	23.5	1.4	1.25	.59	.04	5.10	.8	1.9	34.0
Low-As green charge.	25.4	1.92	22.3	NA	NA	NA	NA	14.3	2.93	1.62	26.4
Converter slag A....	15.4	.28	33.4	5.4	1.58	.78	.40	24.1	.4	.8	4.6
Converter slag B....	12.9	.44	33.5	4.7	NA	.46	.51	22.0	.7	.8	3.7
Silica..............	ND	ND	.7	ND	ND	ND	ND	96.7	.6	2.3	ND
Limestone...........	ND	ND	.4	ND	ND	ND	ND	.2	56.6	.3	ND

NA--Not available.
ND--Not detected.

Equipment Used During Smelting Tests

Figure 3 shows the 800-kva electric furnace that was used for this investigation. The furnace was powered through three 4-inch-diameter graphite electrodes that were positioned in a conventional "delta" configuration on 12-inch centers. A cylindrical furnace shell was modified to increase the furnace capacity, provide a quiescent zone by locating the tapholes away from the turbulent furnace delta, and more closely simulate the bath surface area to depth ratio of a production unit. Figure 4 is a schematic drawing of the modified furnace shell.

Magnesite bricks were used to line the bath portion of the furnace and chrome-magnesite bricks were used for the upper sidewalls. Alumina ram-mix was used to slope the furnace hearth and for the arched roofs over the rectangular furnace extensions. The hearth area was 14.3 square feet and the lined furnace could contain approximately 3,000 lb of molten bath.

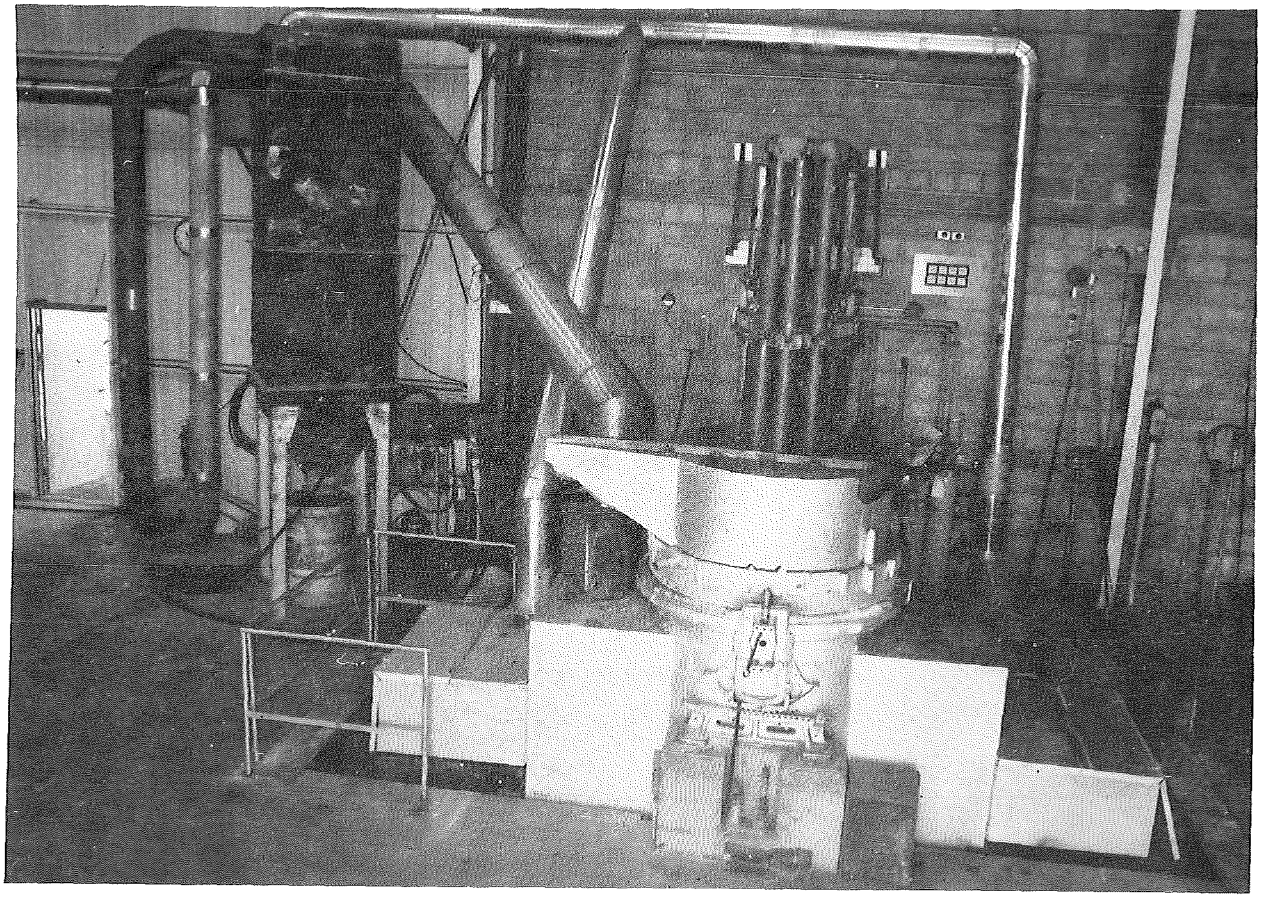

FIGURE 3. - 800-kva electric-arc furnace.

The charge material was gravity fed through the furnace roof and the feed rates were controlled with a 4-inch-wide variable speed belt feeder. A stainless steel feed chute that extended (inside the furnace) from the roof line half way to the furnace hearth was installed for some smelting tests to protect the free-falling feed material from the smelting atmosphere.

The small baghouse to the left of the furnace in figure 3 was installed to quantitatively collect the entrained fines from the furnace offgases. The baghouse was connected to the furnace by the offgas analyses train shown in figure 5. The offgas analyses train was equipped with an infrared gas analyzer to continuously monitor SO_2 levels and a magnetic susceptibility oxygen analyzer that was used periodically during each test. After the smelting offgases had passed through the water-cooled tower, very little ambient air had to be added to keep the baghouse temperature below 200° C.

The plenum and tapping pit hoods that are connected to the furnace in figure 3 were evacuated by a 7,500-cfm fan that exhausted into a positive pressure cyclone and baghouse system. Sulfur dioxide was removed from the dust-free offgases in a countercurrent scrubber in which sodium carbonate solution percolated down through a packed bed.

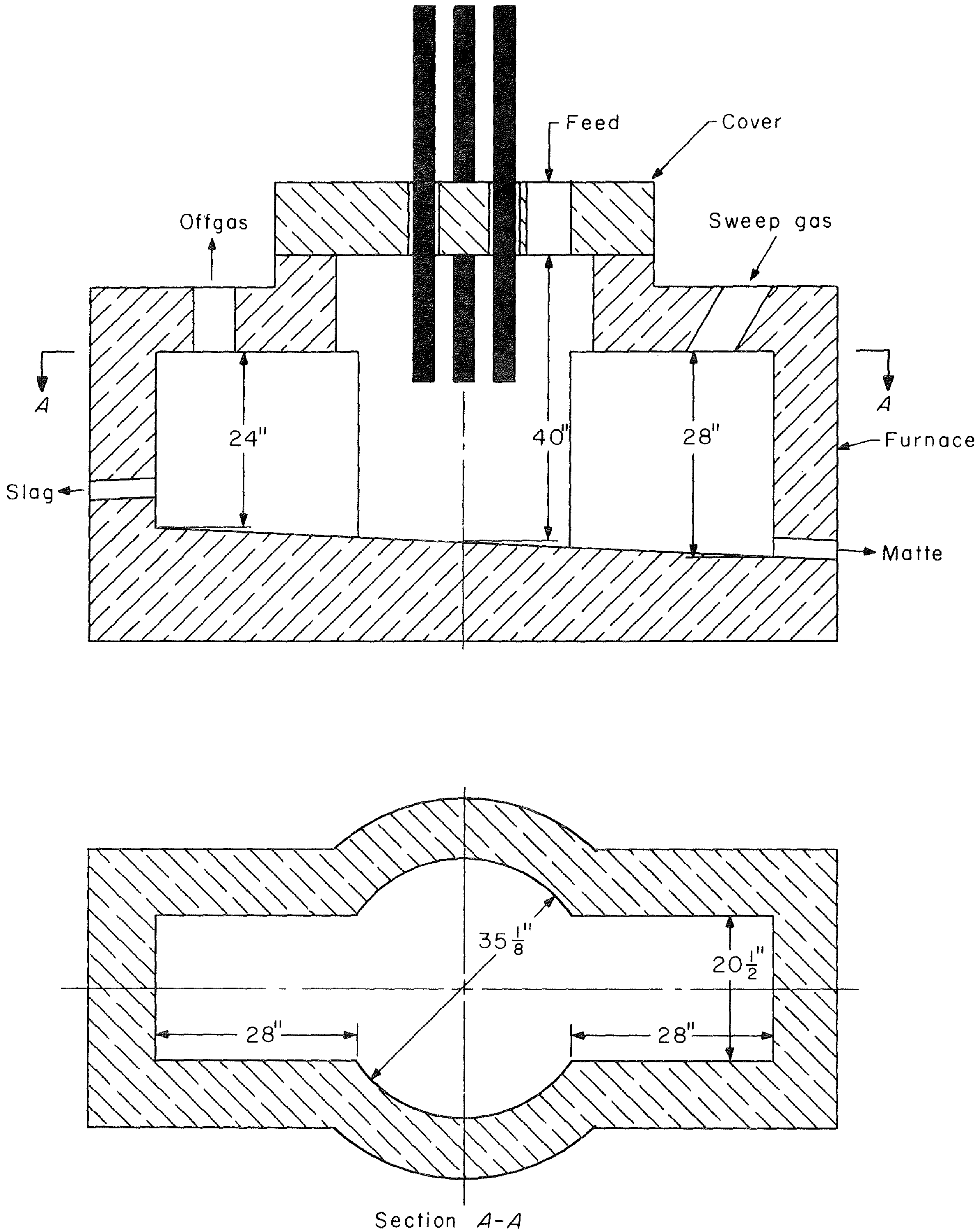

FIGURE 4. - Schematic drawing of the modified furnace shell.

