MASTER METALS, INC., 2850 W. THIRD ST., CLEVELAND, OHIO 44113 • (216) 621-2361 FAX 621-7475

Lead Smelter and Refiner

21 August 1991

Ohio Environmental Protection Agency
Division of Solid and Hazardous Waste Management
1800 WaterMark Drive
Columbus, Ohio 43266-1049

RE: Certification of Precompliance

Dear Sir:

On 21 May 1991 Master Metals, a secondary lead smelting facility, submitted a notification of possible hazardous waste activity based on the industrial furnace regulations.

As specified in Part 266.10 (c), operators of smelting, melting, and refining furnaces, that process hazardous waste solely for metal recovery are conditionally exempt from the industrial furnace regulations unless the hazardous waste has a total concentration of organic compounds listed in Part 261, Appendix VIII, exceeding 500ppm. One feedstock processed by Master Metals contains tetraethyl lead (TEL), an organic compound listed in Appendix VIII. The amount of TEL in the material varies and may at times exceed 500 ppm.

Master Metals had requested for advice as to whether Master Metals is exempt from Part 266.100 and if not exempt what additional standards are applicable to this situation. No response has been forthcoming from USEPA or OEPA on this matter.

Therefore, Master Metals is submitting an engineering study completed for Master Metals by a registered professional engineer. This study, using computer modeling and best engineering judgement, indicates that the smelting of this material meets the emission standards pertaining to organic emissions, particulate matter, specified metals, HCl, and Cl2. In addition, Master Metals conducted stack compliance testing in March 1991, which indicated compliance with the lead, particulate, and sulfur dioxode emissions limitations.

Master Metals believes that the above is suffficient data to prove compliance with the industrial furnace emissions regulations, even though it is not at all clear whether these regulations pertain in this situation.

Please contact Mr. Rudy A. Zupan at (216) 621-2361 if you have any questions, comments, or require additional information.

Sincerely,

Douglas K. Mickey
President

cc: Michael Cyphert, Esq.
Thompson, Hine, & Flory

USEPA, Region V
Waste Management Division 5HR-13

Hazen Research, Inc.
HAZEN
4601 Indiana St., Golden, CO 80403
279-4501; FAX: 278-1528

#18853

FAX TRANSMITTAL

cc: Barry Hansen

Date: 7/16/90 Time: 1330
Pages: 4 Project: 6911

To: Mr. Douglas Mickey; Master Metals
Fax #: (216) 621-7475
From: Paul Queneau, Hazen Research
Re: Reply to your question, as posed by Chris Knopf (#3; 7/9/90)

Question: What is the interaction between sulfur dioxide emission levels and hazardous constituents in the slag?

Reply: Smelting lead-acid-battery wastes with soda ash and iron in short rotary furnaces typically permits capture of at least 98% the furnace charge's sulfur content as slag, matte, and dust. The balance of the sulfur reports to the gas phase entering the baghouse, generally as SO_2.

The silicate slag phase holds up to ≈2% S, i.e., ≈1/3 of the sulfur in your typical furnace charge. Up to ≈1/2 of the sulfur in Master Metals' typical charge is captured as $Na_2S{\cdot}xFeS$ matte, in which is dissolved PbS and other metal sulfides, as well as FeO. For details on our understanding of the furnace metallurgy, refer to our publication, "Optimizing Matte and Slag Compositions in Rotary Furnace Smelting of Leady Residues."

Up to ≈1/4 of the sulfur in a typical Master Metals' furnace charge first reports to the flue gas, then reacts with metal oxides in the gas, probably to form metal sulfates. The sulfates are collected in the baghouse as flue dust, e.g., as $ZnSO_4$ and $PbSO_4$, then subsequently recycled to the furnace.

Whether the slag-matte waste is hazardous via the EP or TCLP leach tests is hypothesized to be a function of the amount of Na_2O in the slag that is available to neutralize the acidic leachant. The solubility of lead is a minimum at about pH 11. The exact pH of this minimum depends on a number of solution variables, including temperature. Too much Na_2O results in increased lead solubility as $Pb(OH)_3^-$; too little Na_2O results in increased lead solubility as $Pb_6(OH)_8^{4+}$ and $Pb_3(OH)_4^{2+}$. Refer to Figure 15.9 and Table 15.17, attached.

Illinois Environmental Protection Agency 2200 Churchill Road, Springfield, IL 62706

217/782-6760

Refer to: 0312580003 -- Cook County
Riverdale/Acme Steel Co.
Waste Stream Permit #830796

May 19, 1988

David J. Holmberg
Manager - Environmental Services
Acme Steel Company
13500 S. Perry Avenue
Riverdale, Illinois 60627-1182

Dear Mr. Holmberg:

In response to your letter of April 26, 1988 and our phone conversations, please be informed that the charcoal dross currently permitted for disposal in permit 830796 can be considered an "industrial material" if it is used as a feedstock for ASARCO or any other similar lead user and not a solid waste. This material can be transferred for users or re-users without being subject to manifest or annual report requirements, and the material is not subject to 90 day limitation on storage without a permit. This in no way relieves Acme Steel from properly containing, labeling, storing and transporting this industrial material in a proper manner and in accordance with all other pertinent rules.

If you have any further questions, please give me a call. If Acme Steel produces any other industrial materials that may be of use for other industries, or if Acme Steel can use other industries' samples or "waste" materials, consider additional uses of the Industrial Material Exchange Service (IMES, or the "waste exchange") for help with these transactions. I've enclosed a copy of the latest IMES publication.

Sincerely,

Michael F. Nechvatal, Manager
Solid Waste Management Section
Division of Land Pollution Control

MFN:bjh/1458j/113

Enclosure

cc: Division File
L. Eastep, Permits
G. Savage, FOS
H. Chappel, Compliance
J. Morgan, IMES

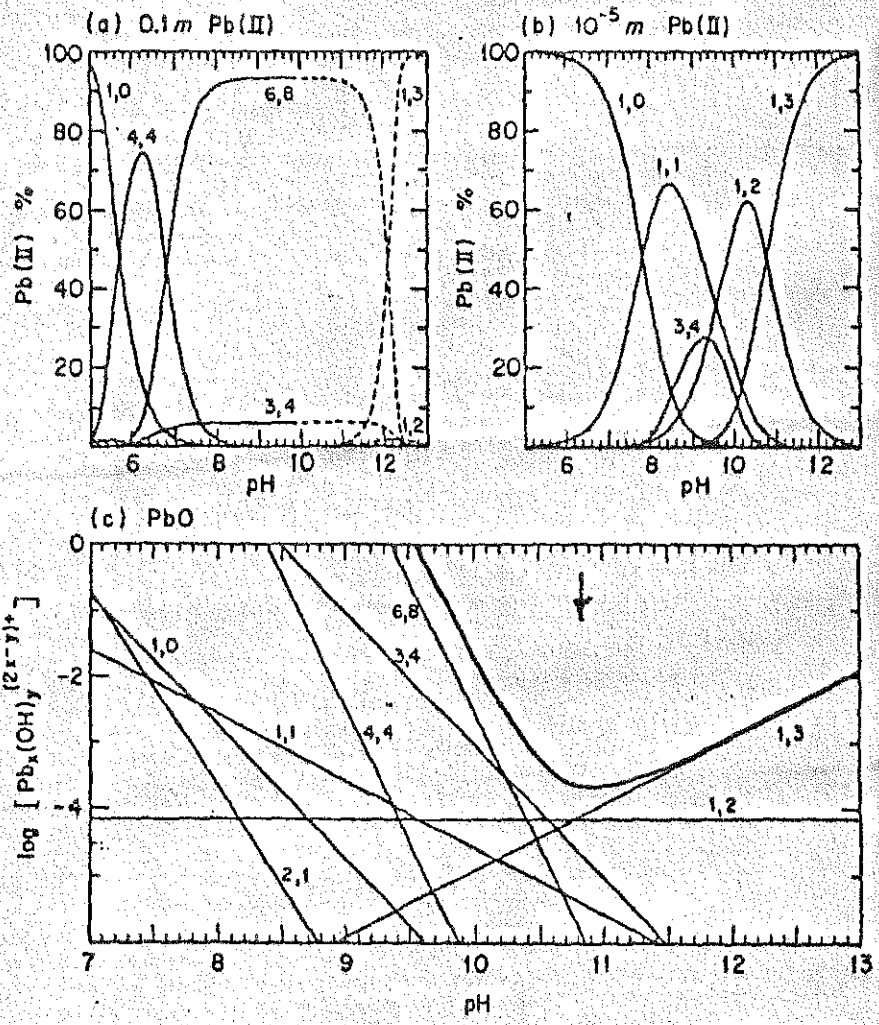

Fig. 15.9. Distribution of hydrolysis products (x,y) at $I = 1$ m and 25° in (*a*) 0.1 m Pb(II), (*b*) 10^{-5} m Pb(II), and (*c*) solutions saturated with PbO. The dashed curves in *a* and *b* denote regions supersaturated with respect to PbO; the heavy curve in *c* is the total concentration of lead(II).

15.4.5 Summary. The hydrolysis behavior of Pb^{2+} ion has been the subject of extensive work involving a large number of physical chemical techniques. This ion is a model case in which the species identification from most of the information is quite consistent. There are seven species (including the uncomplexed Pb^{2+}) which exist under widely varying conditions (see Table 15.17); their distribution is shown in Fig. 15.9. At least four of the hydrolysis species may be considered to be definitely identified, and this is possible because of the

Table 15.17. Summary of Pb^{2+} hydrolysis at 25°C

$$\text{Log } Q_{xy} = \log K_{xy} + aI^{1/2}/(1 + I^{1/2}) + bm_X$$

Species or phase	Log K_{xy}	a	b			$\sigma(\log Q_{xy})$
			$m_X = 0.3$	$m_X = 1.0$	$m_X = 3.5$	
$PbOH^+$	−7.71	−1.022	0.93	0.47	0.156	±0.1
$Pb(OH)_2$	−17.12	−1.022	1.0	0.4	0.09	±0.1
$Pb(OH)_3^-$	−28.06	0	0.67	0.0	−0.21	±0.05
Pb_2OH^{3+}	−6.36	1.022	−0.5	−0.33	−0.17	±0.1
$Pb_3(OH)_4^{2+}$	−23.88	−2.044	4.17	2.13	0.71	±0.2
$Pb_4(OH)_4^{4+}$	−20.88	2.044	0.85	0.41	0.10	±0.1
$Pb_6(OH)_8^{4+}$	−43.61	0	3.18	1.59	0.48	±0.1
PbO(c) (red) (log Q_{s10})	12.72	1.022	0.08	−0.05	−0.05	±0.05

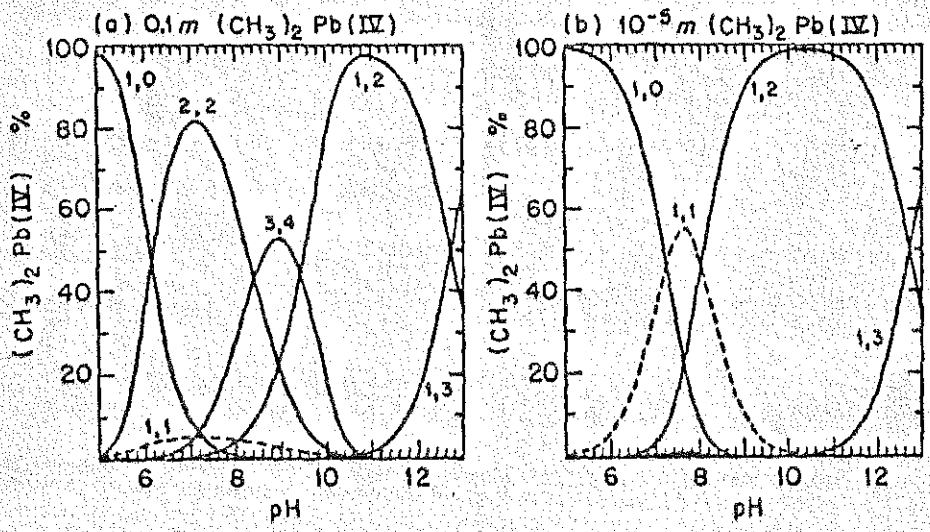

Fig. 15.10. Distribution of dimethyllead(IV) and species (x,y) at $I = 1$ m and 25° in (*a*) 0.1 m $(CH_3)_2Pb(IV)$ and (*b*) 10^{-5} m $(CH_3)_2Pb(IV)$.

wide range of compositions which are available for study. The most prominent polynuclear species are $Pb_4(OH)_4^{4+}$ and $Pb_6(OH)_8^{4+}$. Hydroxyl numbers up to about 1.33 and concentrations of Pb(II) in excess of 2 M are attainable. The stable oxide phase at 25°C is red tetragonal PbO. Hydrolysis of $(CH_3)_2Pb^{2+}$ occurs above pH of 5, and the distribution of species in 1 m salt medium is shown in Fig. 15.10. Pb^{4+} hydrolyzes very extensively, but its hydrolysis products are not well known. $Pb(OH)_6^{2-}$ is probably the anionic species occurring in base.

The Hydrolysis of Cations

CHARLES F. BAES, Jr.
ROBERT E. MESMER
Oak Ridge National Laboratory
Oak Ridge, Tennessee

1976

A WILEY-INTERSCIENCE PUBLICATION
JOHN WILEY & SONS, New York • London • Sydney • Toronto

Hazen Research, Inc.
HAZEN
4601 Indiana St., Golden, CO 80403
279-4501; FAX: 278-1528

* 18667

FAX TRANSMITTAL

cc: Tom Helms

Date: 7/5/90 Time: 1030
Pages: 8 Project: 6911

To: Mr. Douglas Mickey; Master Metals
Fax #: (216) 621-7475

From: Paul Queneau, Hazen Research
Re: Your question on adding soda ash to your main baghouse to limit SO_2 emissions

Adding soda ash (Na_2CO_3) to the gas stream entering your primary baghouse appears to be a winner. That small portion of the sulfur that escapes fixation in the slag can thus be captured. Furthermore, the soda ash provides additional alkalinity to neutralize H_2SO_4 that may form due to excursions below the dew point. For a general description of dry scrubbing practice, in this case using nahcolite ($NaHCO_3$, i.e., sodium bicarbonate), refer to the attached paper by N.D. Shah.

At Carteret, we added lime to the blast furnace flue for SO_2 capture; it worked well. What makes your application using soda ash particularly attractive is that you have 100% dust recycle back to the furnaces. Sodium values added to the baghouse are thus fully utilized in the furnace.

Note that dry scrubbing with soda ash has fundamental differences from SO_2 collection using nahcolite. Nahcolite operates best above 300°F to facilitate its decomposition to soda ash. This decomposition process generates low density Na_2CO_3 having high active surface area. However, when using soda ash directly, the Na_2CO_3 must already be in an active form to provide efficient SO_2 collection.

The following are suggestions that you may wish to consider.

- Key for SO_2 collection is <u>using crude light soda ash</u>, which has high surface area. Collection efficiency using your dense soda ash will almost

cc - Kemey - Hansen - Berthold

Re: Na_2CO_3 to BH for SO_2 Capture

$$\underset{64}{SO_2} + \underset{106}{Na_2CO_3} \longrightarrow \underset{126}{Na_2SO_3} + CO_2$$

Stoic. $Na_2CO_3/SO_2 = 1.67/1$

" $Na_2SO_3/Na_2CO_3 = 1.19/1$

From 6/14/90 mass & heat balance, estimated 3.0 lb SO_2/hr from small furnace. Assume both furnaces are operating, and that combination of Na_2CO_3 hold-up in baghouse, plus use of two furnaces, maintains average ratio of Na_2CO_3/SO_2 in baghouse.

$$(3.0 + 1.2(3.0)) = 6.6 \text{ lb } SO_2/\text{hr, max.}$$

Now assume that you assign 10% of current solids through-put in BH to Na_2CO_3 and Na_2SO_3 (50/50 ratio). May also form some Na_2SO_4.

Current dust load $\cong$ 415 lb dust/hr, i.e.,

$$\left(\frac{4.5 \text{ scoops dust}}{\text{full charge}}\right)\left(\frac{550 \text{ lb dust}}{\text{scoop}}\right)\left(\frac{4 \text{ charges}}{\text{day}}\right)\left(\frac{1 \text{ day}}{24 \text{ hrs}}\right) = 413 \text{ lb/hr}$$

Therefore can increase solids in BH by 41.5 lb/hr, or add $(41.5)((1.0+1.19)/2)$

$= 37.9$ lb Na_2CO_3 added to BH/hr, say 40 lb/hr

Hazen Research, Inc.

from 6/14/90 mass & heat balance, & from 5/17/90 charge calculation, average Na_2CO_3 fed to old furnace ≈ 5 scoops / total heat; new furnace takes ~6 scoops.

$$\left(\frac{5.5 \text{ scoops } Na_2CO_3}{\text{Ave. total heat}}\right)\left(\frac{700 \text{ lb } Na_2CO_3}{\text{scoop}}\right)\left(\frac{4 \text{ heats}}{\text{day}}\right)\left(\frac{1 \text{ day}}{24 \text{ hrs}}\right) = 642 \text{ lb } Na_2CO_3 \text{ used/hr.}$$

Therefore are to be using (37.9/642)(100), or about 6% of plant Na_2CO_3 to BH, which is reasonable.

If stoichiometric RX of SO_2 with Na_2CO_3, can capture (37.9)/(1.67) = 22.7 lb SO_2/hr.

Only expect 6.6 lb SO_2/hr, max.

Therefore use of ~40 lb Na_2CO_3/hr to BH seems reasonable for starter.

Soda ash is recovered during dust recycle. Expect to fix ≥98% of recycled Na_2SO_3 in slag-matte.

Plant analyses should show whether more, or less Na_2CO_3, should be added to BH, once you have operated with 40 lb Na_2CO_3/hr.

Hazen Research, Inc.

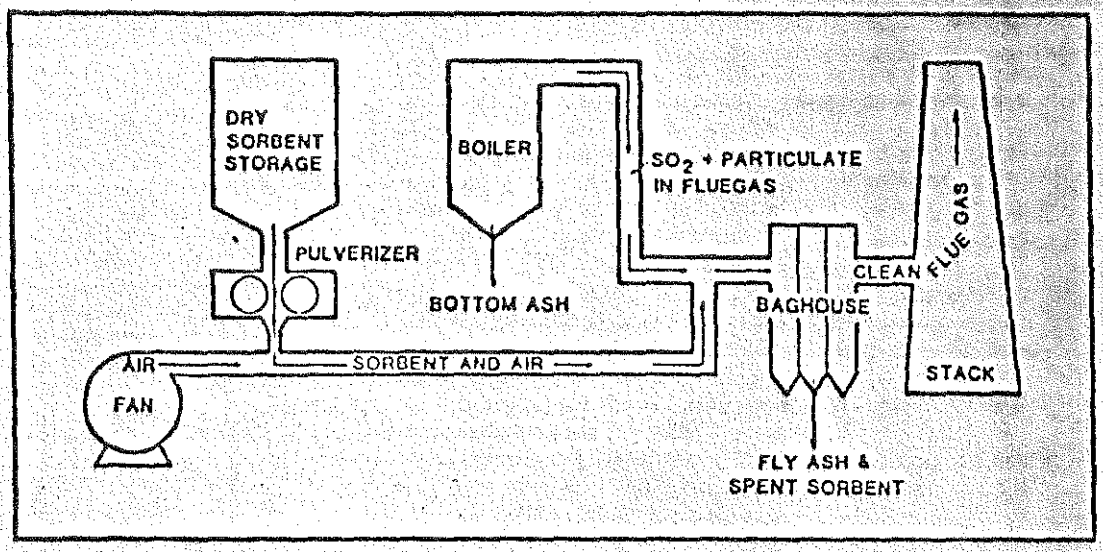

Figure 1. Dry-scrubbing process.

POLLUTION CONTROL PRACTICES:

Dry Scrubbing of SO_2

Among the advantages of dry over wet scrubbing are reduced corrosion erosion, and scaling, and capital costs that are 30 to 50% lower.

N. D. Shah,

Multi Mineral Corp., Grand Junction, Co. 81501

It is advantageous to use dry scrubbing processes to remove SO_2 from flue gases. There are three major flue gas desulfurization processes: wet scrubbing, spray drying, and dry scrubbing.

The factors influencing the selection of a dry-scrubbing process are analyzed in this article. Nahcolite is used as the dry-scrubbing agent for this analysis, because nahcolite (a naturally occurring sodium bicarbonate mineral) is shown to be the most likely candidate for future commercial applications. However, most of the conclusions about nahcolite scrubbing are valid for processes employing other dry-scrubbing agents, if allowances are made for their reduced reactivity, increased cost, etc.

Advantages of dry scrubbing

Wet scrubbing of SO_2 using an alkaline solution is a

Table 1. Factors influencing scrubber selection.

1. Sulfur Content of the Coal
2. Type of Particulate Control
3. Water Requirements
4. Location of the Plant
5. SO_3 Removal
6. NO_x Removal
7. Energy Consumption
8. Cost
9. Operating Experience

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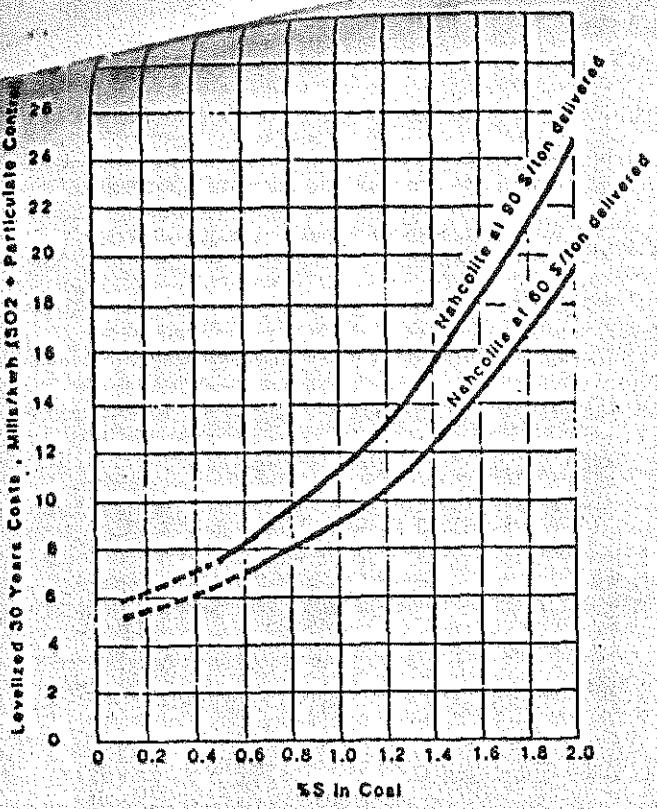

SI Conversion: metric ton = ton × 1.1

Figure 2. Cost of dry scrubbing vs. %S in coal.

well-known technology. A wealth of data are available in the literature concerning the commercial operation of wet scrubbing systems. Even though wet scrubber technology has been commercially proven, process reliability has often been disappointing. Corrosion, erosion, plugging, scaling and freezing have been identified as major problems with wet-scrubbing system.

Because the majority of the wet scrubber problems relate to the use of circulating alkaline water solutions, spray dryer technology has been introduced to reduce water requirements by about one half. In the spray-drying process, a solution is sprayed into the flue gas stream. The sprayed material reacts with SO_2 and at the same time water evaporates (from the heat of the flue gas) resulting in dry waste. The dried material also reacts with the SO_2 during collection in the particulate control device.

Even though spray dryer technology appears more promising than wet scrubbing, a number of questions concerning the commercial reliability of the process remain unanswered. These questions relate to reheat requirements and plugging, scaling and corrosion problems resulting from the use of water. Approximately 1,600 MW of new coal-fired generating capacity under construction has committed to spray drying for SO_2 control. There is no doubt that spray dryer technology offers the potential of reducing or minimizing wet scrubber problems.

Dry-scrubbing processes carry spray-drying philosophy one step further by eliminating water usage entirely. In a dry scrubbing process, a dry alkaline powder is injected, Figure 1, directly into the flue gas stream. The alkaline particles react with SO_2 while suspended in the gas stream. Dry waste product from this reaction is subsequently collected in a particulate collection device (baghouse, precipitator, etc.) and the clean flue gas is vented to the atmosphere. Additional reaction between alkaline particles captured in the particulate control equipment and SO_2 occurs as the flue gas passes through the particulate control equipment.

Although the reactivity of dry scrubbing agents will naturally be somewhat lower than the reactivity of wet-sorbent solutions used in wet scrubbing or spray drying, a dry-scrubbing processes offers four clear advantages:

1. The absence of water results in the minimization or elimination of corrosion, erosion, plugging, scaling and freezing problems.
2. Dry-scrubbing processes control SO_2 and particulates in a single piece of equipment. The capital costs of the process are projected to be 30 to 50% lower than wet scrubber or spray dryer systems. Operating costs are projected to be approximately equivalent to spray dryers.
3. Utilities are familiar with dry material handling systems (for coal and flyash); therefore, a dry-scrubbing process will not pose the problem of adopting an unknown technology.
4. Wet scrubbers require flue gas reheating and result in high pressure drops across the system. The dry-scrubbing process eliminates both the reheating requirements and high-pressure drop conditions, thus resulting in 3 to 5% energy savings based on plant energy.

Disposal techniques

Three areas of concern presently exist for dry-scrubbing processes: the commercial availability of scrubbing agents, the lack of commercial operating data, and the problem of waste disposal.

Dry-scrubbing agents that have been tested in the past are trona, soda ash, commercial sodium bicarbonate, lime, limestone and nahcolite (sodium bicarbonate in mineral form). Based on past dry-scrubbing tests (*1–3*), the best scrubbing agents are commercial sodium bicarbonate, trona, and nahcolite. Economic constraints dictate that commercial sodium bicarbonate is too expensive at its present cost (*4*) of about $230/ton ($254/m ton).

Trona is commercially mined for the production of soda ash. Soda ash manufacturers are reluctant to sell raw trona because tax depletion allowances for trona result in unattractive investment return. At present, nahcolite appears to be the most promising scrubbing agent for dry scrubbing. Nahcolite is not mined commercially today, but Multi Mineral Corp. is presently working to develop a commercial operation to produce one million ton/yr (907,000 m ton/yr) of nahcolite by early 1986.

The operating experience with the dry-scrubbing process has been extended to demonstration tests at the 22-MW scale using nahcolite as the scrubbing agent. These tests are currently being conducted by Public Service Co. of Colorado, Electric Power Research Institute and Multi Mineral Corp. at the Cameo coal-fired generating station. The Cameo test results (*5*) have been very encouraging, and have demonstrated the consistent attainment of SO_2 removals of over 70% at nahcolite stoichiometric ratio of less than one.

The principle constituents of the waste produced from the nahcolite dry-scrubbing process are sodium bicarbonate, carbonate and sulfate. These compounds are relatively water-soluble and may require runoff protection. Many disposal techniques have been proposed for sodium waste disposal, including the following:

- Ocean dumping
- Deep well disposal
- Insolubilization by aqueous coprecipitation
- Insolubilization by sintering
- Land disposal (dry arid basins)
- Use of the salt cake as a byproduct
- Landfill in clay isolation cells

A detailed discussion of these techniques has been pre-

The most cost-effective means of ... by land disposal or landfill in clay cells.

Factors influencing selection

The selection of an SO_2 scrubbing system depends on technical, economic and regulatory factors some of which are shown in Table 1.

Sulfur Content of the Coal. Sulfur content of the coal determines the injection rate of the scrubbing agent, which influences the design size of the particulate collection equipment, the material handling and injection system, and the waste disposal facility. All these factors impact the economics of the process. Figure 2 shows the economic sensitivity (7) of the dry (nahcolite) scrubbing process to sulfur content in the coal. It appears that the 30-year levelized cost of a dry process increases rapidly with the increase in sulfur content of the coal.

The SO_2 removal requirements as defined by the revised (1979) new source performance standard is based on the sulfur level in the coal. Figure 3 shows the SO_2 removal requirements as a function of % sulfur in the coal with a heating value of 10,000 Btu/lb (23,300 kJ/kg).

Figure 4 shows the SO_2 removal efficiency (7) of the dry-scrubbing process as a function of nahcolite stoichiometric ratio. The increased costs of the dry-scrubbing process at higher sulfur contents in the coal partly arises from the increased nahcolite requirements to achieve greater SO_2 removal efficiencies. Consequently, the dry-scrubbing process is most promising for lower sulfur coals.

Type of Particulate Control Equipment. The electrostatic precipitator, baghouse or wet scrubber are the three most common particulate control equipment used in a coal-fired plant. Since the purpose of the dry-scrubbing process is to keep the flue gas dry, using a wet scrubber for particulate control is undesirable. The major disadvantage with the electrostatic precipitator is that it does not provide the additional contact time between SO_2 and the dry sorbent during the collection of the sorbent. If a baghouse is the preferred method of particulate control, the dry-scrubbing process should definitely be considered as a means of SO_2 control.

Wet scrubbers, although effective in removing SO_2 and/or particulates, often create secondary problems related to visible emissions and violation of opacity regulations. The dry injection process with a baghouse obviates these problems by keeping the flue gas in the dry state.