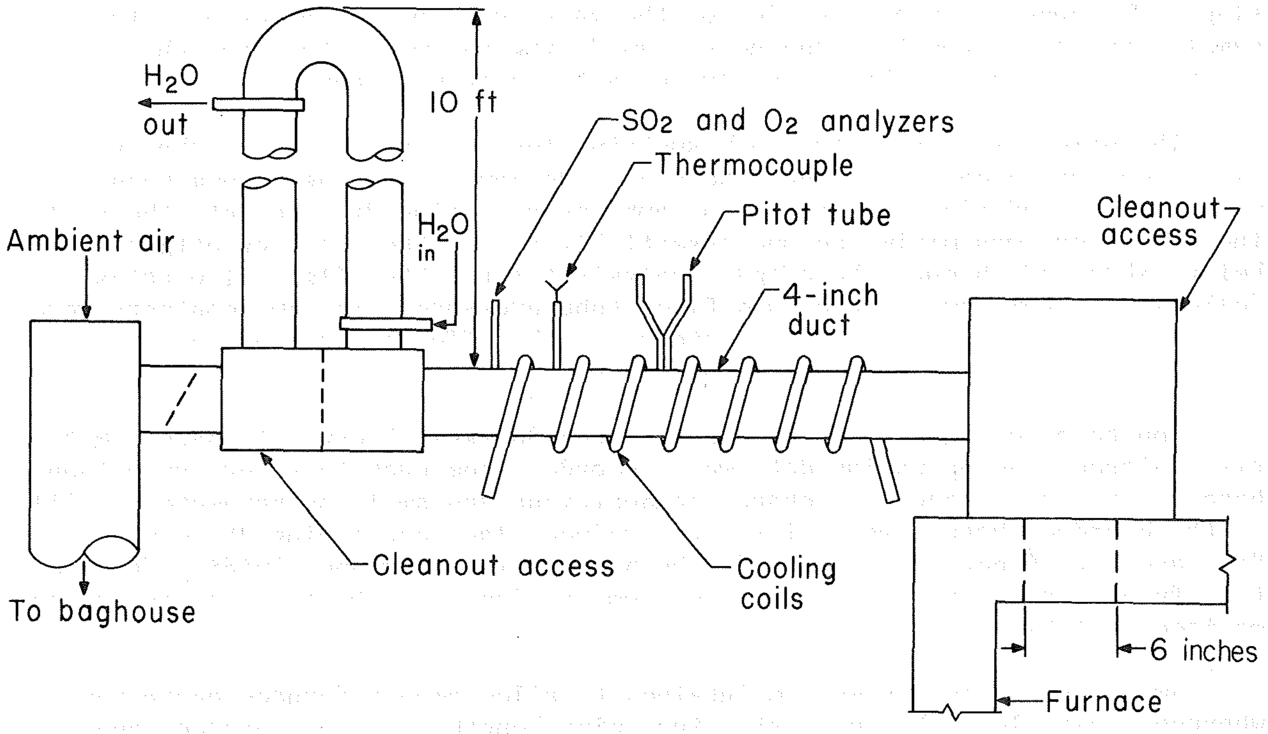

FIGURE 5. - Offgas analysis train on the 800-kva electric-arc furnace.

Operating Procedures for the Smelting Tests

Smelting tests in the 800-kva electric furnace were between 7 and 9 hr long. The amount of charge that was smelted during each test ranged from 5,200 to 9,700 lb.

Before each smelting test, the furnace was loaded with approximately 1,000 lb of charge material and the initial charge was preheated to 1,000° C with a gas-fired burner that was inserted through the furnace sidewall. A smelting test was started by striking the initial arc across approximately 40 lb of metallic copper that had been placed on top of the starting bed in the electrode delta. The belt feeder was started as soon as the initial bed was molten and the material had started to flow the length of the furnace hearth. Care was taken to prevent superheating the bath and eroding the magnesite refractory under the electrode delta.

The smelting system usually equilibrated within 1 hr after the test was started. At that time, the feed rate and power input were matched to keep the surface of the bath molten. One exception was made when the test was designed to determine the effects of operating with a "cold top" over the bath except within the electrode delta.

Slag was tapped from the furnace approximately one-half hour after the smelting system had reached equilibrium. Alternate matte and slag taps were made during the remainder of a smelting test. Generally, about 1,200 lb of matte were poured at a time and the following tap contained about 700 lb of slag. The copper content (grade) of the matte was checked after each tap. A sample was taken from the tapping stream during the matte taps and the matte portion of the furnace bath was sampled after slag was tapped.

The offgas flow rate for each smelting test was regulated so that very little gas was escaping through the electrode ports into the plenum hood. Under these conditions the amount of ambient air being drafted into the smelting atmosphere was minimized and essentially all of the reaction offgases were being exhausted through the offgas analysis train. The offgas flow rates (calculated from temperatures and Pitot tube pressures) and SO_2 contents were continuously monitored. Oxygen contents of the offgases were periodically measured during most of the smelting tests.

Fourteen smelting tests were run in the 800-kva electric furnace. Material balances and operating data were recorded from each test for comparisons based on related changes in charge compositions and smelting parameters. All of the blended charges were fluxed to produce slags containing 38 to 40 pct SiO_2 and 4 to 6 pct CaO to provide the best resistivity and fluidity for electric furnace smelting.[5] [6] The charge compositions for the test series are summarized in table 2.

Smelting parameters were maintained to allow smooth furnace operation whenever possible. The feed rate, feed pipe length into the furnace, and air sweep over the furnace bath were changed independently to determine how the changes affected component distributions in the furnace products. Table 3 contains the smelting parameters for the test series. In tests 5 and 6, the charge feed pipe was extended about 20 inches into the furnace to determine its effect on mechanical dust losses, sulfur elimination, and arsenic distribution. The feed rate was lowered by about 50 pct (to 791 lb/hr) for test 13 to determine the effect of increased gas sweep per unit charge and greater retention time on the arsenic elimination and copper content of the slag.

Smelting test 8 represented the most radical deviation from normal operation. The test was run to measure heat losses from the furnace and determine the effect of ambient air on the arsenic and sulfur eliminations by blowing argon over the bath and determining the offgas compositions during that period. Grab samples of the entrained dusts were collected for X-ray diffraction analyses both with and without inert gas being introduced into the system. Because heat loss measurements were made by holding the furnace for extended periods without any power, no operating data were collected that could be compared with the other smelting tests.

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[5] Persson, J. A., and D. G. Treilhard. Electrothermic Smelting of Copper and Nickel Sulfides and Other Metal Bearing Constituents. J. Metals, v. 25, No. 1, January 1973, pp. 34-39.

[6] Treilhard, D. G. The Jinja Copper Smelter. Can. Min. and Met. Bull., v. 59, No. 645, 1966, pp. 63-72.

TABLE 2. - Charge compositions for smelting tests

Test	Head sample analyses, pct											Moisture
	Pb	Cu	Zn	As	Sb	Ni	SiO_2	Fe	CaO	S	Al_2O_3	
1	2.5	25.2	1.3	2.3	0.77	0.15	11.0	24.8	1.8	20.0	1.5	NA
2	2.9	22.7	1.3	2.0	.77	.18	14.5	25.8	1.6	17.6	1.4	0.8
3	2.8	20.1	1.3	2.4	.62	.18	15.7	25.6	2.3	20.3	1.4	.8
4	2.8	20.1	1.3	2.4	.61	.17	15.8	25.7	2.3	20.4	1.5	1.06
5	2.8	20.1	1.3	2.4	.62	.18	15.7	25.6	2.3	20.3	1.4	.8
6	3.3	22.3	1.5	2.9	.4	.21	14.7	26.7	.81	19.5	1.6	.8
7	2.2	20.2	1.2	2.3	.50	.18	14.3	25.3	1.1	19.9	1.6	.8
8	1.7	25.8	1.0	2.1	.42	.34	15.8	24.0	.16	18.5	1.6	NA
9	1.5	21.1	1.1	6.3	.78	.18	14.8	15.7	1.6	24.4	.62	3.0
10	2.2	19.7	1.1	.94	.24	.31	18.9	25.2	.66	19.1	1.7	1.0
11	2.7	20.1	1.1	1.0	.57	.24	NA	21.4	NA	18.0	NA	NA
12	2.4	21.0	1.2	2.4	.40	.24	15.5	26.2	.32	18.9	.25	NA
13	1.8	23.0	.80	4.1	.50	.18	13.9	21.5	1.9	22.8	1.1	NA
14	1.9	22.5	1.0	3.9	.66	.19	12.1	22.0	NA	20.4	1.2	NA

NA--Not available.

TABLE 3. - Average operating parameters for smelting tests

Parameters	Test													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Smelting rate (lb/hr)	973	907	1,015	1,181	934	1,087	1,120	NA	1,023	1,068	1,123	1,238	791	1,195
Equivalent smelting rate (lb/ft^2 bath/hr)	66	62	69	80	64	74	76	NA	70	73	76	84	54	81
Offgas volume (scfm)	97	97	97	114	99	107	101	NA	103	116	117	115	121	116
Equivalent offgas volume ($scfm/ft^2$ bath)	6.6	6.6	6.6	7.8	6.7	7.3	6.9	NA	7.0	7.9	8.0	7.8	8.2	7.9
Offgas temperature (° C)	599	641	672	679	710	720	689	NA	620	700	695	667	714	732
Mean bath temperature (° C)	1,190	1,207	1,237	1,185	1,205	1,220	1,164	NA	1,070	1,205	1,275	1,263	1,270	1,266

NA--Not available.

Results of Smelting Tests

Smelting tests in the 800-kva electric furnace included as many as five matte taps that were generally followed by a slag tap. Matte that was tapped from the furnace usually contained some slag and vice versa. Therefore, the smelting products were carefully separated after cooling and each component was analyzed and its composition recorded separately. The analytical results reflected the inadvertent fluctuations in feed rates, bath temperatures, and other smelting parameters as well as the intentional changes that were made. All of the analytical data were compiled into the material balance sheets in appendix A. The total accountabilities for each component include accumulations of the sampling and analytical errors inherent to working with relatively large amounts of nonhomogenous products as well as some dust losses during the smelting tests.