Water Requirements. Wet scrubbers and spray dryers consume water at a rate of approximately 1 gpm/MW (3.8 L/min · MW) and ½ gpm/MW (1.9 L/min · MW), respectively. The dry injection process does not use any water and is, therefore, a top candidate for plants in areas where water is a scarce commodity (western U.S.).

Location of the Plant. The application of the dry-scrubbing process for SO_2 control may be limited to the western part of the country for the following reasons:

- The only known deposit of nahcolite, which is the most promising dry-scrubbing agent, is found in Western Colorado. As a result, transportation costs to users in the west will be less.
- A dry-scrubbing system eliminates water usage; since water is a precious commodity in the west, it is logical to consider application of this technology for the western U.S.
- The use of baghouses for particulate control is becoming more popular in the western U.S., because the resistivity of the low-sulfur coal ash is too high for effective collection ... precipitators. A dry-scrubbing process with a baghouse offers combined SO_2 and particulate control in one piece of equipment.
- Waste disposal problems are less acute due to the semi-arid climate.

SO_3 Removal. Past studies (8) have shown that the dry-scrubbing process will remove SO_3 in the same proportion as SO_2. Wet scrubbers do not remove SO_3 but create problems related to corrosion, erosion, etc., when SO_3 comes in contact with water. The dry-scrubbing process should be considered in cases where high SO_3 concentrations are in the flue gas.

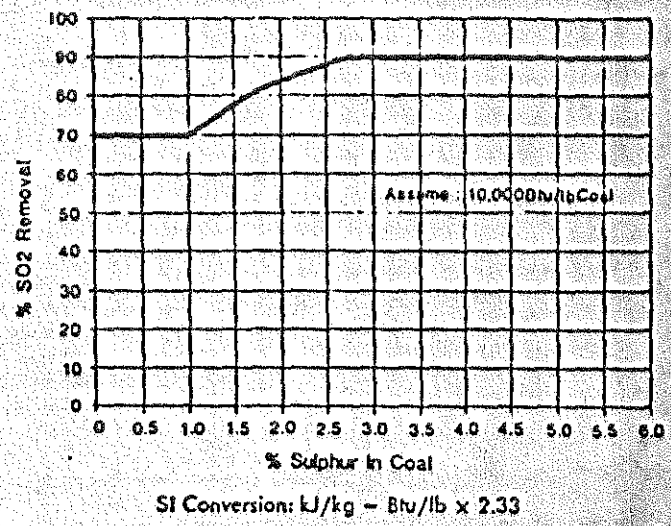

Figure 3. EPA regulations for SO_2 control.

NO_x Removal. Pilot-scale tests (2, 5) have shown that dry scrubbing with nahcolite removes approximately 10 to 40% of the NO_x contained in the flue gas stream. Although further testing needs to be conducted to confirm this result, there is a possibility of simultaneous SO_2 plus NO_x removal with dry scrubbing. This would allow SO_2/NO_x/particulate control in one equipment.

Energy Consumption. Wet scrubbers consume about 3 to 5% of a plant's energy in reheating the flue gas and overcoming the pressure drop across the system. The dry-scrubbing process robs very little of the plant's energy, resulting in substantial savings.

Cost. Figure 5 shows the capital cost for SO_2 and particulate control among the wet scrubber, spray dryer and dry-

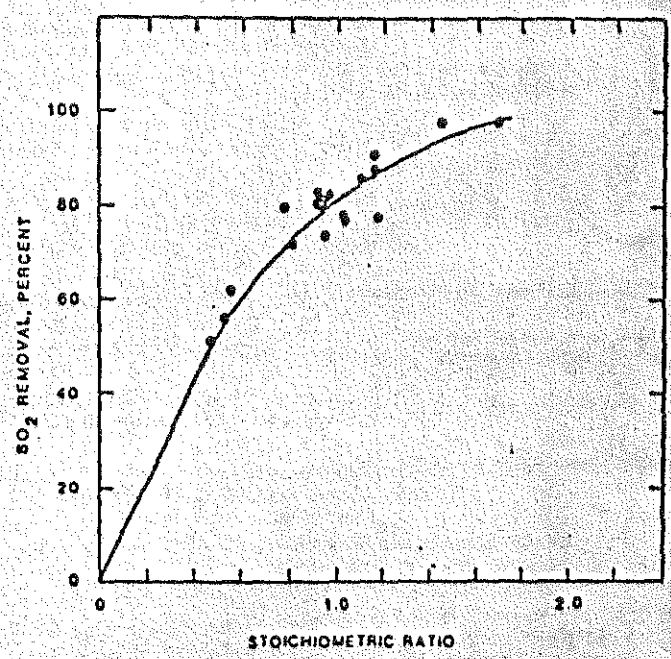

Figure 4. SO_2 removal efficiency.

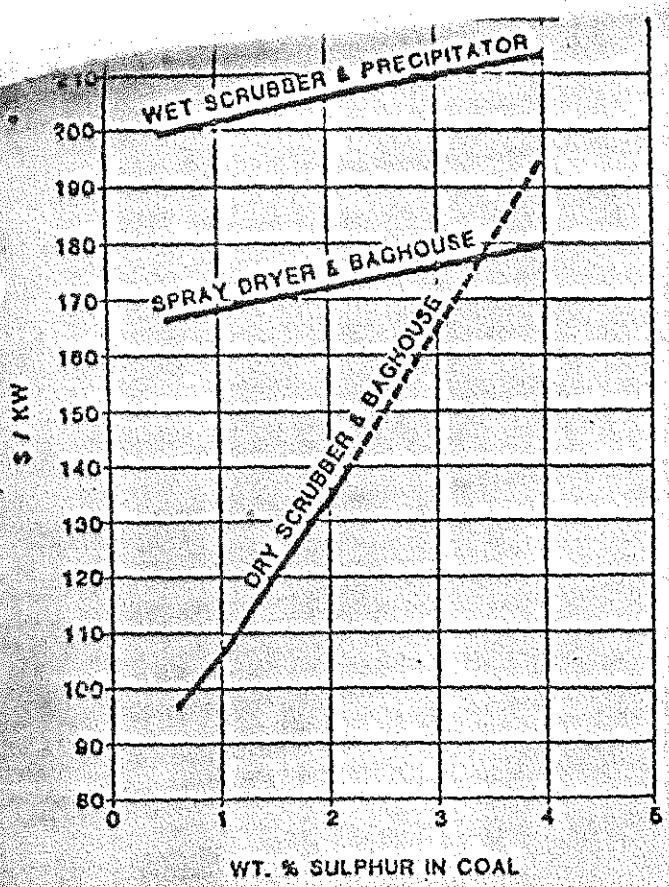

Figure 5. Capital cost comparison.

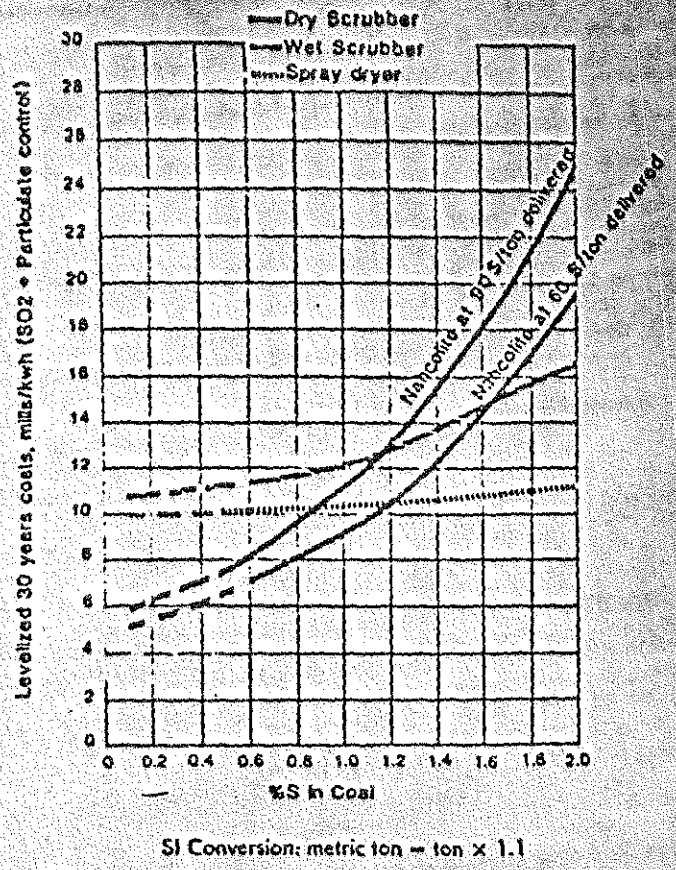

Figure 6. Cost comparison.

scrubbing process as a function of percentage sulfur in coal. Based on these results, the dry-scrubbing process is attractive for coals containing less than 3% sulfur.

The levelized costs of an SO_2 control system depend largely on the sulfur content of the coal and reagent costs. The costs of the wet scrubber, spray dryer and dry-scrubbing process as a function of these variables are shown in Figure 6. The dry-scrubbing process appears attractive for lower-sulfur, coal-fired installations. At a nahcolite cost of $90/ton ($99/m ton) delivered, the dry-scrubbing process appears attractive for plants burning less than 0.9% sulfur coal.

Operating Experience. The dry-scrubbing process has a limited operating history. Most of its operating data is based on pilot- and bench-scale testing. To date, the process has been successfully demonstrated at the 22-MW scale. But the simplicity of the dry-scrubbing process should significantly impact the amount of operating experience required to establish the technology as a commercial reality. The spray dryer, also a relatively new technology, has little commercial operating data available. Wet scrubbers have been in commercial use for more than a decade.

Commercial nahcolite production

Multi Mineral Corp. is presently pursuing commercial production of nahcolite from its resource interest. An initial production of nahcolite at one million ton per year (909,000 m ton/yr) by early 1986 is planned. This production level will be sufficient to scrub 70% of the SO_2 from approximately 5,000 MW of generating capacity burning 1% sulfur coal.

An upgrading process, which results in a nahcolite purity of approximately 80%, has been tested on a pilot scale. We plan to market a product which will be approximately 80% sodium bicarbonate and minus ¼ in. (0.6 cm) in size. Other sizes and grades may become available as the commercial operation evolves.

It is estimated that the price of the nahcolite will vary depending on the product specifications, but will probably range from $50 to $100/ton ($55 to 110/m ton) for a nahcolite product containing approximately 80% sodium bicarbonate. #

Literature cited

1. "Evaluation of Dry Alkalis for Removing Sulfur Dioxide from Boiler Flue Gases," EPRI Report No. FP-207 (Oct., 1976).
2. Han Liu, *et al.*, "Evaluation of Fabric Filter as Chemical Contractor for Control of Sulfur Dioxide from Flue Gas," NTIS Report No. PB 194 196 (Dec., 1969).
3. Shah, N.D., D.P. Teixeira, and R.C. Carr, "Application of Dry Sorbent Injection for SO_2 and Particulate Control," Paper Presented at EPA FGD Symp. (Nov., 1977).
4. *Chem. Marketing Reporter*, 220, No. 12, p. 46 (Sept., 1981).
5. Muzio, L.J., *et al.*, "Demonstration of SO_2 Removal on a 22-MW Coal-Fired Utility Boiler by Dry Injection of Nahcolite," Paper Presented at EPRI Conf. on Fabric Filter Tech. (July, 1981).
6. "Evaluation of Dry Sorbent and Fabric Filtration for FGD," EPA Report No. 68-02-1412 by TRW (Jan., 1977).
7. Lapp, D.E., *et al.*, "Use of Nahcolite for Coal-Fired Power Plants," Paper Presented at 7th National Conf. on Energy and Environment (Dec., 1980).
8. "Bench-Scale Study of the Dry Removal of SO_2 with Nahcolite and Trona," EPRI Report No. CS-1744 (March, 1981).

N. D. Shah is manager of Nahcolite use development with the Multi Mineral Corp. A holder of a B.S.Ch.E. degree from the Univ. of Bombay, a M.S.Ch.E. from the Univ. of North Dakota, and a Ph.D. degree in chemical engineering from the Colorado School of Mines, he has been involved with pilot testing and evaluation of dry scrubbing technology for eight years. Prior to joining the firm, he worked as a project manager of dry scrubbing activities for Electric Power Research Institute.

certainly be very low. You should be able to purchase the light soda ash from Kerr-McGee.

Kerr-McGee generates light ash (≈98% Na_2CO_3) in its bicarbonate calciners at Searls Lake (Trona, CA). Light ash is a process intermediate, rather than an item of commerce. I understand, however, that it may be obtainable for about a 20% price premium over your current soda ash cost.

- Sufficient flue-gas velocity ~~and~~ is needed to prevent the fine soda ash added to the flue from settling out in the flue before it reaches the baghouse. The longer the soda ash has to contact the flue gas, the greater should be the efficiency of SO_2 capture.

- At Carteret, we fed fine lime to the flue through a square flange installed on the top of the round flue. Upon the flange was mounted a hopper equipped with vibrator. This approach may also be appropriate for injecting soda ash. A slide gate controlled flow of the fine solids into the flue, as assisted by the negative pressure in the flue.

- Most of the SO_2 fixation is likely to occur while the gas flows through the soda ash mixed with the flue dust on the bags. The SO_2 collection rate improves somewhat with temperature, indicating that the soda ash might best be added to the diluted gas just before the convective cooler (≈ 640 °F). At this temperature, no fusion problem is anticipated. Mechanical constraints in your plant may necessitate that the soda ash be dispersed in the flue after the cooler immediately upstream from the baghouse.

- Calculations (attached) indicate that you could begin at a soda ash Na_2CO_3 injection rate of ≈40 lb Na_2CO_3/hr. Please check the various tonnages that went into the calculations to be sure that they in fact represent your current soda ash (640 lb/hr), maximum SO_2 (6.6 lb/hr), and dust (415 lb/hr) tonnage. I assumed that 2% of the sulfur fed to the furnace reported to the flue as SO_2, and that there was ≈10% extra capacity in the bags to accept the Na_2CO_3-Na_2SO_3-Na_2SO_4 solids.

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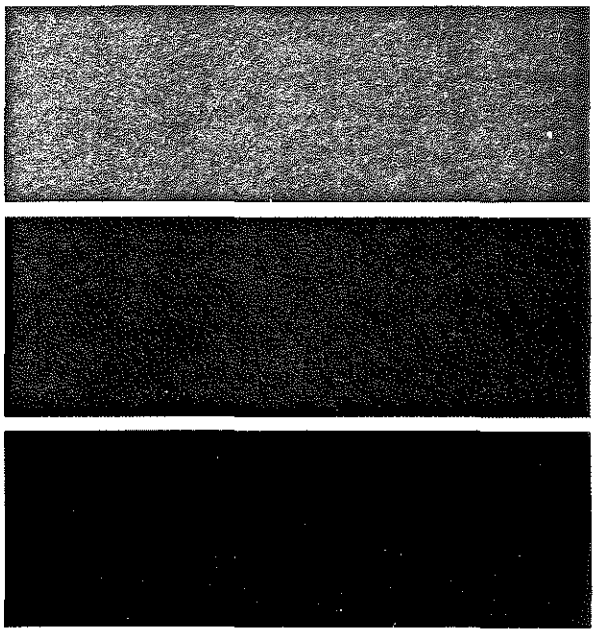
REPORT NO. 91-1174 1603
COMPANY Master Metals
TITLE Compliance
DATE 3-12-91

MASTER METALS INC.
CLEVELAND, OHIO

FURNACE & FUGITIVE BAGHOUSES
PARTICULATE, SULFUR DIOXIDE & LEAD
EMISSION EVALUATION

CONDUCTED - MARCH 12, 1991



SOURCE EVALUATION RESULTS

PREPARED BY

Envisage Environmental Incorporated

P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

Envisage Environmental Incorporated P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

March 27, 1991

Mr. Douglas K. Mickey
President
Master Metals Incorporated
2850 West Third Street
Cleveland, Ohio 44113

Dear Mr. Mickey:

The following report is the result of the particulate, sulfur dioxide, and lead emission evaluation conducted on March 12, 1991 at the above location. Three (3) test runs were conducted on this date at the exhaust stacks of the two (2) baghouses serving the lead smelter. The systems are designated Furnace Baghouse and Fugitive Baghouse.

The results are true and accurate to the degree specified in the pertinent sections of the Code of Federal Regulations, in force at the time of testing.

I am looking forward to answering any questions you may have and assisting you in the future.

Respectfully submitted,

Tom E. Holder

Tom E. Holder
Environmental Engineer
ENVISAGE ENVIRONMENTAL INC.

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Envisage Environmental Incorporated
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INTRODUCTION

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INTRODUCTION

On March 12, 1991, Envisage Environmental Inc. conducted an emission evaluation at Master Metals Incorporated, 2850 West Third Street, Cleveland, Ohio. Testing was conducted at the exhaust stacks of the two (2) baghouses used for air pollution control of the lead smelting operation. Test parameters included particulate, sulfur dioxide, and lead conducted at each location.

The purpose of these tests was to determine compliance with applicable State and Federal Regulations concerning air pollution emissions. The furnace and the baghouses were monitored by Master Metals Inc. and EPA personnel. Test parameters were in accordance with USEPA Reference Methods 1-6 and 12.

The Envisage testing team consisted of Messrs. Bob Hovan, Joe Dossa, Mark Gierke, and Steve Norris. The Ohio EPA was represented by Mr. Douglas Seaman, Division of Air Pollution Control, Cleveland, Ohio. Mr. Rudy Zupan, Master Metals Inc., coordinated the testing.

Results are presented in this report for particulate, sulfur dioxide, and lead emissions with the various velocity, volumetric and temperature measurements associated with these tests for each baghouse.

DESCRIPTION OF PROGRAM

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DESCRIPTION OF PROGRAM

The evaluation consisted of three (3) test runs, each one (1) hour in length. At each location, six (6) sample points were used in each of the two (2) ports. Sample time per point was five (5) minutes for a total sample time per run of sixty (60) minutes. Diagrams of the sample point locations are included in this report.

The samples were withdrawn from the gas streams isokinetically through three (3) foot Pyrex lined probes. The entire lengths of the probes were heated and attached to a Method 5 sample train modified for the collection of sulfur dioxide and lead. The hot boxes were set to maintain a temperature of 248 degree F. and the heated areas were monitored to ensure condensation did not form prior to the impingers. Exit gas temperature of the impingers was maintained below 68 degrees F. with an ice bath. The nozzle, probe and connecting glassware were cleaned before testing and at the conclusion of each test run with acetone. Leak checks of the pitot tube lines and the sample trains were all acceptable by EPA regulations. Cyclonic flow was less than ten (10) degrees at each location.

The method 5 impinger train was modified by replacing the distilled water with the following: # 1 - 100 ml 80% Isopropanol, # 2 - 200 ml 3% Hydrogen Peroxide, # 3 - 100 ml 0.1 Nitric Acid, # 4 - empty, # 5 - 200 grams silica gel. Analysis for sulfur dioxide was by the barium-thorin titration method. The filters and impinger solutions were analyzed for lead by atomic absorption spectrometry.

Flue gas analysis was conducted by drawing an integrated air bag sample throughout each test run and analyzed with a Hays Republic Model 621A "Orsat" Portable Gas Analyzer. The average of at least three readings for each run were used in calculating the emission rates.

Description of Program - continued

Calibration of the equipment used, including the dry gas meters, orifice meters, and the "S" type pitot tubes were conducted within 60 days of the test date. Copies of the data are included in this report.

All analytical procedures were performed in accordance with the methods specified in the Code of Federal Regulations, Title 40 Part 60, Volume 43. Blanks were collected and analyzed on the distilled water and acetone used in the evaluation. The residue from the distilled water was less than could be measured on a 0.1 milligram analytical balance and was considered zero. The acetone blank was recorded and incorporated into the results.

The example equations included in this report represents the data collected during Run # 1 conducted at the Fugitive Baghouse exhaust.

TEST RESULTS SUMMARY

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TEST RESULTS SUMMARY

Master Metals Inc

2850 West 3rd Street

Cleveland, Ohio

Furnace Baghouse - Particulate,

Lead, & Sulfur Dioxide Emission Evaluation

Conducted - March 12, 1991

PARAMETER	RUN # 1	RUN # 2	RUN # 3
Particulate Emissions			
Pounds/hour	0.25	0.41	0.24
Grains/dscf	0.0021	0.0033	0.0019
Lead Emissions - Pounds/hour	0.009	0.004	0.002
Sulfur Dioxide Emissions			
Pounds/hour	0.06	* BDL	* BDL
Pounds/dscf	6.88E-08	* BDL	* BDL
ppmV	0.4	* BDL	* BDL
System Flow Rates			
Feet/second	80.61	80.71	79.27
ACFM	15,835	15,854	15,572
DSCFM	14,082	14,474	14,649
Moisture Content			
Volume percent	2.73	1.66	1.24
Sample Location Temperature			
Degrees Fahrenheit	112	104	89

* Below Detectable Limit

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TEST RESULTS SUMMARY

Master Metals Inc

2850 West 3rd Street

Cleveland, Ohio

Fugitive Baghouse - Particulate,

Lead, & Sulfur Dioxide Emission Evaluation

Conducted - March 12, 1991

PARAMETER	RUN # 1	RUN # 2	RUN # 3
Particulate Emissions			
Pounds/hour	0.82	0.78	0.50
Grains/dscf	0.0024	0.0023	0.0015
Lead Emissions - Pounds/hour	0.015	0.013	0.014
Sulfur Dioxide Emissions			
Pounds/hour	0.09	* BDL	* BDL
Pounds/dscf	3.71E-08	* BDL	* BDL
ppmV	0.2	* BDL	* BDL
System Flow Rates			
Feet/second	91.81	91.85	92.04
ACFM	38,937	38,953	39,034
DSCFM	39,989	39,887	40,053
Moisture Content			
Volume percent	1.31	1.07	1.04
Sample Location Temperature			
Degrees Fahrenheit	54	57	56

* Below Detectable Limit

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TEST RESULTS DETAILED

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TEST RESULTS

Master Metals Inc

Furnace Baghouse - Particulate, Lead, & Sulfur Dioxide Emission Evaluation

DATE: March 12, 1991	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
Time of Day			0934 1046	1121 1226	1253 1357
1 Gas Volume-dry,std.	Vmstd	cu. ft.	47.65	48.11	49.21
2 Condensate Vapor Vol.	Vwstd	cu. ft.	1.34	0.81	0.62
3 Gas Stream Moisture	Bws	vol.dec	0.0273	0.0166	0.0124
4 Mol.Wt-flue gas (dry)	Msd	lb/lb mo.	28.84	28.84	28.84
5 Mol.Wt-flue gas (wet)	Ms	lb/lb mo.	28.54	28.66	28.70
6 Flue Gas Velocity	Vs	ft/sec	80.61	80.71	79.27
7 Flue Gas Volume-Actual	ACFM	cu. ft.	15,835	15,854	15,572
8 Flue Gas Volume-Std.	DSCFM	cu. ft.	14,082	14,474	14,649
9 Particulate Conc.	Cs				
- Probe		gr/dscf	0.0019	0.0031	0.0018
- Filter		gr/dscf	0.0002	0.0002	0.0001
- Lead		gr/dscf	7.4E-05	3.4E-05	1.7E-05
- Total		gr/dscf	0.0021	0.0033	0.0019
10 Emission Rate	E				
- Probe		lb/hr	0.23	0.39	0.22
- Filter		lb/hr	0.02	0.02	0.02
- Lead		lb/hr	0.009	0.004	0.002
11 - Total		lb/hr	0.25	0.41	0.24
Isokinetic Rate	I	%	96.3	94.6	95.6

* Totals DO NOT Include Lead

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TEST RESULTS

Master Metals Inc

Fugitive Baghouse - Particulate, Lead, & Sulfur Dioxide Emission Evaluation

DATE: March 12, 1991	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
Time of Day			0940 1045	1120 1224	1252 1356
1 Gas Volume-dry,std.	Vmstd	cu. ft.	59.71	58.51	59.51
2 Condensate Vapor Vol.	Vwstd	cu. ft.	0.79	0.64	0.63
3 Gas Stream Moisture	Bws	vol.dec	0.0131	0.0107	0.0104
4 Mol.Wt-flue gas (dry)	Msd	lb/lb mo.	28.84	28.84	28.84
5 Mol.Wt-flue gas (wet)	Ms	lb/lb mo.	28.69	28.72	28.72
6 Flue Gas Velocity	Vs	ft/sec	91.81	91.85	92.04
7 Flue Gas Volume-Actual	ACFM	cu. ft.	38,937	38,953	39,034
8 Flue Gas Volume-Std.	DSCFM	cu. ft.	39,989	39,887	40,053
9 Particulate Conc.	Cs				
- Probe		gr/dscf	0.0021	0.0022	0.0013
- Filter		gr/dscf	0.0003	0.0001	0.0001
- Lead		gr/dscf	4.4E-05	3.9E-05	4.1E-05
- Total		gr/dscf	0.0024	0.0023	0.0015
10 Emission Rate	E				
- Probe		lb/hr	0.74	0.74	0.45
- Filter		lb/hr	0.09	0.04	0.04
- Lead		lb/hr	0.015	0.013	0.014
11 - Total		lb/hr	0.82	0.78	0.50
Isokinetic Rate	I	%	91.7	90.1	91.3

* Totals DO NOT Include Lead

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SO2 LABORATORY SUMMARY

Master Metals Inc

Furnace Baghouse - Particulate,

Lead, & Sulfur Dioxide Emission Evaluation

DATE: March 12, 1991	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
20 Normality of Ba(ClO4)2	N	meq/ml	0.0097	0.0097	0.0097
21 Volume of solution	Vsln	ml	240.0	240.0	230.0
22 Volume aliquot titrant	Va	ml	20.00	20.00	20.00
23 Volume Ba(ClO4)2 Blank	Vtb	ml	0.0	0.0	0.0
24 Volume Ba(ClO4)2 Sampl	Vt	ml	0.40	0.00	0.00

SO2 TEST RESULTS

Master Metals Inc

Furnace Baghouse - Particulate,

Lead, & Sulfur Dioxide Emission Evaluation

DATE: March 12, 1991		Units	RUN # 1	RUN # 2	RUN # 3
12 Concentration SO2	Cso2	lb/dscf	6.88E-08	* BDL	* BDL
13 Concentration SO2	PPM	ppmV	0.4	* BDL	* BDL
14 Emission Rate SO2	Eso2	lb/hr	0.06	* BDL	* BDL

* Below Detectable Limit

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SO2 LABORATORY SUMMARY

Master Metals Inc

Fugitive Baghouse - Particulate,

Lead, & Sulfur Dioxide Emission Evaluation

DATE: March 12, 1991	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
20 Normality of Ba(ClO4)2	N	meq/ml	0.0097	0.0097	0.0097
21 Volume of solution	Vsln	ml	240.0	230.0	225.0
22 Volume aliquot titrant	Va	ml	20.00	20.00	20.00
23 Volume Ba(ClO4)2 Blank	Vtb	ml	0.0	0.0	0.0
24 Volume Ba(ClO4)2 Sampl	Vt	ml	0.27	0.00	0.00

SO2 TEST RESULTS

Master Metals Inc

Fugitive Baghouse - Particulate,

Lead, & Sulfur Dioxide Emission Evaluation

DATE: March 12, 1991		Units	RUN # 1	RUN # 2	RUN # 3
12 Concentration SO2	Cso2	lb/dscf	3.71E-08	* BDL	* BDL
13 Concentration SO2	PPM	ppmV	0.2	* BDL	* BDL
14 Emission Rate SO2	Eso2	lb/hr	0.09	* BDL	* BDL

* Below Detectable Limit

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SAMPLE POINT LOCATION DIAGRAM

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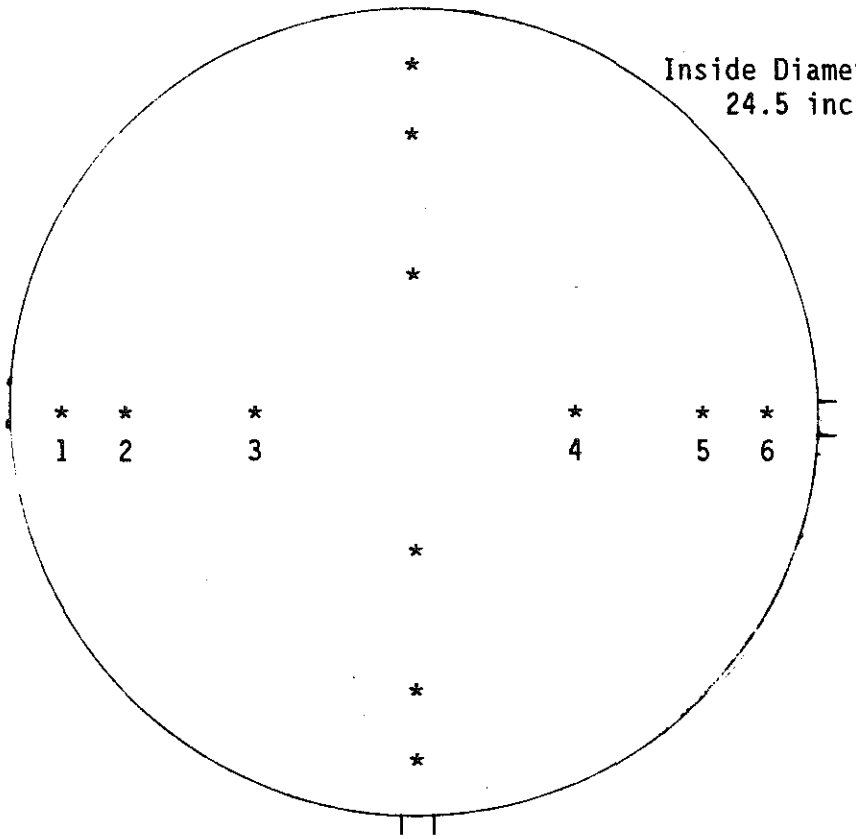
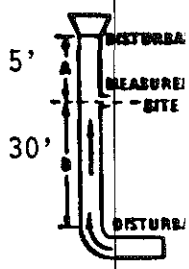
SAMPLE POINT LOCATIONS