The total weight that was recovered of each component was used to calculate the distribution of the component between matte, slag, and "process" dust that occurred in each test.

The composite analyses shown in tables 4, 5, and 6 are based on weighted averages of the values included in appendix A. These compositions relate more closely to the intentional changes in smelting parameters that were made during the test series.

TABLE 4. - Matte compositions

Test	Cu	Pb	Zn	As	Sb	Ni	Fe	S
1	47.1	4.59	0.92	1.01	0.64	0.49	18.4	24.5
2	47.1	4.30	.88	.79	.65	.74	18.3	23.0
3	38.7	3.96	1.21	1.08	.56	.44	26.7	25.8
4	36.8	4.83	1.32	1.34	.76	.41	25.6	25.1
5	39.5	4.30	.95	.95	.83	.48	24.9	25.6
6	34.3	3.34	1.22	.93	.59	.32	30.0	26.1
7	33.4	4.31	1.15	.70	.63	.28	30.7	25.6
8	NA	NA	NA	NA	NA	NA	NA	NA
9	40.0	3.36	.81	1.61	1.18	.37	24.4	25.7
10	36.6	3.31	.88	.63	.60	.42	28.8	25.1
11	38.0	4.07	.77	.67	.68	.45	27.1	24.8
12	36.4	3.47	.92	.99	.67	.41	28.0	24.7
13	38.1	2.89	.89	1.35	.59	.27	24.3	23.4
14	36.1	3.02	.91	1.42	.77	NA	25.6	25.1

NA--Not available.

TABLE 5. - Slag compositions

Test	Cu	Pb	Zn	As	Sb	Ni	Fe	S	SiO_2	CaO	Al_2O_3
1.........	1.31	0.73	1.79	0.63	0.46	0.04	35.1	1.41	34.5	4.80	3.78
2.........	1.78	1.16	1.59	.56	.49	.06	36.0	1.65	38.5	3.06	3.18
3.........	3.07	.98	1.29	.44	.33	.05	30.2	1.47	41.1	5.14	3.28
4.........	2.33	1.18	1.49	.51	.26	.03	30.3	2.09	40.8	5.47	3.0
5.........	.62	.65	1.31	.34	.21	.03	30.6	1.00	42.3	5.41	3.45
6.........	.57	.85	1.38	.32	.33	.02	27.0	.97	45.3	4.09	4.81
7.........	.58	.94	1.44	.32	.22	.04	27.0	.90	45.3	3.65	4.25
8.........	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9.........	3.26	.70	.81	.41	.06	.07	22.3	1.37	55.1	3.36	2.80
10.........	.84	1.01	1.04	.17	.24	.03	28.4	1.01	48.8	.70	3.66
11.........	1.12	1.04	1.04	.23	.19	.03	31.9	1.28	49.4	1.01	3.40
12.........	.90	1.03	1.14	.30	.12	.04	32.5	1.19	42.9	.99	3.00
13.........	.83	.50	.99	.36	.16	.03	29.0	.99	42.5	5.30	3.29
14.........	.79	.53	1.12	.37	.13	.06	26.4	.87	44.4	5.40	3.40

NA--Not available.

TABLE 6. - Baghouse dust compositions

Test	Cu	Pb	Zn	As	Sb	Ni	Fe	S	SiO_2
1.........	9.05	3.50	1.70	44.0	2.56	0.02	8.41	7.56	1.87
2.........	9.57	5.10	2.05	42.2	2.50	.03	9.57	6.75	1.10
3.........	3.38	4.80	2.18	56.3	3.21	.01	7.8	4.26	1.02
4.........	4.71	5.75	3.36	50.1	3.40	.02	4.3	3.64	NA
5.........	1.68	7.50	4.00	54.4	4.10	.01	2.3	2.3	12.8
6.........	1.42	7.50	3.35	55.2	3.30	NA	5.6	7.98	.71
7.........	2.74	7.80	3.30	52.9	3.40	NA	2.3	6.34	NA
8.........	NA	NA	NA	NA	NA	NA	NA	NA	NA
9.........	3.84	4.36	2.61	55.6	2.35	NA	3.09	2.66	1.20
10.........	5.3	14.6	5.8	27.9	2.77	.02	6.3	7.60	1.97
11.........	6.4	13.9	7.6	24.1	3.07	.02	5.3	7.90	NA
12.........	6.7	7.26	3.71	37.7	2.49	.01	7.26	7.71	2.31
13.........	6.3	3.70	2.10	47.0	2.67	.02	4.94	7.00	2.76
14.........	5.6	3.50	1.63	48.4	2.08	NA	17.6	9.30	NA

NA--Not available.

In addition to the general distribution of the charge constituents during electric furnace smelting, the investigation stressed the effect of smelting conditions on arsenic distribution and sulfur elimination. Figure 6 is a graphic description of smelting test 5 that typifies how each test was evaluated regarding the relationship between the furnace operation and offgas compositions. The rapid response that was exhibited by the SO_2 monitoring system to the termination of feeding indicates the reliability of offgas data. Average bath temperatures were determined for table 3 by measuring the area under the curves (as shown for test 5 in fig. 6) and dividing by the total elapsed time. Table 7 summarizes the resultant operating data, related SO_2 eliminations, and arsenic distributions.

TABLE 7. - Operating data from smelting tests

Data	Test													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Average SO_2 content of offgas (pct SO_2):														
During feeding....	NA	9.6	10.3	10.9	17.8	12.1	16.0	NA	15.5	13.1	14.0	16.8	13.7	15.7
During holding....	NA	3.8	4.4	3.1	7.1	5.6	7.5	NA	7.2	7.1	7.6	9.9	6.3	6.0
Sulfur elimination (pct of input).....	NA	NA	NA	NA	37	29	25	NA	NA	33	37	35	46	34
Arsenic distribution (pct of input):														
In flue dust......	39.8	62.7	63.9	57.5	61.1	38.3	47.9	NA	41.1	49.8	45.0	58.3	65.2	68.2
In matte..........	42.3	22.7	28.2	34.3	23.3	22.0	22.5	NA	17.6	34.3	30.5	25.4	20.5	25.9
Power consumption (kwhr/ton).........	387	417	398	390	512	471	504	NA	482	441	494	428	658	475
Electrode consumption (lb/ton)......	10.1	12.7	11.1	8.1	13.5	13.1	11.4	NA	12.5	12.9	9.5	11.6	18.0	13.7

NA--Not available.

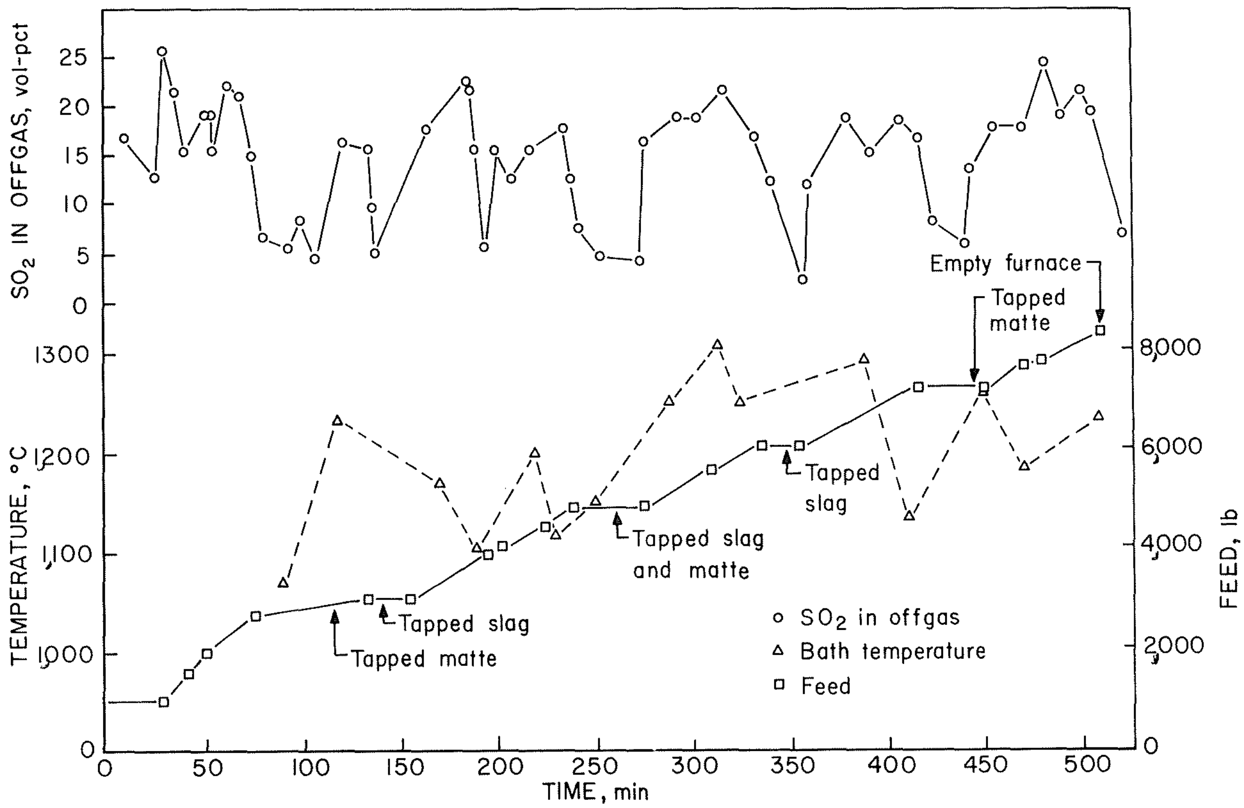

FIGURE 6. - Graphic description of smelting test 5.

After the offgas flow rate was balanced with the gases being evolved from the smelting reaction, the flow rate was approximately 100 scfm during each test. The offgas equivalent ranged from 8,400 to 13,455 scf/ton of charge depending on the smelting rate that occurred during a specific test.

Incremental offgas flow rates and SO_2 concentrations were used to calculate [(scf SO_2/min) (time)] the sulfur eliminations that are included in table 7. The reliability of the values was checked as follows by calculating sulfur accountabilities for the tests from which sufficient data were available:

Test	S in charge, lb	S in products, lb	S in offgases, lb	S accounted for, pct
5	1,693	1,181	625	107
6	1,624	1,355	467	112
7	1,635	1,320	558	115
10	1,612	1,109	524	102
11	1,599	907	585	93
12	1,843	1,367	646	109
13	1,193	668	550	102
14	1,641	1,162	558	105

Flue samples of the entrained solids were collected only during smelting test 8. The first dust sample was taken from the offgas stream after the system had equilibrated under normal smelting conditions. Then a 25-scfm stream of argon was blown over the bath to prevent ambient air from entering the system and a second particulate sample was taken from the offgas stream. After the argon flow was stopped, the flow rate in the offgas stream was reduced from approximately 100 to 50 scfm and a third particulate sample was taken. X-ray diffraction analyses of the entrained fines identified As_2O_3 as the primary arsenic phase in all three samples, and traces of As_2S_2 were found in the samples that were taken while injecting inert gas and when the offgas flow rate was reduced. It is apparent that the elimination of arsenic is not dependent on ambient air being introduced during the smelting process.[7] Arsenic analyses of the smelting products did not indicate any effect from the changes that were induced in the smelting environment.

The power consumption data in table 7 were calculated from the power input during actual smelting and the associated time. In order to approximate a continuous operation, the power consumed while melting the furnace nest and during unavoidable delays was not included in the calculations. A bath temperature cooling curve was established from immersion thermocouple measurements that were taken with the power off during smelting test 8. However, the values that were collected could not be correlated with the operating power inputs or with the power levels that required to maintain bath temperatures under the same furnace conditions.

DISCUSSION

The test results indicated that the matte grade (copper content) was primarily determined by the chemical compositions (Cu, Fe, S, and O) of the furnace charges. As shown in appendix A, the first matte that was tapped from the furnace in some tests was appreciably higher in copper content than matte from later taps. This was caused by the metallic copper plate that was used for startup and by some roasting of the initial charge while preheating the furnace. The two following smelting variables clearly influenced the matte grade:

1. Matte grade was increased by increasing the gas sweep over the furnace bath as indicated by the offgas volume per ton of charge smelted.

2. The matte grade was higher as the SiO_2 contents of the furnace charges increased over the range from 11 to 19 pct.

There is some question as to whether the SiO_2 content actually affects the matte grade or whether other conditions occurring simultaneously are responsible.

Heat is generated in the electric smelting furnace by current flowing through the molten slag. Consequently, the electrical properties of the slag

[7] Mellor, J. W. A Comprehensive Treatise on Inorganic and Theoretical Chemistry. Longmans Green and Co., v. 9, 1947, 967 pp.

are very important. The charges for the smelting tests were fluxed to produce slags containing from 38 to 40 pct SiO_2. However, many of the charges were fluxed on the basis of predicted chemical compositions and sulfur eliminations. The resultant SiO_2 contents ranged from less than 34 to over 55 pct. The wide range did not cause any serious operational problems, but slag with SiO_2 contents over 43 pct were quite viscous and hard to tap while the slags that contained less than 35 pct SiO_2 caused electrode-arc instability. The results indicated slags containing 36 to 42 pct SiO_2 promote steady power conditions and fluid smelting products at normal operating temperatures.

Copper contents of the electric furnace slags ranged from 0.57 to 3.26 pct which is much higher than the 0.4 to 0.5 pct copper contained in the reverberatory slags from a commercial operation. Although the higher copper losses can be partially attributed to high slag viscosities, the furnace configuration and experimental practice were probably the principal factors contributing toward high copper slags. The turbulence that is characteristic of an electric smelting furnace[8] and the close proximity of the tapping holes to the furnace delta (fig. 4) caused excessive entrapment of matte prills in the electric furnace slags. Bath depths that were maintained in the 800-kva furnace made it necessary to tap too close to the slag-matte interface. Consequently, some matte was removed during slag taps and vice versa. The resultant mixing contributed to the high copper contents of the slags.

It was confirmed that relatively high concentrations of SO_2 can be obtained in electric furnace offgases by controlling the volume of air flowing into the furnace. In the seven tests that included the best sulfur accountability data, a smelting rate of 102 $lb/ft^2/hr$ produced an average of 11.3 pct SO_2 in the offgases. It is anticipated that offgases containing 4 to 8 pct SO_2 would be produced when smelting similar materials at slower rates in a commercial electric furnace.[9]

The distributions of contained impurities and byproduct elements can be followed in appendix A. With the exception of arsenic which reports more readily to the copper matte, the distribution of impurities and byproduct elements in the electric furnace products appeared to be about the same as in a commercial reverberatory furnace.

From 38.3 to 68.2 pct of the contained arsenic was eliminated by fuming and 1.5 to 11.8 pct was lost to the slag during the smelting process. Figure 7 shows that the amount of arsenic contained in the flue dust was directly proportional to the arsenic content of the furnace charge. Generally, the inverse was true for the amount of arsenic in the slag. Changes in offgas volumes and air sweep through the furnace did not have any appreciable effect on the arsenic distribution.

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[8]Barth, Otto. Electric Smelting of Sulfide Ores. Internat. Symp. AIME, New York, Feb. 15-18, 1960.

[9]Dayton, S. Inspiration's Design for Clean Air. Eng. and Min. J., June 1974, pp. 85-96.

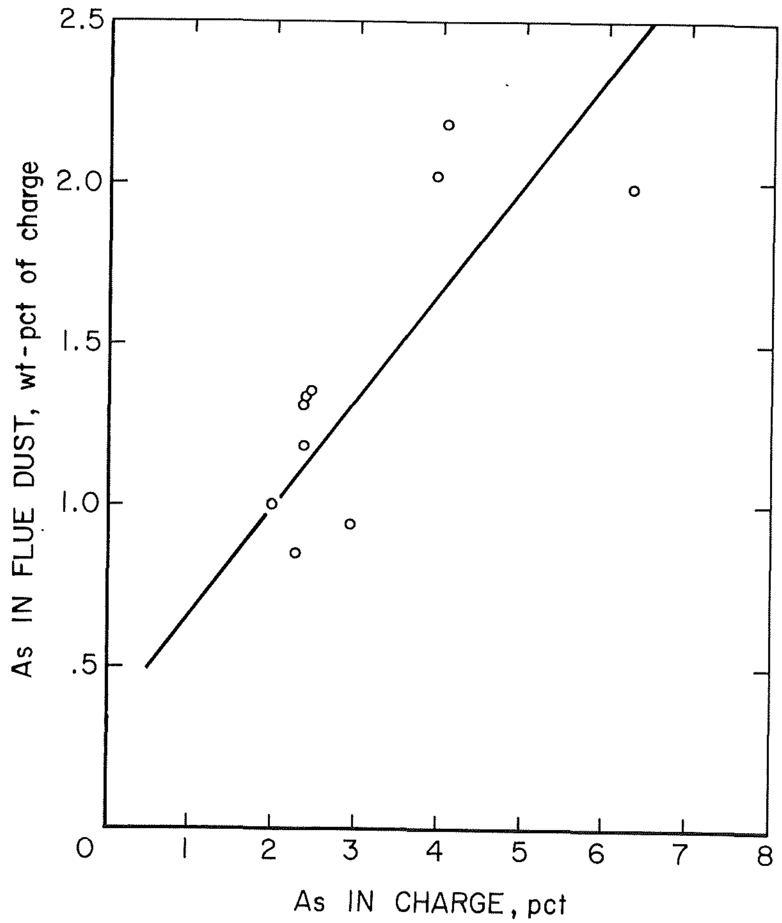

FIGURE 7. - Arsenic content of the flue dust as a function of the arsenic content of the furnace charge.

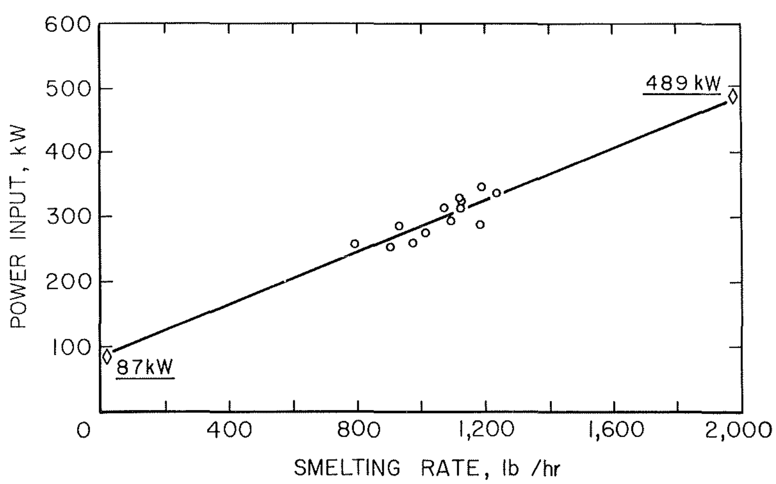

FIGURE 8. - Energy required to smelt cold copper concentrate.

The power consumption data that are included in table 7 range from 387 to 658 kwhr/ton and average 466 kwhr/ton of solid charge smelted. Because the test values increased rapidly as the smelting rates were lowered and did not include all of the power that was used during an entire test, the total power consumed in each test was used to establish an equivalent value. The average power input for each test (total power/total time) was plotted against the respective smelting rate. Extrapolation of the relationship shown in figure 8 indicates that 87 kw is equal to the heat loss from the furnace and 489 kw would be required at a smelting rate of 2,000 lb/hr. By difference, the energy required for actual smelting was 402 kwhr/ton of solid charge. The experimental and calculated energy requirements agree well with the 440 kwhr/ton that is required to smelt cold copper concentrate in a commercial electric furnace with nominal heat losses.[10]

CONCLUSIONS

Electric furnace smelting of copper concentrates is very similar to reverberatory furnace smelting of the same materials. Slags containing 36 to 42 pct SiO_2

[10] Herbert, I. C. Extractive Metallurgy. Min. Annual Rev. (Suppl. to Min. J.), July 20, 1973, pp. 227-253.

promote steady power conditions and matte grades that are compatible with established converting techniques. With the exception of arsenic which reports more readily to the copper matte, the distribution of impurity and byproduct elements is essentially the same as in a reverberatory furnace. The amount of arsenic contained in the flue dust is directly proportional to the arsenic content of the furnace charge and changes in air sweep through the furnace do not affect the arsenic distribution.