Master Metals
Furnace Baghouse Exhaust





Point Number	Distance from Inside Wall
1	23.4 inches
2	20.9 inches
3	17.2 inches
4	7.3 inches
5	3.6 inches
6	1.1 inches

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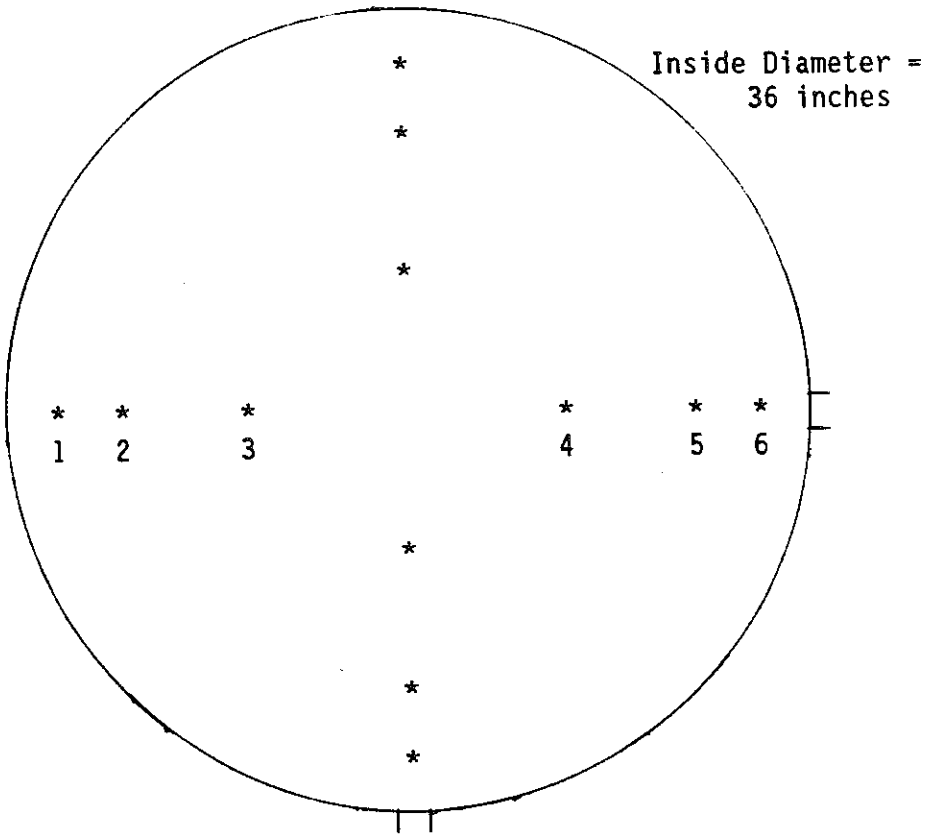
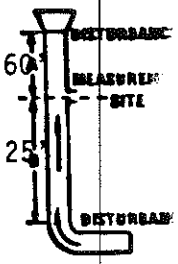
SAMPLE POINT LOCATIONS

Master Metals
Fugative Baghouse Exhaust





Point Number	Distance from Inside Wall
1	34.4 inches
2	30.7 inches
3	25.3 inches
4	10.7 inches
5	5.3 inches
6	1.6 inches

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SAMPLING TRAIN DIAGRAM

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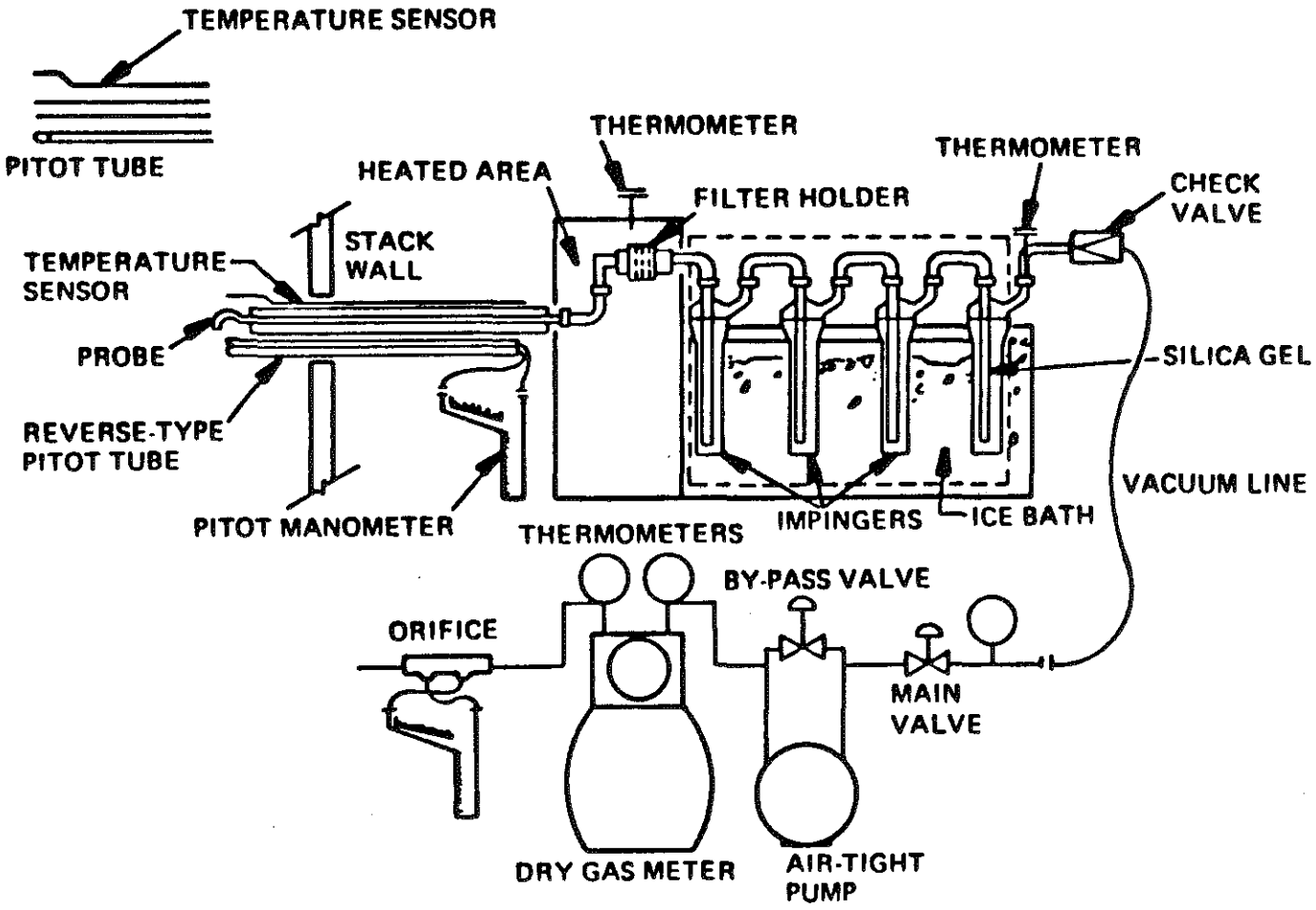

EPA METHOD 5 PARTICULATE SAMPLE APPARATUS

LABORATORY SECTION

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LABORATORY SUMMARY SHEET

Master Metals Inc

Furnace Baghouse - Particulate, Lead, & Sulfur Dioxide Emission Evaluation

DATE: March 12, 1991	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
1 Sampling Time	t	minutes	60.0	60.0	60.0
2 Barometric Pressure	Pb	in. Hg	30.18	30.18	30.18
3 Static Pressure	Pg	in. H2O	-7.20	-7.20	-7.20
Stack Pressure	Ps	in. Hg	29.65	29.65	29.65
4 Gas Meter Volume	Vm	cu. ft.	50.30	52.53	53.44
5 Stack Area	A	sq. ft.	3.27	3.27	3.27
6 Nozzle Diameter	Dn	dec. in.	0.1875	0.1875	0.1875
7 Meter Temperature		degrees F	105.0	124.5	121.4
	Tm	degrees R	565.0	584.5	581.4
8 Stack Temperature		degrees F	112.3	103.6	89.3
	Ts	degrees R	572.3	563.6	549.3
9 Velocity Head	^P	in. H2O	1.365	1.380	1.374
10 Orifice Pressure	^H	in. H2O	2.11	2.08	2.15
11 Carbon dioxide	CO2	%	0.0	0.0	0.0
12 Oxygen	O2	%	20.9	20.9	20.9
13 Carbon monoxide	CO	%	0.0	0.0	0.0
14 Nitrogen	N2	%	79.1	79.1	79.1
15 Pitot Coefficient	Cp		0.84	0.84	0.84
16 Water Collected	Vlc	ml	28.4	17.3	13.1
Sample Weight:	Mn				
17 - Probe		g	0.0059	0.0098	0.0057
18 - Filter		g	0.0006	0.0005	0.0004
19 - Lead		mg	0.22974	0.10752	0.05289

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LABORATORY SUMMARY SHEET

Master Metals Inc

Fugitive Baghouse - Particulate,

Lead, & Sulfur Dioxide Emission Evaluation

DATE: March 12, 1991	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
1 Sampling Time	t	minutes	60.0	60.0	60.0
2 Barometric Pressure	Pb	in. Hg	30.18	30.18	30.18
3 Static Pressure	Pg	in. H2O	1.90	1.90	1.90
Stack Pressure	Ps	in. Hg	30.32	30.32	30.32
4 Gas Meter Volume	Vm	cu. ft.	59.95	59.45	59.95
5 Stack Area	A	sq. ft.	7.07	7.07	7.07
6 Nozzle Diameter	Dn	dec. in.	0.1875	0.1875	0.1875
7 Meter Temperature		degrees F	78.8	85.3	80.7
	Tm	degrees R	538.8	545.3	540.7
8 Stack Temperature		degrees F	54.2	56.9	56.0
	Ts	degrees R	514.2	516.9	516.0
9 Velocity Head	^P	in. H2O	1.663	1.660	1.665
10 Orifice Pressure	^H	in. H2O	3.10	3.13	3.14
11 Carbon dioxide	CO2	%	0.0	0.0	0.0
12 Oxygen	O2	%	20.9	20.9	20.9
13 Carbon monoxide	CO	%	0.0	0.0	0.0
14 Nitrogen	N2	%	79.1	79.1	79.1
15 Pitot Coefficient	Cp		0.84	0.84	0.84
16 Water Collected	Vlc	ml	16.8	13.5	13.3
Sample Weight:	Mn				
17 - Probe		g	0.0083	0.0082	0.0051
18 - Filter		g	0.0010	0.0004	0.0005
19 - Lead		mg	0.17072	0.14720	0.15735

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PLANT	Master Metals, Furnace Baghouse
DATE	March 12, 1991
RUN NO.	1
CASE NO.	3

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
352	0.6168	0.6162	0.0006	FILTER
N/A	- -	- -	- -	IMPINGERS
202	105.3060	105.3001	0.0059	PROBE *

* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED			
	IMPINGER VOLUME (ml)	SILICA GEL WEIGHT (g)	
FINAL	418	241.6	
INITIAL	400	231.2	
NET LIQUID COLLECTED	18	10.4	
TOTAL NET VOLUME	28.4	g*	ml

* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

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PLANT Master Metals, Furnace Baghouse

DATE March 12, 1991

RUN NO. 2

CASE NO. 7

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
246	0.5765	0.5760	0.0005	FILTER
N/A	- -	- -	- -	IMPINGERS
302	106.1179	106.1081	0.0098	PROBE *

* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED			
	IMPINGER VOLUME (ml)	SILICA GEL WEIGHT (g)	
FINAL	404	244.5	
INITIAL	400	231.2	
NET LIQUID COLLECTED	4	13.3	
TOTAL NET VOLUME	17.3	g *	ml

* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

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P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

PLANT Master Metals, Furnace Baghouse

DATE March 12, 1991

RUN NO. 3

CASE NO. 77

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
268	0.5900	0.5896	0.0004	FILTER
N/A	- -	- -	- -	IMPINGERS
1	162.9029	162.8972	0.0057	PROBE *

* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED			
	IMPINGER VOLUME (ml)	SILICA GEL WEIGHT (g)	
FINAL	405	239.3	
INITIAL	400	231.2	
NET LIQUID COLLECTED	5	8.1	
TOTAL NET VOLUME	13.1	g *	ml

* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

PLANT Master Metals, Fugitive Baghouse

DATE March 12, 1991

RUN NO. 1

CASE NO. 8

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
270	0.5905	0.5895	0.0010	FILTER
N/A	- -	- -	- -	IMPINGERS
301	108.9172	108.9089	0.0083	PROBE *

* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED			
	IMPINGER VOLUME (ml)	SILICA GEL WEIGHT (g)	
FINAL	402.6	246.3	
INITIAL	400	232.1	
NET LIQUID COLLECTED	2.6	14.2	
TOTAL NET VOLUME	16.8	g *	ml

* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

PLANT Master Metals, Fugitive Baghouse

DATE March 12, 1991

RUN NO. 2

CASE NO. 14

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
245	0.5794	0.5790	0.0004	FILTER
N/A	- -	- -	- -	IMPINGERS
168	108.0401	108.0319	0.0082	PROBE *

* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED			
	IMPINGER VOLUME (ml)	SILICA GEL WEIGHT (g)	
FINAL	400	245.6	
INITIAL	400	232.1	
NET LIQUID COLLECTED	0	13.5	
TOTAL NET VOLUME	13.5	g *	ml

* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

PLANT	Master Metals, Fugitive Baghouse
DATE	March 12, 1991
RUN NO.	3
CASE NO.	20

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
247	0.5805	0.5800	0.0005	FILTER
N/A	- -	- -	- -	IMPINGERS
603	106.6528	106.6477	0.0051	PROBE *

* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED			
	IMPINGER VOLUME (ml)	SILICA GEL WEIGHT (g)	
FINAL	400	245.4	
INITIAL	400	232.1	
NET LIQUID COLLECTED	0	13.3	
TOTAL NET VOLUME	13.3	g*	ml

* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

ORSAT ANALYSIS DATA

Company Master Metals Incorporated

Location Furnace Baghouse Exhaust

Date March 12, 1991

	RUN # 1	RUN # 2	RUN # 3
ORSAT DATA			
Sample 1			
CO2 Reading	0.0	0.0	0.0
O2 Reading	20.9	20.9	20.9
CO Reading	20.9	20.9	20.9
Sample 2			
CO2 Reading	0.0	0.0	0.0
O2 Reading	20.9	20.9	20.9
CO Reading	20.9	20.9	20.9
Sample 3			
CO2 Reading	0.0	0.0	0.0
O2 Reading	20.9	20.9	20.9
CO Reading	20.9	20.9	20.9
AVERAGES			
% CO2	0.0	0.0	0.0
% O2	20.9	20.9	20.9
% CO	0	0	0
% N2	79.1	79.1	79.1

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

ORSAT ANALYSIS DATA

Company Master Metals Incorporated

Location Fugitive Baghouse Exhaust

Date March 12, 1991

	RUN # 1	RUN # 2	RUN # 3
ORSAT DATA			
Sample 1			
CO2 Reading	0.0	0.0	0.0
O2 Reading	20.9	20.9	20.9
CO Reading	20.9	20.9	20.9
Sample 2			
CO2 Reading	0.0	0.0	0.0
O2 Reading	20.9	20.9	20.9
CO Reading	20.9	20.9	20.9
Sample 3			
CO2 Reading	0.0	0.0	0.0
O2 Reading	20.9	20.9	20.9
CO Reading	20.9	20.9	20.9
AVERAGES			
% CO2	0.0	0.0	0.0
% O2	20.9	20.9	20.9
% CO	0	0	0
% N2	79.1	79.1	79.1

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client
ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AUDREY

Report Date: March 18, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0762-0764

Sample I.D.: #1 - EEI - Filter 246
#2 - EEI - Filter 268
#3 - EEI - Filter 270

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
	Total	Total	Total		Acidity ($CaCO_3$)				
Metals:	mg/Filter	mg/Filter	mg/Filter		Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead	0.06	0.03	0.14		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide:** Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen:** Nitrate **(N)**				
Iron					Nitrite **(N)**				
Magnesium					Ammonia **(N)**				
Manganese					**T Kjeldahl (N)**				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand:** BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total **(P)**				
Tin					**Residue:** Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client XX KWLI ____ Auto Sampler ____ Other ____

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KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client
ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AUDREY

Report Date: March 20, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0750-0752

Sample I.D.: #1 - EEI - OR1-1, 3/12/91
#2 - EEI - OR1-2, 3/12/91
#3 - EEI - OR1-3, 3/12/91

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
	Total	Total	Total		Acidity ($CaCO_3$)				
Metals:	mg/L	mg/L	mg/L		Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead	0.58	<0.05	0.16		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide:** Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen:** Nitrate **(N)**				
Iron					Nitrite **(N)**				
Magnesium					Ammonia **(N)**				
Manganese					T Kjeldahl **(N)**				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand:** BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total **(P)**				
Tin					**Residue:** Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client xx KWLI _____ Auto Sampler _____ Other _____

KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

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ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client
ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AUDREY

Report Date: March 20, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0753-0755

Sample I.D.: #1 - EEI - OR2-1, 3/12/91
#2 - EEI - OR2-2, 3/12/91
#3 - EEI - OR2-3, 3/12/91

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
Metals:	Total mg/L	Total mg/L	Total mg/L	—	Acidity ($CaCO_3$)				
					Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead	1.24	<0.05	<0.05		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide:** Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen:** Nitrate **(N)**				
Iron					Nitrite **(N)**				
Magnesium					Ammonia **(N)**				
Manganese					**T Kjeldahl (N)**				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand:** BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total **(P)**				
Tin					**Residue:** Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client xx KWLI _____ Auto Sampler _____ Other _____

KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AUDREY

Report Date: March 20, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0756-0758

Sample I.D.: #1 - EEI - OR3-1, 3/12/91
#2 - EEI - OR3-2, 3/12/91
#3 - EEI - OR3-3, 3/12/91

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
	Total	Total	Total		Acidity ($CaCO_3$)				
Metals:	mg/L	mg/L	mg/L		Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead	0.58	0.05	<0.05		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide:** Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen:** Nitrate **(N)**				
Iron					Nitrite **(N)**				
Magnesium					Ammonia **(N)**				
Manganese					**T Kjeldahl (N)**				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand:** BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total **(P)**				
Tin					**Residue:** Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client xx KWLI _____ Auto Sampler _____ Other _____

KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client
ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AUDREY

Report Date: March 18, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0765-0767

Sample I.D.: #1 - EEI - Filter 245
#2 - EEI - Filter 247
#3 - EEI - Filter 252

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
	Total	Total	Total		Acidity ($CaCO_3$)				
Metals:					Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead mg/Filter	0.11	0.12	0.19		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide:** Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen:** Nitrate **(N)**				
Iron					Nitrite **(N)**				
Magnesium					Ammonia **(N)**				
Manganese					**T** Kjeldahl **(N)**				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand:** BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total **(P)**				
Tin					**Residue:** Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client xx KWLI _____ Auto Sampler _____ Other _____

KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client
ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AUDREY

Report Date: March 20, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0747-0749

Sample I.D.: #1 - EEI - NR3-1, 3/12/91
#2 - EEI - NR3-2, 3/12/91
#3 - EEI - NR3-3, 3/12/91

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
	Total	Total	Total		Acidity ($CaCO_3$)				
Metals:	mg/L	mg/L	mg/L		Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead	0.24	<0.05	0.09		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide**: Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen**: Nitrate **(N)**				
Iron					Nitrite **(N)**				
Magnesium					Ammonia **(N)**				
Manganese					T Kjeldahl **(N)**				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand**: BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total **(P)**				
Tin					**Residue**: Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client xx KWLI _____ Auto Sampler _____ Other _____

KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

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ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client
ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AUDREY

Report Date: March 20, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0741-0743

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Sample I.D.: #1 - E.E.I - NR1-1 3-12-91
#2 - E.E.I - NR1-2 3-12-91
#3 - E.E.I - NR1-3 3/12/91

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
	Total	Total	Total		Acidity ($CaCO_3$)				
Metals:	mg/L	mg/L	mg/L		Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead	0.13	0.06	0.15		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide:** Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen:** Nitrate **(N)**				
Iron					Nitrite **(N)**				
Magnesium					Ammonia **(N)**				
Manganese					T Kjeldahl **(N)**				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand:** BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total **(P)**				
Tin					**Residue:** Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client xx KWLI _____ Auto Sampler _____ Other _____

KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

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ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client: ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AUDREY

Report Date: March 20, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0744-0746

Sample I.D.: #1 - EEI - NR2-1, 3/12/91
#2 - EEI - NR2-2, 3/12/91
#3 - EEI - NR2-3, 3/12/91

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
	Total	Total	Total		Acidity ($CaCO_3$)				
Metals:	mg/L	mg/L	mg/L		Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead	0.13	0.10	0.15		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide:** Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen:** Nitrate (N)				
Iron					Nitrite (N)				
Magnesium					Ammonia (N)				
Manganese					T Kjeldahl (N)				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand:** BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total (P)				
Tin					**Residue:** Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client xx KWLI _____ Auto Sampler _____ Other _____

KUDUKIS WASTEWATER LABS, INC.

2779 BROADWAY AVENUE, CLEVELAND, OHIO 44115
(216) 696 - 0280 FAX: (216) 696 - 6831

ANALYSIS CERTIFIED BY: John Ondo **Laboratory Manager**

Client
ENVISAGE ENVIRONMENTAL
P.O. BOX 152
RICHFIELD, OHIO 44286

ATTN: AYDREY

Report Date: March 20, 1991
P.O. #:
Client:
Sample Received: 3/14/91
Lab Sample #: 1-0759-0761

Sample I.D.: #1 - EEI - 80% IPA Blank, 3/12/91
#2 - EEI - 0.1 $NHNO_3$ Blank, 3/12/91
#3 - EEI - 3% H_2O_2 Blank, 3/12/91

ANALYSIS	#1	#2	#3	#4	ANALYSIS	#1	#2	#3	#4
	Total	Total	Total		Acidity ($CaCO_3$)				
Metals:	mg/L	mg/L	mg/L		Alkalinity ($CaCO_3$)				
Cadmium					**Bacteria:**				
Chromium: Total					F. Coliform/100ml				
Hexavalent					T. Coliform/100ml				
Trivalent					Total Plate Count/1ml				
Copper					Chloride				
Lead	<0.05	<0.05	<0.05		Chlorine: T. Res.				
Nickel					Conductivity - uMHOS/cm				
Silver					**Cyanide:** Total				
Zinc					Amenable				
					Free				
Aluminum					Reactive				
Antimony					Flash Point °F				
Arsenic					Fluoride				
Barium					Hardness ($CaCO_3$)				
Beryllium					MBAS				
Calcium					**Nitrogen:** Nitrate **(N)**				
Iron					Nitrite **(N)**				
Magnesium					Ammonia **(N)**				
Manganese					**T Kjeldahl (N)**				
Mercury					Oil & Grease				
Potassium					**Oxygen Demand:** BOD_5				
Selenium					COD				
Silicon					**pH**				
Sodium					Phenols				
Thallium					Phosphorus: Total **(P)**				
Tin					**Residue:** Total				
					Total Volatile				
					Suspended				
					Volatile Suspended				
					Sulfate				
					Sulfide: Total				
					Reactive				

ug/L = micrograms/Liter(ppb) • mg/L = milligrams/Liter(ppm) • mg/kg = milligrams/kilogram • > = greater than • < = less than (below detection)

Sampled By: Client xx KWLI _____ Auto Sampler _____ Other _____

EMISSION SAMPLING

EQUIPMENT SPECIFICATIONS

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

Equipment and Specifications
U.S.E.P.A. Reference methods 1-5

Control Unit (Meter Box)	Equipment Designation
___Envisage Environmental Inc.	Control Unit #'s MB- 08 & 09
___Anderson Samplers	Control Unit #'s MB- 01 - 02
✓ Remanufactured R.A.C.	Control Unit #'s MB- 03 - 07

Sample Box

✓ E.E.I.	SB- 01, 02 & 05 - 07
___Remanufactured R.A.C.	SB- 03 & 04
___E.E.I. Special Design	SB- 08 - 11

Impingers - per sample train (each set changed for each test run)

✓ E.E.I.	3 Modified Smith Greenburg type
✓ E.E.I.	1 Smith Greenburg type

Probes	length	Lining types
___E.E.I.	2 foot	SS, PYREX, QUARTZ
✓✓ E.E.I.	3 foot	SS, PYREX, QUARTZ, TEFLON
___E.E.I.	5 foot	SS, PYREX, QUARTZ, TEFLON
___E.E.I.	3 foot	SS, PYREX, TEFLON
___E.E.I.	7 foot	SS, PYREX, TEFLON
___E.E.I.	10 foot	SS, PYREX, TEFLON
___E.E.I.	12 foot	SS, PYREX, TEFLON
___E.E.I.	15 foot	SS, PYREX, TEFLON
___E.E.I.	24 foot	SS, TEFLON

Temperature Sensors	Equipment Designation
___Omega Engineering	PY- 01 & 02
___Thermo Electric	PY- 03 - 08
✓✓ Fluke 51	PY- 01 - 02 - 03 - 04 - 05
___Fisher Scientific	Mercury Thermometer
___Fisher Scientific	Bimetallic Thermometer

Pressure Gauges	Type
✓✓ Dwyer Incline Manometer	Oil, 0 - 10 inch water
___Dwyer Magnehelic	Magnetic/Mechanical 0 - 1 inch water
___Dwyer Magnehelic	Magnetic/Mechanical 0 - 10 inch water
___Dwyer "U" Tube Manometer	Mercury, 36 inches
___Dwyer "U" Tube Manometer	Water, 72 inches
___Dwyer Microtector (Micro - Manometer)	Water, 0 - 1 inches of water

Chemicals and Reagents

✓✓ Water	Deionized/ Distilled
✓ Acetone	Reagent Grade (<0.001% residual)
✓ Silica Gel	6 - 16 Mesh
✓ Stopcock Grease	Acetone- Insoluble & Heat Resistant

CALIBRATION SECTION

Envisage
Environmental
Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

"S" TYPE PITOT TUBE CALIBRATION

"S" Type Pitot Tube (Probe) # # 303 - 3 ft. Probe

Calibration Date: March 4, 1991

$$C_p = C_{std} \sqrt{\frac{\Delta P_{std}}{\Delta P_p}} \qquad \text{(EPA Equation 2-2)}$$

where:

C_p = Coefficient of Type S pitot tube, dimensionless

C_{std} = Coefficient of Standard Pitot Tube (0.99), dimensionless

ΔP_{std} = Velocity head measured by standard pitot tube, inches H_2O

ΔP_p = Velocity head measured by Type S pitot tube, inches H_2O

	ΔP_{std}	ΔP_p	C_p
Side A	0.16	0.22	0.844
Side B	0.16	0.22	0.844
Side A	0.30	0.42	0.837
Side B	0.30	0.42	0.837
Side A	0.52	0.72	0.841
Side B	0.52	0.72	0.841

Average - 0.84

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

METER BOX CALIBRATION

Meter Box Number: RAC # 4

Calibration Date: March 5, 1991

$$Y = \frac{V_t \; P_b \; (T_m + 460)}{V_m \left[P_b + \frac{\Delta H}{13.6} \right] (T + 460)}$$

$$\Delta H_@ = \frac{0.0317 \; \Delta H}{P_b \; (Tm + 460)} \left[\frac{(T_t + 460) \; t}{V_t} \right]$$

Delta H (^H)	in. H2O	0.5	1.0	3.0	5.0	7.0
Pres.Barometer (P_b)	in. Hg	29.62	29.62	29.62	29.62	29.62
Vol.Meter Box (V_m)	cu. ft.	4.219	6.010	10.400	13.409	15.826
Vol.Test Meter(V_t)	cu. ft.	4.152	5.825	10.045	12.900	15.209
Temp. Meter Box (T_m)	^oF	88.0	95.7	100.7	106.9	110.2
	^oR	548.0	555.7	560.7	566.9	570.2
Temp. Test Meter (T_t)	^oF	78.0	78.0	78.0	78.0	78.0
	^oR	538.0	538.0	538.0	538.0	538.0
Time (t)	minutes	10.0	10.0	10.0	10.0	10.0
METER FACTOR (Y)		1.001	0.999	0.999	1.001	1.001
- Average				1.00		
METER COEFFICIENT ($\Delta H_@$)		1.640	1.643	1.643	1.642	1.644
- Average				1.64		