Smelting in the electric furnace at a rate of 102 $lb/ft^2/hr$ with minimal ambient air entering the system produced an average of 11.3 pct SO_2 in the offgases. Based on these results, offgases containing 4 to 8 pct SO_2 would be produced when smelting similar materials at established rates in a commercial electric furnace.

APPENDIX.--CHEMICAL ANALYSES OF FURNACE CHARGES AND SMELTING PRODUCTS

TABLE A-1. - Compositions for smelting test 1

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (6,871 lb)	[1]1,729	-	158	-	1,707	-	172	-	91	-	53	-	10.6	-	759	-	122	-	102	-	1,372	-
Products:																						
Matte--1 (992 lb)......	502	50.6	10	1.05	166	16.7	33	3.32	9	0.86	6.2	0.63	5.5	0.55	-	-	-	-	-	-	251	25.3
Slag--1 (560 lb).......	4	.77	3	.50	216	38.6	4	.68	10	1.80	2.6	.47	.2	.03	190	33.9	23	4.17	19	3.35	5	.9
Matte--2 (1,358 lb)....	671	49.4	15	1.10	242	17.8	45	3.30	12	.91	8.0	.59	6.9	.51	-	-	-	-	-	-	325	23.9
Slag--2 (643 lb).......	14	2.11	4	.64	226	35.2	5	.85	11	1.70	2.6	.40	.3	.04	217	33.8	31	4.81	25	3.88	11	1.73
Matte--3 (1,116 lb)....	459	41.1	10	.91	231	20.7	81	7.28	11	.95	8.0	.72	4.7	.42	-	-	-	-	-	-	272	24.4
Slag--3 (861 lb).......	9	1.10	6	.68	283	32.9	6	.73	16	1.90	4.3	.50	.3	.03	305	35.4	46	5.35	34	3.97	13	1.50
Matte--4..............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slag--4...............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Baghouse (75 lb).......	7	9.05	33	44.0	6	8.41	3	3.50	1	1.70	1.9	2.56	-	.02	1	1.87	-	-	-	-	6	7.56
Other (41 lb)..........	11	27.1	2	4.2	9	21.2	1	3.37	1	2.35	.3	.63	-	.029	2	5.50	-	-	-	-	8	20.2
Total (5,646 lb)....	1,677	-	83	-	1,379	-	178	-	71	-	33.9	-	17.9	-	715	-	100	-	78	-	891	-

[1]Weights are based on ASARCO analyses of charge materials before blending.

TABLE A-2. - Material accountabilities for smelting test 1

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (50.4 wt-pct)......	94.4	22.2	37.4	92.4	35.2	41.9	161.3	-	-	-	61.8
Slag (30.0 wt-pct).......	1.6	8.2	42.5	8.7	40.6	17.9	7.5	93.8	82.0	76.5	2.1
Baghouse (1.1 wt-pct)....	.4	20.9	.4	1.7	1.1	3.6	0	.1	-	-	.4
Other (0.6 wt-pct).......	.6	1.3	.5	.6	1.1	.6	0	.3	-	-	.6
Total (82.1 wt-pct).	97.0	52.5	80.8	103.4	78.0	64.0	168.9	94.2	82.0	76.5	64.9

TABLE A-3. - Compositions for smelting test 2

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (7,680 lb)	[1]1,744	-	152	-	1,982	-	221	-	102	-	59	-	14	-	1,116	-	121	-	109	-	1,349	-
Products:																						
Matte--1 (1,193 lb)....	583	48.9	3	0.25	206	17.2	57	4.77	10	0.80	7.4	0.62	8.9	0.75	-	-	-	-	-	-	269	22.5
Slag--1 (812 lb).......	10	1.23	5	.62	300	36.9	9	1.10	13	1.64	5.0	.62	.2	.04	262	32.3	26	3.2	26	3.2	8	1.00
Matte--2 (1,129 lb)....	514	45.5	13	1.14	230	20.4	40	3.51	10	.92	9.4	.83	9.3	.82	-	-	-	-	-	-	254	22.5
Slag--2 (1,082 lb).....	10	.91	5	.47	393	36.3	11	1.03	17	1.59	5.5	.51	.3	.03	431	39.9	38	3.5	34	3.1	11	1.01
Matte--3 (886 lb)......	414	46.7	9	1.00	160	18.0	42	4.79	8	.92	6.8	.77	6.6	.74	-	-	-	-	-	-	211	23.8
Slag--3 (1,014 lb).....	13	1.3	6	.58	368	36.3	12	1.17	17	1.63	4.7	.47	.9	.10	418	41.3	28	2.80	32	3.15	22	2.17
Matte--4 (325 lb)......	152	46.7	3	1.00	59	18.0	13	4.09	3	.92	.5	.16	2.4	.74	-	-	-	-	-	-	77	23.8
Slag--4 (296 lb).......	26	8.74	2	.70	92	31.1	5	1.63	4	1.20	.5	.18	.4	.14	122	41.2	7	2.29	12	4.16	13	4.40
Baghouse (183 lb)......	18	9.57	77	42.2	18	9.57	9	5.10	4	2.05	4.6	2.50	.1	.03	2	1.10	-	-	-	-	12	6.75
Other (76 lb)..........	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total (6,996 lb)....	1,740	-	123	-	1,816	-	198	-	86	-	43.4	-	28.0	-	1,235	-	98	-	102	-	877	-

[1]Weights are based on ASARCO analyses of charge materials before blending.

TABLE A-4. - Material accountabilities for smelting test 2

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (46.0 wt-pct)......	95.4	18.4	32.5	68.8	30.4	40.8	186.4	-	-	-	60.1
Slag (41.7 wt-pct).......	3.4	11.8	58.2	16.7	50.0	26.6	12.9	110.5	81.0	95.4	4.0
Baghouse (2.4 wt-pct)....	1.0	50.7	.9	4.1	3.9	7.8	.7	.2	-	-	.9
Other (1.0 wt-pct).......	-	-	-	-	-	-	-	-	-	-	-
Total (91.1 wt-pct).	99.8	80.9	92.6	89.6	84.3	75.2	200.0	110.7	81.0	95.4	65.0

TABLE A-5. - Compositions for smelting test 3

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (8,863 lb)	[1]1,778	-	209	-	2,268	-	250	-	113	-	55	-	16	-	1,394	-	203	-	128	-	1,799	-
Products:																						
Matte--1 (1,076 lb)....	426	39.6	12	1.12	255	23.7	47	4.4	9	0.81	8.7	0.81	4.7	0.44	-	-	-	-	-	-	274	25.5
Slag--1 (431 lb).......	5	1.16	2	.46	131	30.4	4	.93	6	1.39	1.7	.39	.1	.02	185	42.9	24	5.57	14	3.25	2	.46
Matte--2 (842 lb)......	349	41.4	9	1.11	210	24.9	33	3.86	9	1.01	6.1	.72	3.9	.46	-	-	-	-	-	-	201	23.9
Slag--2 (1,080 lb).....	19	1.76	5	.46	342	31.7	10	.93	14	1.29	4.0	.37	.5	.05	439	40.7	55	5.10	37	3.43	29	2.69
Matte--3 (1,217 lb)....	458	37.6	15	1.20	330	27.1	44	3.60	16	1.30	7.1	.58	5.4	.44	-	-	-	-	-	-	326	26.8
Slag--3 (851 lb).......	29	3.41	4	.47	257	30.2	10	1.17	12	1.41	3.4	.40	.6	.07	350	41.1	46	5.40	28	3.29	11	1.29
Matte--4 (1,487 lb)....	556	37.4	14	.94	439	29.5	59	3.97	22	1.48	5.0	.34	6.4	.43	-	-	-	-	-	-	392	26.4
Slag--4 (810 lb).......	25	3.09	3	.37	328	40.5	8	.99	9	1.11	1.7	.21	.4	.05	341	42.1	40	4.93	25	3.09	19	2.34
Baghouse (201 lb)......	7	3.38	113	56.3	16	7.8	10	4.8	4	2.18	6.4	3.21	-	.01	2	1.02	-	-	-	-	9	4.26
Other (138 lb).........	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total (8,133 lb)....	1,874	-	117	-	2,248	-	224	-	101	-	42.8	-	22.0	-	1,307	-	163	-	104	-	1,263	-

[1]Weights are based on ASARCO analyses of charge materials before blending.