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

METER BOX CALIBRATION

Meter Box Number: RAC # 6

Calibration Date: January 29, 1991

$$Y = \frac{V_t \; P_b \; (T_m + 460)}{V_m \left[P_b + \frac{\Delta H}{13.6} \right] (T + 460)}$$

$$\Delta H_@ = \frac{0.0317 \; \Delta H}{P_b \; (Tm + 460)} \left[\frac{(T_t + 460) \; t}{V_t} \right]$$

Delta H (^H)	in. H2O	0.5	1.0	3.0	5.0	7.0
Pres.Barometer (P_b)	in. Hg	29.45	29.45	29.45	29.45	29.45
Vol.Meter Box (V_m)	cu. ft.	4.018	5.689	9.878	12.697	14.969
Vol.Test Meter(V_t)	cu. ft.	3.963	5.589	9.613	12.391	14.646
Temp. Meter Box (T_m)	°F	87.0	90.0	97.8	99.4	100.6
	°R	547.0	550.0	557.8	559.4	560.6
Temp. Test Meter (T_t)	°F	79.0	79.0	79.0	79.0	79.0
	°R	539.0	539.0	539.0	539.0	539.0
Time (t)	minutes	10.0	10.0	10.0	10.0	10.0
METER FACTOR (Y)		1.000	1.000	1.000	1.000	1.000
- Average				1.00		
METER COEFFICIENT ($\Delta H_@$)		1.820	1.820	1.820	1.820	1.820
- Average				1.82		

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

"S" TYPE PITOT TUBE CALIBRATION

"S" Type Pitot Tube (Probe) # 301 - 3 ft Probe

Calibration Date: January 14, 1991

$$C_p = C_{std} \sqrt{\frac{\Delta P_{std}}{\Delta P_p}} \qquad \text{(EPA Equation 2-2)}$$

where:

C_p = Coefficient of Type S pitot tube, dimensionless

C_{std} = Coefficient of Standard Pitot Tube (0.99), dimensionless

ΔP_{std} = Velocity head measured by standard pitot tube, inches H_2O

ΔP_p = Velocity head measured by Type S pitot tube, inches H_2O

	ΔP_{std}	ΔP_p	C_p
Side A	0.15	0.21	0.837
Side B	0.15	0.21	0.837
Side A	0.25	0.35	0.837
Side B	0.25	0.35	0.837
Side A	0.40	0.55	0.844
Side B	0.40	0.55	0.844

Average - 0.84

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

NOZZLE DIAMETER CALIBRATION

I.D. of nozzles are checked periodically by inside micrometer on at least 12 different diameters. If deviation exceeds +0.001" on an average or 0.002" maximum, nozzle is reworked. Sharpening occurs after each test.

CALIBRATION FREQUENCY

The frequency of calibration is dictated by the Federal Register, Volume 42, Number 160, August 18, 1977. The regulations state that you must "use methods and equipment which have been approved by the Administrator to calibrate the orifice meter, pitot tube, dry gas meter, and probe heater. Recalibrate after each test".

The methods of calibration are determined from "Maintenance, Calibration, and Operation of Isokinetic Source Sampling Equipment," published by the U.S. EPA Office of Air Program Publications APTD-0576. Per the above listed regulations, the equipment was checked after the stack test and the values of Y, Cp (Test) and nozzle diameter had not appreciably changed from the acceptable tolerances.

FIELD DATA SHEETS

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

FIELD DATA

PLANT Master Metals
DATE 3/12/91
SAMPLING LOCATION New Outlet Furnace
SAMPLE TYPE M. 1-6
OPERATOR JD MG.
AMBIENT TEMPERATURE 40's
BAROMETRIC PRESSURE
STATIC PRESSURE -7.2
HEATER BOX SETTING 248, ±25°F

PROBE LENGTH & TYPE 3' pyrex
NOZZLE I.D. 3/16"
ASSUMED MOISTURE % 8
METER BOX NUMBER 4
METER ΔH @ 1.64
C FACTOR .90
PITOT CORRECTION FACTOR .84
PRE-TEST LEAK CHECK 0 CFM@ 17 "Hg
POST-TEST LEAK CHECK 0 CFM@ 9 "Hg

SCHEMATIC OF TRAVERSE POINT LAYOUT

#2 0 @ 4.1"
#4 0 @ 4.8"

READ AND RECORD ALL DATA EVERY 5 MINUTES

PAGE 1 OF

Run #1 Case #3

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE INLET	GAS METER TEMPERATURE OUTLET	PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
	0/0934	314.000	1.80	1.342	1.80	115	94	74	5.0	260	35
	5	317.72	1.80	1.342	1.95	116	106	76	6.0	265	36
3	10	321.84	1.90	1.378	2.05	115	118	78	6.0	259	36
4	15	326.10	1.85	1.360	2.00	114	125	80	6.0	261	36
5	20	330.20	1.80	1.342	1.95	112	128	83	6.0	247	37
6	25	334.36	1.85	1.360	2.00	110	127	85	6.0	245	36
1	30	338.67	2.30	1.517	2.45	110	111	90	7.0	261	36
2	35	343.27	2.10	1.449	2.25	111	130	91	7.0	270	37
3	40	347.80	1.90	1.378	2.05	112	135	94	6.0	268	38
4	45	352.09	1.80	1.342	1.95	112	136	94	6.0	258	38
5	50	356.42	1.70	1.304	1.85	112	136	96	6.0	266	38
6	55	360.35	1.60	1.265	1.70	109	134	97	5.5	252	38
	60/1040	364.295									
								Leak check	OK		
		50.295		1.365	2.11	112.33	105.04	N. Norman	DAPC		
									3/12/91		

#2 @ @ 3.7"

Run #3 Case # 77

pre 0 @ 15"

#2 0 @ 5.0"
#4 0 @ 5.0"

PLANT Master Metals - Fiberglass Outlet DATE 3/12/91 post LEAK CHECK 0 CFM@ 7 "Hg PAGE 3 OF

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE INLET	GAS METER TEMPERATURE OUTLET	PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
1	0/1253	417.900	1.50	1.225	1.65	101	119	106	4.0	271	37
2	5	421.82	2.20	1.483	2.45	100	131	105	5.0	270	40
3	10	426.77	2.05	1.432	2.25	95	141	106	4.0	251	40
4	15	431.23	1.95	1.396	2.25	90	144	106	4.0	265	40
5	20	435.86	1.70	1.304	1.95	80	141	105	3.5	254	40
6	25	440.00	1.80	1.342	2.05	87	139	105	4.0	260	41
1	30	444.31	1.80	1.342	2.05	84	132	107	4.0	235	41
2	35	448.70	2.20	1.483	2.55	80	136	106	4.0	247	41
3	40	453.52	2.00	1.414	2.30	80	139	107	4.0	241	40
4	45	458.21	1.90	1.378	2.20	85	138	108	4.0	264	40
5	50	462.69	1.80	1.342	2.05	80	138	108	4.0	250	41
6	55	467.00	1.80	1.342	2.05	84	138	108	4.0	255	41
	60/1357	471.34									
		53.44		1.374	2.15	89.33		121.375			

Leak check OK
D. Norman DHPC
3/12/91

post pitots #2 0 @ 4.5"
#4 0 @ 5.0"

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RUN #L CASE # 7

pre 0 @ 18"

#2 [illegible]
#4 0 @ 5.0"

PLANT Master Metals Furnace Outlet DATE 3/12/91 LEAK CHECK post 0 CFM@ 11 "Hg PAGE 2 OF

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE INLET	GAS METER TEMPERATURE OUTLET	PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
1	01/1121	364.600	1.60	1.265	1.95	108	108	103	5.0	266	35
2	5	368.62	2.10	1.449	2.30	109	132	102	4.0	271	35
3	10	373.22	1.90	1.378	2.05	108	142	105	5.0	268	36
4	15	377.50	1.75	1.323	1.90	111	146	106	5.5	246	36
5	20	381.70	1.75	1.323	1.90	104	148	108	5.5	235	36
10	25	385.92	1.70	1.304	1.85	102	147	109	5.0	237	38
1	30	390.04	1.70	1.304	1.85	101	136	109	5.0	258	37
2	35	394.20	2.10	1.449	2.25	110	142	109	4.0	263	37
3	40	398.74	2.05	1.432	2.20	100	147	108	5.5	259	37
4	45	403.26	2.00	1.414	2.20	99	147	109	5.5	249	37
5	50	407.77	1.95	1.396	2.15	96	150	111	5.5	250	38
10	55	412.25	2.30	1.517	2.50	95	151	112	6.0	252	38
	60/1226	417.13									
		52.53		1.38	2.075	103.58	124.46				

Sorb meter OK

J. Sherman PARC
3/12/91

post #2 0 @ 4.8"
pitots #4 0 @ 4.0"

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FIELD DATA

PLANT Master Metals
DATE 3-12-91
SAMPLING LOCATION Fugitive Baghouse
SAMPLE TYPE 1-6
OPERATOR RH SN
AMBIENT TEMPERATURE 30s
BAROMETRIC PRESSURE
STATIC PRESSURE ~~[illegible]~~ +1.9
HEATER BOX SETTING 245± 25°

36" diameter

PROBE LENGTH & TYPE 3ft pyrex
NOZZLE I.D. ~~[illegible]~~ 0.187"
ASSUMED MOISTURE % 5
METER BOX NUMBER 6
METER ΔH @ 1.82
C FACTOR 1.0
PITOT CORRECTION FACTOR .84
PRE-TEST LEAK CHECK 0 CFM@ 15 "Hg
POST-TEST LEAK CHECK 0 CFM@ 9 "Hg
Pitot Tubes #2 ok 4.3
#4 ok 3.8

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

PAGE ____ OF ____

Run 1 CASE #8

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE INLET	GAS METER TEMPERATURE OUTLET	PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
1	0 // 940	772.40	2.9	1.70	3.3	54	98	98	5.0	248	36
2	5	776.94	2.8	1.67	3.1	54	80	62	5.0	266	36
3	10	781.76	2.9	1.70	3.3	54	88	68	5.5	270	36
4	15	786.87	2.7	1.64	3.0	54	90	69	5.0	248	36
5	20	791.48	2.5	1.58	2.9	54	92	70	5.0	272	36
6	25	796.16	2.7	1.64	3.0	54	92	71	6.0	268	36
1	30	801.34	2.6	1.61	2.95	54	84	72	5.0	273	38
2	35	805.82	2.7	1.64	3.0	54	88	73	6.0	268	38
3	40	810.60	2.7	1.64	3.0	54	92	74	6.0	238	38
4	45	815.49	2.9	1.70	3.3	54	94	76	7.0	273	38
5	50	820.44	2.9	1.70	3.3	55	94	76	7.0	265	38
6	55	825.47	2.8	1.67	3.1	55	95	76	6.0	270	38
	60 // 1045	852.345									
		59.945		1.663	3.10	54.17					
							78.79				

Check checked OK
D. Kaman DAPC
3/12/91

Post Pitot #2 0 @ 4.0
#4 0 @ 3.4

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PLANT Motor Motor Outlet DATE 3-12-91 Pre LEAK CHECK 0 CFM@ 15 "Hg PAGE 2 OF

Run 2 CAR 14 FUGATIVE Post Lk Ck 0 @ 9

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE INLET	GAS METER TEMPERATURE OUTLET	PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
1	0// 11:20	830.70	2.9	1.70	3.3	56	72	72	6.0	235	38
2	5	835.78	2.9	1.70	3.3	57	86	76	6.0	242	39
3	10	840.82	2.8	1.67	3.1	57	92	77	5.5	247	38
4	15	845.75	3.0	1.73	3.5	57	96	78	6.5	250	38
5	20	850.93	2.8	1.67	3.1	57	98	78	5.5	264	38
6	25	855.90	2.7	1.64	3.0	57	99	80	5.5	260	40
1	30	860.76	2.8	1.67	3.1	57	90	78	5.5	269	40
2	35	865.62	2.8	1.67	3.1	57	93	80	5.5	270	42
3	40	870.55	2.9	1.70	3.3	57	95	80	6.0	265	42
4	45	875.66	2.7	1.64	3.0	57	96	80	5.0	272	42
5	50	880.56	2.5	1.58	2.9	57	96	79	5.0	272	42
6	55	885.42	2.5	1.58	2.9	57	95	80	5.0	259	42
	60// 12:24	~~890.75~~ 890.15									
		59.45		1.66	3.13	56.92	85.25				

Leak Check OK
D. Swaman DAPC
3/12/91

Pre Pitot #2 @ 3.4 Post #2 @ 3.2

PLANT Mirror Motors Fugitive DATE 3/12/91 LEAK CHECK 0 CFM @ 17 "Hg PAGE 5 OF

Run 3 Cycle 20

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE INLET	GAS METER TEMPERATURE OUTLET	PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
1	0/1252	890.60	2.9	1.70	3.3	50	76	70	5.0	241	44
2	5	895.55	2.8	1.67	3.1	57	88	72	5.0	245	44
3	10	900.43	3.0	1.73	3.5	56	86	72	6.0	250	44
4	15	905.72	2.8	1.67	3.1	57	90	73	5.5	248	44
5	20	910.68	2.6	1.61	2.95	57	92	74	4.0	255	44
6	25	915.56	2.5	1.58	2.9	57	94	74	4.0	257	44
1	30	920.41	2.7	1.64	3.0	56	94	72	5.0	246	46
2	35	925.44	2.7	1.64	3.0	57	90	73	5.0	236	46
3	40	930.21	2.8	1.67	3.1	56	92	75	5.0	265	46
4	45	935.28	2.9	1.70	3.3	57	92	74	6.5	268	46
5	50	940.36	2.9	1.70	3.3	57	92	75	6.5	262	48
6	55	945.63	2.8	1.67	3.1	56	93	75	6.0	259	48
	60/1356	950.55									
		59.95		1.665	3.14	56	80.67				

Leak check OK
D. Seaman DATC
3/12/91

Pitot #2 0 at 3.8 Pitot #2 0 at 3.1
#4 0 at 4.2 #4 0 at 3.2

EMISSIONS SAMPLING

NOMENCLATURE

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

PARTICULATE SAMPLING NOMENCLATURE

A = Cross sectional area of stack or duct, ft^2.

A_n = Cross sectional area of nozzle, ft^2.

B_{ws} = Water vapor in gas stream, proportion by volume.

C = Nomograph correction factor, dimensionless.

C_p = Pitot tube coefficient, dimensionless.

C_s = Concentration of particulate matter in gas stream, dry basis-corrected to standard conditions, gr/dscf.

D_n = Nominal diameter of probe nozzle tip, inches.