TABLE A-6. - Material accountabilities for smelting test 3

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (52.1 wt-pct)......	100.6	23.9	54.4	73.2	49.6	47.1	127.5	-	-	-	66.3
Slag (35.8 wt-pct).......	4.4	6.7	44.0	12.4	36.3	19.3	10.0	93.6	80.3	81.3	3.4
Baghouse (2.3 wt-pct)....	.4	54.1	.7	4.0	3.5	11.6	-	-	-	-	.5
Other (1.6 wt-pct).......	-	-	-	-	-	-	-	-	-	-	-
Total (91.8 wt-pct).	105.4	84.7	99.1	89.6	89.4	77.9	137.5	93.6	80.3	81.3	70.2

TABLE A-7. - Compositions for smelting test 4

Material	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (8,817 lb)	[1]1,776	-	209	-	2,268	-	248	-	114	-	54	-	15	-	1,394	-	203	-	128	-	1,800	-
Products:																						
Matte--1 (1,137 lb)....	458	40.3	15	1.30	272	23.9	60	5.26	12	1.06	7.8	0.69	4.9	0.43	-	-	-	-	-	-	289	25.4
Slag--1 (829 lb).......	16	1.97	5	.55	266	32.1	8	.99	13	1.60	3.5	.42	.3	.04	320	38.6	48	5.79	25	3.06	26	1.98
Matte--2 (1,541 lb)....	559	36.3	21	1.38	385	25.0	86	5.56	20	1.28	13.3	.86	6.9	.45	-	-	-	-	-	-	390	25.3
Slag--2 (894 lb).......	7	.8	4	.46	271	30.3	8	.87	15	1.66	1.6	.18	.2	.02	390	43.6	49	5.48	27	3.07	8	.95
Matte--3 (894 lb)......	316	35.4	14	1.52	237	26.5	36	4.04	12	1.36	6.2	.69	3.3	.37	-	-	-	-	-	-	224	25.1
Slag--3 (827 lb).......	31	3.74	4	.52	241	29.2	13	1.59	9	1.07	1.1	.13	.4	.05	333	40.3	43	5.23	25	2.99	24	2.96
Matte--4 (1,049 lb)....	367	35.0	12	1.14	288	27.5	41	3.92	17	1.62	7.7	.73	3.9	.37	-	-	-	-	-	-	259	24.7
Slag--4 (410 lb).......	15	3.74	2	.52	120	29.2	6	1.59	7	1.66	1.7	.42	.1	.03	165	40.3	22	5.32	12	2.99	4	1.08
Baghouse (208 lb)......	10	4.71	104	50.1	9	4.3	12	5.75	7	3.36	7.1	3.40	.04	.02	-	-	-	-	-	-	7.6	3.64
Other (106 lb).........	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total (7,895 lb)....	1,779	-	181	-	2,089	-	270	-	112	-	49.9	-	20.0	-	1,208	-	162	-	89	-	1,224	-

[1]Weights are based on ASARCO analyses of charge materials before blending.

TABLE A-8. - Material accountabilities for smelting test 4

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (52.4 wt-pct)......	95.7	29.7	52.1	89.9	53.5	64.8	126.7	-	-	-	64.6
Slag (33.6 wt-pct).......	3.9	7.1	39.6	14.1	38.6	14.4	6.7	86.7	79.8	69.5	3.4
Baghouse (2.4 wt-pct)....	.6	49.8	.4	4.8	6.1	13.1	-	-	-	-	.4
Other (1.2 wt-pct).......	-	-	-	-	-	-	-	-	-	-	-
Total (89.6 wt-pct).	100.2	86.6	92.1	108.8	98.2	92.3	133.4	86.7	79.8	69.5	68.4

TABLE A-9. - Compositions for smelting test 5

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (8,342 lb)	[1]1,674	-	197	-	2,134	-	234	-	107	-	52	-	15	-	1,312	-	191	-	120	-	1,693	-
Products:																						
Matte--1 (1,040 lb)....	402	38.7	8	0.81	267	25.7	39	3.72	10	0.93	7.1	0.68	4.7	0.45	-	-	-	-	-	-	271	26.1
Slag--1 (647 lb).......	3	.5	2	.37	192	29.7	4	.68	8	1.20	.4	.06	.1	.02	2.80	43.2	35	5.35	22	3.33	5	.78
Matte--2 (1,369 lb)....	541	39.5	13	.95	354	25.9	55	4.02	13	.95	12.9	.95	6.4	.46	-	-	-	-	-	-	354	25.9
Slag--2 (923 lb).......	5	.54	4	.43	277	30.0	6	.65	12	1.30	3.8	.41	.3	.03	387	42.0	51	5.53	31	3.36	9	.98
Matte--3 (1,390 lb)....	557	40.1	15	1.07	332	23.9	70	5.0	13	.95	11	.79	7.4	.53	-	-	-	-	-	-	345	24.8
Slag--3 (443 lb).......	4	.94	1	.31	127	28.6	3	.73	6	1.40	1.5	.34	.2	.05	187	42.1	21	4.82	15	3.35	4	.87
Matte--4 (611 lb)......	242	39.6	6	.98	144	23.6	26	4.25	6	.98	5.6	.92	2.7	.44	-	-	-	-	-	-	158	25.9
Slag--4 (1,202 lb).....	8	.66	4	.33	388	32.3	8	.66	16	1.33	2.7	.22	.3	.02	507	42.1	67	5.56	43	3.58	13	1.08
Baghouse (202 lb)......	3	1.68	110	54.4	5	2.3	15	7.5	8	4.00	8.2	4.10	-	.01	26	12.8	-	-	-	-	5	2.3
Other (163 lb).........	11	6.75	17	10.4	3	1.84	23	14.1	12	7.36	5	3.07	-	-	38	23.3	-	-	-	-	15	9.20
Total (7,990 lb)....	1,776	-	180	-	2,110	-	249	-	104	-	56.4	-	22	-	1,425	-	174	-	111	-	1,181	-

[1]Weights are based on ASARCO analyses of charge materials before blending.

TABLE A-10. - Material accountabilities for smelting test 5

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (52.9 wt-pct)......	104.1	21.3	51.4	81.2	39.3	70.4	141.3	-	-	-	66.7
Slag (38.5 wt-pct).......	1.2	5.6	46.1	9.0	39.3	12.7	5.3	103.7	91.1	92.5	1.8
Baghouse (2.4 wt-pct)....	.2	55.8	1.2	6.4	7.5	15.8	-	2.0	-	-	.3
Other (2.0 wt-pct).......	.7	8.6	.1	9.8	11.2	9.6	-	12.9	-	-	.9
Total (95.8 wt-pct).	106.2	91.3	98.8	106.4	97.3	108.5	146.6	108.6	91.1	92.5	69.7

TABLE A-11. - Compositions for smelting test 6

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (8,330 lb)	[1]1,898	22.3	244	2.93	2,224	26.7	275	3.30	121	1.45	33	0.4	17	0.21	1,224	14.7	67	0.81	137	1.64	1,624	19.5
Products:																						
Matte--1 (1,619 lb)....	553	34.16	15	.94	495	30.6	54	3.35	18	1.11	9.5	.59	4.3	.27	-	-	-	-	-	-	423	26.2
Slag--1 (725 lb).......	3	.44	2	.30	182	25.1	5	.67	8	1.15	2.0	.28	.1	.02	329	45.4	37	5.12	39	5.43	6	.79
Matte--2 (1,137 lb)....	376	33.1	10	.89	352	31.0	39	3.41	13	1.15	6.4	.56	2.8	.25	-	-	-	-	-	-	299	26.3
Slag--2 (363 lb).......	3	.84	1	.26	97	26.7	3	.87	5	1.40	1.3	.35	.1	.03	164	45.3	14	3.93	17	4.70	4	1.20
Matte--3 (1,363 lb)....	481	35.3	13	.97	394	28.9	47	3.47	19	1.36	8.7	.64	5.5	.40	-	-	-	-	-	-	353	25.9
Slag--3 (875 lb).......	5	.58	3	.34	245	28.0	8	.94	13	1.50	3.3	.38	2	.02	396	45.2	32	3.61	40	4.61	9	.92
Matte--4 (729 lb)......	255	35.0	7	.97	211	29.0	22	3.07	9	1.23	4.1	.56	2.8	.38	-	-	-	-	-	-	189	25.9
Slag--4 (509 lb).......	3	.58	2	.34	143	28.0	5	1.00	8	1.60	1.5	.29	.1	.02	230	45.2	18	3.61	23	4.61	5	.92
Baghouse (142 lb)......	2	1.42	78	55.2	8	5.6	11	7.5	5	3.35	4.7	3.30	-	-	1	.71	-	-	-	-	11	7.98
Other (393 lb).........	53	13.5	73	18.6	15	3.82	17	4.32	12	3.05	7.1	1.81	-	-	38	9.67	-	-	-	-	55	14.0
Total (7,860 lb)....	1,735	-	204	-	2,142	-	221	-	110	-	48.7	-	15.9	-	1,158	-	101	-	119	-	1,355	-

[1]Value includes 40 lb of Cu starting plate.

TABLE A-12. - Material accountabilities for smelting test 6

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (58.2 wt-pct)......	87.7	18.4	65.3	58.9	48.8	87.0	90.6	-	-	-	77.8
Slag (29.7 wt-pct).......	.8	3.3	30.0	7.6	28.1	24.5	2.9	91.4	150.7	86.9	1.5
Baghouse (1.7 wt-pct)....	.1	32.0	.4	4.0	4.1	14.2	-	-	-	-	.7
Other (4.8 wt-pct).......	2.8	29.9	.7	9.8	9.9	21.8	-	3.2	-	-	3.4
Total (94.4 wt-pct).	91.4	83.6	96.4	80.3	90.9	147.5	93.5	94.6	150.7	86.9	83.4

TABLE A-13. - Compositions for smelting test 7

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (8,215 lb)	[1]1,699	20.2	186	2.27	2,078	25.3	181	2.20	96	1.17	41	0.50	15	0.18	1,174	14.3	94	1.14	131	1.59	1,635	19.9
Products:																						
Matte--1 (1,243 lb)....	459	36.9	12	1.0	359	28.9	37	2.97	14	1.16	6.1	.49	3.2	.26	-	-	-	-	-	-	343	27.6
Slag--1 (229 lb).......	1	.61	.8	.36	63.2	27.6	2	1.02	3.0	1.30	.6	.28	.1	.047	104	45.2	9.3	4.04	10	4.34	2	.75
Matte--2 (1,311 lb)....	414	31.6	8	.64	412	31.4	59	4.53	14	1.07	9.2	.70	3.8	.29	-	-	-	-	-	-	330	25.2
Slag--2 (860 lb).......	4	.46	4	.48	229	26.5	8	.93	12	1.40	.6	.07	.2	.02	401	46.6	35.0	4.08	37	4.30	6	.70
Matte--3 (1,258 lb)....	404	32.1	8	.60	400	31.8	66	5.26	15	1.21	8.4	.67	3.4	.27	-	-	-	-	-	-	312	24.8
Slag--3 (1,232 lb).....	9	.73	3.6	.29	335	27.2	12	.96	18	1.46	3.6	.29	.5	.04	548	44.5	41.4	3.36	52	4.22	13	1.06
Matte--4 (901 lb)......	299	33.2	5	.59	277	30.7	41	4.56	11	1.25	5.9	.66	2.7	.30	-	-	-	-	-	-	221	24.5
Slag--4 (245 lb).......	1	.49	6	.23	66	26.8	2	.94	4	1.50	.8	.33	.1	.038	110	44.8	8.2	3.36	10	4.22	2	.82
Baghouse (132 lb)......	4	2.74	70	52.9	3	2.3	10	7.80	4	3.30	4.5	3.14	-	-	-	-	-	-	-	-	8	6.34
Other (223 lb).........	20	8.97	35	15.7	10	4.48	15	6.73	4	1.79	3.4	1.52	-	-	-	-	-	-	-	-	83	37.2
Total (7,634 lb)....	1,615	-	146	-	2,164	-	252	-	99	-	43.1	-	14.0	-	1,163	-	94	-	109	-	1,320	-

[1]Value includes 40 lb of Cu starting plate.

TABLE A-14. - Material accountabilities for smelting test 7

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (57.4 wt-pct)......	92.8	17.7	69.7	112.2	56.3	72.2	87.3	-	-	83.2	73.8
Slag (31.2 wt-pct).......	.9	4.4	33.3	13.3	38.5	13.7	6.0	99.1	99.9	-	1.4
Baghouse (1.6 wt-pct)....	.2	37.6	.1	5.5	4.2	11.0	-	-	-	-	.5
Other (2.7 wt-pct).......	1.2	18.8	1.0	8.3	4.2	8.3	-	-	-	-	4.2
Total (92.9 wt-pct).	95.1	78.5	1,041	139.3	103.2	105.2	93.3	99.1	99.9	83.2	80.9

TABLE A-15. - Compositions for smelting test 9

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (5,594 lb)	[1]1,224	21.1	354	6.32	878	15.7	83.9	1.50	59.3	1.06	43.6	0.78	10.1	0.18	828	14.8	88	1.58	35	0.62	1,365	24.4
Products:																						
Matte--1 (1,380 lb)....	530	38.4	25	1.81	348	25.2	43	3.11	11.2	.81	19.6	1.42	4.4	.32	-	-	-	-	-	-	353	25.6
Slag--1...............	No slag was tapped																					
Matte--2 (1,259 lb)....	491	39.0	15	1.17	330	26.2	37	2.90	11.1	.88	12.3	.98	4.0	.32	-	-	-	-	-	-	335	26.6
Slag--2 (24 lb)........	.3	1.35	.2	.99	6.1	25.6	.3	1.35	.3	1.10	.1	.58	.1	.23	7.7	32.2	6.1	1.93	.4	1.72	2	8.01
Matte--3 (212 lb)......	104	49.1	2	.87	30	13.9	16	7.64	1.2	.55	2.3	1.07	1.8	.85	-	-	-	-	-	-	51	23.8
Slag--3 (809 lb).......	9.7	1.20	3.0	.37	155	19.2	2.3	.28	5.4	.67	.5	.06	.2	.02	528	65.2	27	3.33	22	2.74	6	.70
Matte--4 (110 lb)......	61	55.1	1	.97	14.1	12.8	4	3.48	.6	.51	.6	.56	.8	.73	-	-	-	-	-	-	23.5	21.4
Slag--4 (433 lb).......	31	7.22	2	.46	121	28.0	6.2	.77	4.5	1.03	.2	.05	.6	.14	163	37.6	15	3.50	13	2.96	10	2.24
Baghouse (349 lb)......	13.4	3.84	194	55.6	11	3.09	15.2	4.36	9.1	2.61	8.2	2.35	-	-	4.2	1.20	-	-	-	-	9.3	2.66
Other (78 lb)..........	9.5	12.2	24	30.8	5.7	7.31	9.7	12.4	5.4	6.92	2.1	2.69	-	-	2.5	3.21	-	-	-	-	10.1	12.9
Total (4,654 lb)....	1,250	-	271	-	1,020	-	133	-	49	-	45.9	-	11.9	-	704	-	43	-	35.4	-	799	-

[1]Value includes 44 lb of Cu starting plate.

TABLE A-16. - Material accountabilities for smelting test 9

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (52.9 wt-pct)......	96.9	13.5	82.2	118.5	40.6	79.8	108.9	0.2	-	-	55.8
Slag (22.6 wt-pct).......	3.4	1.5	32.2	10.5	17.2	1.8	8.9	84.3	48.9	102.0	1.3
Baghouse (6.2 wt-pct)....	1.1	31.5	1.2	10.3	7.9	11.0	-	.6	-	-	.7
Other (1.4 wt-pct).......	.8	30.2	.6	19.4	16.5	12.6	-	-	-	-	.7
Total (83.1 wt-pct).	102.2	76.7	116.2	158.7	82.2	105.2	117.8	85.1	48.9	102.0	58.5

TABLE A-17. - Compositions for smelting test 10

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (8,438 lb)	[1]1,716	19.7	79	0.94	2,126	25.2	186	2.20	89	1.05	20	0.24	26	0.31	1,595	18.9	56	0.66	146	1.73	1,612	19.1
Products:																						
Matte--1 (237 lb)......	85	36.0	1.1	.47	69	29.2	7	2.95	2	.83	1.2	.51	.9	.36	-	-	-	-	-	-	60	25.4
Slag--1 (685 lb).......	.6	.84	.8	.11	197	28.7	6.6	.96	7.2	1.05	.8	.12	.2	.03	338	49.4	3.4	.49	25.4	3.71	7.0	1.02
Matte--2 (1,516 lb)....	526	34.7	9.1	.60	464	30.6	46	3.04	15	.99	8.2	.54	5.6	.37	-	-	-	-	-	-	379	25.0
Slag--2 (1,115 lb).....	9	.81	1.8	.16	310	27.8	10	.90	11.1	1.0	2.9	.26	.3	.03	542	48.6	8.0	.72	43	3.87	9.7	.87
Matte--3 (1,489 lb)....	560	37.6	10.3	.69	423	28.4	51	3.04	12	.83	9.2	.62	6.6	.44	-	-	-	-	-	-	380	25.5
Slag--3 (484 lb).......	6	1.30	.9	.18	130	26.9	5	.98	4.5	.92	1.2	.25	.2	.04	244	50.5	4.5	.92	16	3.31	5	1.12
Matte--4 (901 lb)......	345	38.3	5.8	.64	239	26.5	34	3.72	6.9	.77	6.1	.68	4.4	.49	-	-	-	-	-	-	223	24.7
Slag--4 (633 lb).......	8	1.30	1.6	.26	192	30.3	7	1.16	7.4	1.17	2.0	.32	.3	.04	299	47.3	4.4	.70	22	3.50	7	1.15
Baghouse (137 lb)......	7	5.3	38.2	27.9	9	6.3	20	14.6	8	5.8	3.8	2.77	-	.02	2.7	1.97	-	-	-	-	10	7.6
Other (214 lb).........	13	6.07	7	3.27	10	4.67	7	3.27	4.3	2.0	1	.47	.1	.05	4.7	2.20	-	-	-	-	12	5.61
Total (7,411 lb)....	1,560	-	77	-	2,043	-	194	-	78	-	36	-	19	-	1,430	-	20	-	106	-	1,093	-

[1]Value includes 54 lb of Cu starting plate.

TABLE A-18. - Material accountabilities for smelting test 10

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (49.1 wt-pct)......	88.3	33.3	56.2	73.8	40.8	123.5	67.3	-	-	-	65.6
Slag (34.6 wt-pct).......	1.4	6.5	39.0	15.9	33.9	34.5	3.1	89.3	36.2	73.2	1.8
Baghouse (1.6 wt-pct)....	.4	48.4	.4	10.8	9.0	19.0	-	.2	-	-	.6
Other (2.5 wt-pct).......	.8	8.9	.5	3.5	4.8	5.0	-	.3	-	-	.7
Total (87.8 wt-pct).	90.9	97.1	96.1	104.0	88.5	182.0	70.4	89.8	36.2	73.2	68.7

TABLE A-19. - Compositions for smelting test 11

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (8,881 lb)	[1]1,845	20.1	92.4	1.04	1,901	21.4	240	2.70	97.7	1.1	50.6	0.57	21.3	0.24	-	-	62.2	0.70	-	-	1,599	18.0
Product:																						
Matte--1 (1,133 lb)....	407	35.9	7.1	.63	321	28.3	45	3.97	9.6	.85	7.6	.67	4.6	.41	-	-	-	-	-	-	286	25.2
Slag--1 (1,628 lb).....	12	.74	4.5	.28	519	31.9	19	1.17	18.6	1.14	4.5	.28	.3	.02	727	44.7	19	1.17	54	3.32	18	1.11
Matte--2 (1,164 lb)....	439	37.7	7.2	.62	312	26.8	57	4.90	8.5	.73	8.0	.69	5.3	.46	-	-	-	-	-	-	284	24.4
Slag--2 (1,426 lb).....	26	1.82	3.2	.22	449	31.5	15	1.05	13.5	.95	2.1	.15	.6	.04	637	44.7	12	.84	49	3.4	14	.98
Matte--3 (1,046 lb)....	424	40.5	8.1	.77	274	26.2	34	3.25	7.8	.75	7.0	.67	5.2	.50	-	-	-	-	-	-	262	25.0
Slag--3 (648 lb).......	3	.46	.7	.11	213	32.9	5	.77	6.5	1.00	.6	.09	.1	.02	279	43.1	7	1.08	23	-	6	.93
Matte--4..............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slag--4...............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Baghouse (137 lb)......	9	6.4	33.0	24.1	7	5.3	19	13.9	10.4	7.6	4.2	3.07	-	.02	-	-	-	-	-	-	11	7.9
Other (202 lb).........	21	10.4	9.6	4.75	22	10.9	14	6.93	9.2	4.55	1.7	.84	-	.03	-	-	-	-	-	-	19	9.41
Total (7,384 lb)....	1,341	-	73.4	-	2,118	-	208	-	84.1	-	35.9	-	16.1	-	1,642	-	38	-	126	-	907	-

[1]Value includes 60 lb of Cu starting plate.

TABLE A-20. - Material accountabilities for smelting test 11

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (37.6 wt-pct)......	68.8	24.2	47.7	56.7	26.5	45.1	70.9	-	-	-	51.9
Slag (41.7 wt-pct).......	2.2	9.1	62.2	16.1	39.5	14.2	4.7	-	60.3	-	3.0
Baghouse (1.5 wt-pct)....	.5	35.7	.4	8.0	10.6	8.3	-	-	-	-	.7
Other (2.3 wt-pct).......	1.1	10.4	1.2	5.9	9.4	3.4	-	-	-	-	1.2
Total (83.1 wt-pct).	72.6	79.4	111.5	86.7	86.0	71.0	75.6	-	60.3	-	56.8

TABLE A-21. - Compositions for smelting test 12

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (9,750 lb)	[1] 2,104	21.0	235	2.41	2,555	26.2	229	2.35	114	1.17	390	0.40	23.4	0.24	1,511	15.5	31	0.32	24	0.25	1,843	18.9
Product:																						
Matte--1 (1,726 lb)....	593	34.4	16.3	.94	505	29.3	58	3.36	16	.93	10.9	.63	6.3	.37	-	-	-	-	-	-	390	22.6
Slag--1 (803 lb).......	8	1.01	2.8	.35	272	33.9	11	1.40	11	1.31	1.0	.12	.2	.03	328	40.8	7.0	.87	25	3.08	12	1.47
Matte--2 (1,269 lb)....	478	37.7	13.6	1.07	344	27.1	40	3.12	12	.91	8.5	.67	5.7	.45	-	-	-	-	-	-	319	25.1
Slag--2 (1,140 lb).....	6	.54	3.5	.31	385	33.8	11	1.00	14	1.19	1.9	.17	.7	.06	473	41.5	12	1.03	34	2.99	12	1.07
Matte--3 (1,338 lb)....	504	37.7	12.9	.96	365	27.3	59	4.41	12	.90	10.0	.75	6.0	.45	-	-	-	-	-	-	348	26.0
Slag--3 (1,198 lb).....	15	1.25	3.2	.27	366	30.6	10	.83	12	1.00	.7	.06	.5	.04	543	45.3	12	1.00	35	2.92	14	1.17
Matte--4 (891 lb)......	326	36.6	8.7	.98	247	27.7	25	2.85	9	1.00	5.8	.65	3.2	.36	-	-	-	-	-	-	232	26.0
Slag--4 (217 lb).......	1	.52	.5	.23	68	31.4	2	.82	2	1.00	.3	.14	-	.02	97.0	44.7	3	1.13	7	3.18	2	.81
Baghouse (350 lb)......	24	6.7	132	37.7	25	7.26	25	7.26	13	3.71	8.7	2.49	-	.01	8	2.37	-	-	-	-	27	7.7
Other (220 lb).........	17	7.69	9	4.07	17	7.69	12	5.43	6	2.71	1.4	.63	.2	.08	5	2.26	-	-	-	-	4	1.81
Total (9,153 lb)....	1,972	-	203	-	2,596	-	254	-	106	-	49.2	-	22.6	-	1,455	-	33	-	101	-	1,367	-

[1] Value includes 56 lb of Cu starting plate.

TABLE A-22. - Material accountabilities for smelting test 12

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (53.6 wt-pct)......	90.4	21.9	57.2	79.1	42.2	90.3	90.6	-	-	413	69.9
Slag (34.4 wt-pct).......	1.4	4.3	42.7	15.1	33.5	10.0	6.0	95.4	106.7	-	2.2
Baghouse (3.6 wt-pct)....	1.1	56.1	1.0	11.1	11.4	22.3	-	.5	-	-	1.5
Other (2.3 wt-pct).......	.8	3.9	.7	5.4	5.6	3.6	-	.4	-	-	.6
Total (93.9 wt-pct).	93.7	86.2	101.6	110.7	92.7	126.2	96.6	96.3	106.7	413	74.2

TABLE A-23. - Compositions for smelting test 13

Materials	Cu		As		Fe		Pb		Zn		Sb		Ni		SiO_2		CaO		Al_2O_3		S	
	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct	Lb	Wt-pct
Furnace charge (5,231 lb)	[1]1,263	23.0	212	4.06	1,125	21.5	94	1.80	42	0.80	26.2	0.50	9.4	0.18	727	13.9	101	1.93	58	1.11	1,193	22.8
Products:																						
Matte--1 (1,700 lb)....	632	37.2	20	1.18	419	24.6	45	2.65	15	.88	10.0	.59	3.8	.22	-	-	-	-	-	-	383	22.5
Slag--1 (892 lb).......	4	.47	2	.24	256	28.7	4	.42	8	.90	.4	.04	.2	.02	389	43.6	49	5.52	30.6	3.43	7	.76
Matte--2 (974 lb)......	387	39.7	16	1.6	230	23.6	32	3.33	9	.90	5.8	.60	3.5	.36	-	-	-	-	-	-	243	24.9
Slag--2 (580 lb).......	8	1.38	3	.56	171	29.4	4	.64	7	1.14	2.0	.34	.2	.03	237	40.9	29	4.96	18	3.09	8	1.32
Matte--3..............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slag--3...............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Matte--4..............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slag--4...............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Baghouse (243 lb)......	15	6.3	114	47.0	12	4.94	9	3.70	5	2.10	6.5	2.67	-	.02	7	2.76	-	-	-	-	17	7.00
Other (98 lb)..........	13	13.3	20	20.4	14	14.3	10	10.2	6	6.12	3.5	3.57	-	.05	4	4.08	-	-	-	-	11	11.2
Total (4,511 lb)....	1,059	-	175	-	1,101	-	103	-	49	-	28.2	-	7.7	-	637	-	78	-	49	-	668	-

[1]Value includes 60 lb of Cu starting plate.

TABLE A-24. - Material accountabilities for smelting test 13

Products, wt-pct of total furnace charge	Accountability, wt-pct of input										
	Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (51.1 wt-pct)......	80.7	16.9	57.7	82.0	56.9	60.3	77.7	-	-	-	52.4
Slag (28.1 (wt-pct)......	1.0	2.5	37.9	7.9	34.9	9.1	4.2	86.1	77.2	83.4	1.2
Baghouse (4.6 wt-pct)....	1.2	53.7	1.1	9.6	12.2	24.8	-	.9	-	-	1.4
Other (1.9 wt-pct).......	1.0	9.3	1.2	10.2	13.4	13.4	-	.5	-	-	.9
Total (85.7 wt-pct).	83.9	82.4	97.9	109.7	117.4	107.6	81.9	87.5	77.2	83.4	55.9

TABLE A-25. - Compositions for smelting test 14

Materials	Cu Lb	Cu Wt-pct	As Lb	As Wt-pct	Fe Lb	Fe Wt-pct	Pb Lb	Pb Wt-pct	Zn Lb	Zn Wt-pct	Sb Lb	Sb Wt-pct	Ni Lb	Ni Wt-pct	SiO_2 Lb	SiO_2 Wt-pct	CaO Lb	CaO Wt-pct	Al_2O_3 Lb	Al_2O_3 Wt-pct	S Lb	S Wt-pct
Furnace charge (8,045 lb)	[1]1,852	22.5	317	3.94	1,770	22.0	153	1.90	80.5	1.00	53.1	0.66	47.5	0.19	973	12.1	-	-	95	1.18	1,641	20.4
Products:																						
Matte--1 (2,069 lb)....	715	34.6	33	1.59	503	24.3	60	2.90	19	.92	15.1	.73	-	-	-	-	-	-	-	-	502	24.3
Slag--1 (694 lb).......	4	.52	3	.37	176	25.4	3	.44	8	1.14	1.7	.24	.8	.12	325	46.8	41	5.92	24	3.40	6	.80
Matte--2 (1,201 lb)....	459	38.2	14	1.17	324	27.0	38	3.16	11	.92	9.5	.79	-	-	-	-	-	-	-	-	305	25.4
Slag--2 (1,055 lb).....	9	.85	5	.47	287	27.2	7	.66	12	1.14	.5	.05	.3	.03	455	43.1	58	5.49	34	3.22	10	.95
Matte--3 (1,081 lb)....	396	36.6	15	1.39	285	26.4	34	3.15	10	.93	8.7	.80	-	-	-	-	-	-	-	-	286	26.5
Slag--3 (719 lb).......	7	.97	2	.28	190	26.4	3	.42	8	1.11	1.1	.15	.3	.04	317	44.1	34	4.73	27	3.76	6	.83
Matte--4..............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slag--4................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Baghouse (337 lb)......	19	5.6	163	48.4	18	5.22	12	3.50	6	1.63	7.0	2.08	-	-	-	-	-	-	-	-	31	9.3
Other (156 lb).........	17	10.9	5	3.21	17	10.9	12	7.69	4	2.56	2.0	1.28	-	-	-	-	-	-	-	-	18	11.5
Total (7,312 lb)....	1,625	-	239	-	1,799	-	169	-	77	-	45.6	-	1.4	-	1,097	-	134	-	85	-	1,162	-

[1]Value includes 42 lb of Cu starting plate.

TABLE A-26. - Material accountabilities for smelting test 14

Products, wt-pct of total furnace charge	Accountability, wt-pct of input: Cu	As	Fe	Pb	Zn	Sb	Ni	SiO_2	CaO	Al_2O_3	S
Matte (54.1 wt-pct)......	84.8	19.5	62.8	86.1	49.3	62.7	-	--	-	-	66.5
Slag (30.7 wt-pct).......	1.0	2.9	36.9	8.6	34.3	6.2	-	112.7	-	89.0	1.3
Baghouse (4.2 wt-pct)....	1.0	51.4	1.0	7.7	6.8	13.2	-	-	-	-	1.9
Other (1.9 wt-pct).......	.9	1.6	.9	8.1	5.5	3.8	-	-	-	-	1.1
Total (90.9 wt-pct).	87.7	75.4	101.6	110.5	95.9	85.9	-	112.7	-	89.0	70.8

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