E = Particulate Emission Rate, lb/hr.

ΔH = Average pressure differential across orifice, in. H_2O.

$\Delta H_@$ = Orifice meter calibration factor, in. H_2O.

I = Percent of Isokinetic sampling, %.

K_p = Pitot tube constant, $85.49 \frac{ft}{sec} \left[\frac{(lb/lb\text{-}mole)(in.Hg)}{(^oR)(in.H_2O)} \right]$

M_d = Molecular weight of gas, dry basis, lb/lb-mole.

M_n = Total amount of particulate matter collected, g.

M_s = Molecular weight of gas, wet basis, lb/lb-mole.

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Particulate Sampling Nomenclature - continued

M_w = Molecular weight of water, 18 lb/lb-mole.

P_{bar} = Barometric Pressure, in. Hg.

P_g = Pressure differential from gas stream to atmosphere, (static pressure) in.H_2O.

P_s = Absolute gas stream pressure, (P_{bar} + P_g/13.6) in.Hg.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

P_w = Density of water, 0.0022 lb/ml.

$\hat{P}_{avg}$ = Average of the square roots of the velocity head readings, ($\sqrt{\hat{p}}$) (in.H O_2).

Q = Volumetric flow rate at gas stream conditions, A.C.F.M.

Q_{sd} = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

R = Ideal gas constant, 21.85 in. Hg-ft^3/ ^oR-lb-mole.

t = Total sampling time, minutes.

T_m = Average dry gas meter temperature, ^oR.

T_s = Average absolute gas stream temperature, ^oR.

T_{std} = Standard absolute temperature, 528° Rankine.

V_{lc} = Volume of water collected in impingers & silica gel, ml.

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Particulate Sampling Nomenclature - continued

V_m = Volume of gas sample measured at meter box (meter conditions), ft^3

$V_{m(std)}$ = Volume of gas sample measured at meter box (corrected to standard conditions), ft^3.

V_s = Average gas stream velocity, ft/sec.

$V_{w(std)}$ = Volume of water vapor in gas sample (standard conditions) ft^3.

13.6 = Specific gravity of mercury (Hg).

% CO_2 = Percent by volume of CO_2 in gas stream (dry basis).

% O_2 = Percent by volume of O_2 in gas stream (dry basis).

% CO = Percent by volume of CO in gas stream (dry basis).

% N_2 = Percent by volume of N_2 in gas stream (dry basis).

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EMISSION SAMPLING

CALCULATIONS

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1) Volume of dry gas sampled through meter box at standard conditions,

$$V_{m(std)} = V_m \left[\frac{T_{std}}{T_m} \right] \left[\frac{P_b + \frac{\Delta H}{13.6}}{P_{std}} \right]$$

(EPA Equation 5-1)

Where:

$V_{m(std)}$ = Volume of gas sample measured at meter box (corrected to standard conditions), ft^3.

V_m = Volume of gas sample measured at meter box (meter conditions), ft^3.

T_{std} = Standard absolute temperature, 528° Rankine.

T_m = Average dry gas meter temperature, ^oR.

P_{bar} = Barometric Pressure, in. Hg.

ΔH = Average pressure differential across orifice, in. H_2O.

13.6 = Specific gravity of mercury (Hg).

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

V_m = 59.95 ft^3

T_m = 538.8 ^oR

ΔH = 3.10 in. H_2O

P_{bar} = 30.18 in. Hg

$$V_{m(std)} = 59.95 \left[\frac{528.0}{538.8} \right] \left[\frac{30.18 + \frac{3.10}{13.6}}{29.92} \right]$$

$$= 59.95 \quad (0.9799) \quad (1.0163)$$

$$= \underline{59.71} \quad ft^3$$

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2) Volume of water vapor collected at standard conditions,

$$V_{w(std)} = V_{lc} \left[\frac{P_w}{M_w} \right] \left[\frac{(R)(T_{std})}{P_{std}} \right]$$

(EPA Equation 5-2)

Where:

$V_{w(std)}$ = Volume of water vapor in gas sample (standard conditions) ft^3.
V_{lc} = Volume of water collected in impingers & silica gel, ml.
P_w = Density of water, 0.0022 lb/ml.
M_w = Molecular weight of water, 18 lb/lb-mole.
R = Ideal gas constant, 21.85 in. Hg-ft^3/ ^oR-lb-mole.
T_{std} = Standard absolute temperature, 528 ^{o} Rankine.
P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

V_{lc} = 16.8 ml

$$V_{w(std)} = 16.8 \left[\frac{0.0022}{18.0} \right] \left[\frac{(21.85)(528.0)}{29.92} \right]$$

$$= \underline{0.79} \ ft^3$$

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5) Molecular Weight of gas in gas stream,

$$M_s = M_d (1 - B_{ws}) + M_w (B_{ws})$$

(EPA Equation 2-5)

Where:

M_s = Molecular weight of gas, wet basis, lb/lb-mole.

M_d = Molecular weight of gas, dry basis, lb/lb-mole.

B_{ws} = Water vapor in gas stream, proportion by volume.

M_w = Molecular weight of water, 18 lb/lb-mole.

Example: Run 1

M_d = 28.84 lb/lb-mole

B_{ws} = 0.0131

$$M_s = 28.84 (1 - 0.0131) + 18 (0.0131)$$

$$= 28.459 + 0.235$$

$$= 28.69 \text{ lb/lb-mole}$$

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6) Average Gas Stream Velocity,

$$V_s = K_p \; C_p \; \hat{P}_{avg} \sqrt{\frac{T_s}{P_s \; M_s}}$$

(EPA Equation 2-9)

Where:

V_s = Average gas stream velocity, ft/sec.

K_p = Pitot tube constant, 85.49 $\frac{ft}{sec} \left[\frac{(lb/lb\text{-}mole)(in.Hg)}{(^oR)(in.H_2O)} \right]^{1/2}$

C_p = Pitot tube coefficient, dimensionless.

$\hat{P}_{avg}$ = Average of the square roots of the velocity head readings, ($\sqrt{\hat{p}}$) ($in.H_2O$).

T_s = Average absolute gas stream temperature, ^oR.

P_s = Absolute gas stream pressure, (P_{bar} + P_g/13.6) in.Hg.

P_{bar} = Barometric Pressure, in. Hg.

P_g = Pressure differential from gas stream to atmosphere, (static pressure) $in.H_2O$.

M_s = Molecular weight of gas, wet basis, lb/lb-mole.

Example: Run 1

C_p = 0.84

$\hat{P}_{avg}$ = 1.663 $in.H_2O^{1/2}$

T_s = 514.2 ^oR

P_s = P_{bar} + P_g /13.6 = 30.18 + 1.90 /13.6 = 30.32 in.Hg

M_s = 28.69 lb/lb-mole

$$V_s = (85.49)(0.84)(1.663)\sqrt{\frac{514.2}{(30.32)(28.69)}}$$

$$= \underline{91.81} \text{ ft/sec}$$

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7) Volumetric Flow Rate at Gas Stream Conditions,

$$Q = A \times V_s \times 60$$

Where:

Q = Volumetric flow rate at gas stream conditions, A.C.F.M.

A = Cross sectional area of stack or duct, ft^2.

V_s = Average gas stream velocity, ft/sec.

60 = Conversion factor from seconds to minutes.

Example: Run 1

A = 7.07 ft^2

V_s = 91.81 ft/sec

$$Q = (7.07)(91.81)\ 60$$

$$= 38{,}937 \text{ ACFM}$$

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8) Volumetric Flow Rate at Standard Conditions,

$$Q_{sd} = 60 \quad (1 - B_{ws}) \quad V_s \quad A \left[\frac{T_{std}}{T_s} \right] \left[\frac{P_s}{P_{std}} \right]$$

(EPA Equation 2-10)

Where:

Q_{sd} = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

60 = Conversion factor from seconds to minutes.

B_{ws} = Water vapor in gas stream, proportion by volume.

V_s = Average gas stream velocity, ft/sec.

A = Cross sectional area of stack or duct, ft^2.

T_{std} = Standard absolute temperature, 528 ^{o} Rankine.

T_s = Average absolute gas stream temperature, ^oR.

P_s = Absolute gas stream pressure, $(P_{bar} + P_g/13.6)$ in.Hg.

P_{bar} = Barometric Pressure, in. Hg.

P_g = Pressure differential from gas stream to atmosphere, (static pressure) in.H_2O.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

B_{ws} = 0.0131

V_s = 91.81 ft/sec

A = 7.07 ft^2

T_s = 514.2 ^oR

P_s = $P_{bar} + P_g/13.6 = 30.18 + 1.90/13.6 = 30.32$ in.Hg

$$Q_{sd} = 60 \quad (1 - 0.0131) \quad (91.81) \quad (7.07) \left(\frac{528.0}{514.2} \right) \left(\frac{30.32}{29.92} \right)$$

= 39,989 SCFM

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9) Gas Stream Particulate Concentration,

$$C_s = 15.43 \text{ gr./g} \left[\frac{M_n}{V_{m(std)}} \right]$$

(EPA Equation 5-6)

Where:

C_s = Concentration of particulate matter in gas stream, dry basis-corrected to standard conditions, gr/dscf.

M_n = Total amount of particulate matter collected in probe wash and on filter, g.

$V_{m(std)}$ = Volume of gas sample measured at meter box (corrected to standard conditions), ft^3.

Example: Run 1

$$M_n = \underset{(\text{probe})}{0.0083} + \underset{(\text{filter})}{0.0010} = 0.0093 \text{ g}$$

$$V_{m(std)} = 59.71 \text{ ft}^3$$

$$C_s = 15.43 \left[\frac{0.0093}{59.71} \right]$$

$$= \underline{0.0024} \text{ gr/dscf}$$

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10) Particulate Emission Rate,

$$E = Q_{sd} \quad C_s \quad \left[\frac{1 \text{ pound}}{7000 \text{ grains}}\right] \quad \left[\frac{60 \text{ minutes}}{1 \text{ hour}}\right]$$

Where:

E = Particulate Emission Rate, lb/hr.

Q_{sd} = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

C_s = Concentration of particulate matter in gas stream, dry basis-corrected to standard conditions, gr/dscf.

Example: Run 1

Q_{sd} = 39,989 ft^3

C_s = 0.0024 gr/dscf

$$E = (\ 39{,}989\ )\ (\ 0.0024\ )\ \left[\frac{60}{7000}\right]$$

$$= \underline{\ 0.82\ } \text{ lb/hr}$$

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11) Percent of Isokinetic Sampling,

$$I = \frac{100\ T_s \left[K_3\ V_{lc} + \left[\frac{V_m}{T_m} \right] \left[P_{bar} + \frac{\Delta H}{13.6} \right] \right]}{60\ A_n\ V_s\ P_s\ t}$$

(EPA Equation 5-7

Where:

I = Percent of Isokinetic sampling, %.

T_s = Average absolute gas stream temperature, ^oR.

K_3 = Constant, 0.002669 in.Hg-ft^3/ml-^oR.

V_{lc} = Volume of water collected in impingers & silica gel, ml.

V_m = Gas sample volume measured at meter box (meter conditions), ft^3.

T_m = Average dry gas meter temperature, ^oR.

P_{bar} = Barometric Pressure, in. Hg.

ΔH = Average pressure differential across orifice, in. H_2O.

t = Total sampling time, minutes.

V_s = Average gas stream velocity, ft/sec.

P_s = Absolute gas stream pressure, in.Hg.

D_n = Nominal diameter of probe nozzle tip, inches.

A_n = Cross sectional area of nozzle, ft^2.

Example: Run 1

T_s	=	514.2	^oR	ΔH	=	3.10	in.H_2O
V_{lc}	=	16.8	ml	t	=	60.0	min.
V_m	=	59.95	ft^3	V_s	=	91.81	ft/sec
T_m	=	538.8	^oR	P_s	=	30.32	in.Hg
A_n	=	0.0001917	ft^2	P_{bar}	=	30.18	in.Hg

$$I = \frac{514.2\ (100) \left[0.002669\ (16.8) + \left[\frac{59.95}{538.8} \right] \left[30.18 + \frac{3.10}{13.6} \right] \right]}{60\ (0.0001917)\ (91.81)\ (30.32)\ (60.0)}$$

$$= \underline{91.7}\ \%$$

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ESTIMATE OF STACK EMISSIONS (FROM NEW BAGHOUSE) WHEN OPERATING THE 3.6-M ROTARY FURNACE,

and Summary of Results of Furnace and Flue Calculations

	Drying		Melting		Reduction	
Operation time during each furnace charging cycle:	1.0	Hr	2.0	Hr	3.0	Hr
Initial temperature for drying, melting, or reduction:	194	°F	590	°F	1445	°F
Temperature at finish of drying, melting, or reduction:	590	°F	1445	°F	1697	°F
Natural gas firing rate:	5.7 MM	Btu/Hr	5.6 MM	Btu/Hr	5.6 MM	Btu/Hr
Average off-gas temperature from the furnace:	1652	°F	1796	°F	2156	°F
Natural gas consumed by the furnace:	5260	Ft3/Hr	5245	Ft3/Hr	5201	Ft3/Hr
Oxygen consumed by the furnace:	8978	Ft3/Hr	8953	Ft3/Hr	8877	Ft3/Hr
Diluted flue gas to the stack						
Flow rate entering stack @ 95 °F :	19,341	ACFM	12,888	ACFM	17,285	ACFM
Flow, DSCFM = 77°F @ 1 atm.:	17,208	DSCFM	11,745	DSCFM	15,822	DSCFM
Moisture content of gas to stack:	4.3%	Vol%	1.9%	Vol%	1.5%	Vol%
Particulates to stack, grains/dscf:	0.0026	g/DSCF	0.0026	g/DSCF	0.0025	g/DSCF
SO2 to the stack:	0.51	Lb/Hr	0.12	Lb/Hr	0.029	Lb/Hr
Emissions from Stack (Lb/Hr)						
Tetraethyl lead:	*BDL	Lb/Hr	*BDL	Lb/Hr	*BDL	Lb/Hr
Total chlorine expressed as chloride:	0.023	Lb/Hr	0.016	Lb/Hr	0.021	Lb/Hr
Lead as Pb:	0.13	Lb/Hr	0.085	Lb/Hr	0.11	Lb/Hr
Antimony as Sb:	0.0049	Lb/Hr	0.0032	Lb/Hr	0.0043	Lb/Hr
Arsenic as As:	**ID	Lb/Hr	**ID	Lb/Hr	**ID	Lb/Hr
Barium as Ba:	<0.01	Lb/Hr	<0.01	Lb/Hr	<0.01	Lb/Hr
Silver as Ag:	<0.01	Lb/Hr	<0.01	Lb/Hr	<0.01	Lb/Hr
Cadmium as Cd:	<0.01	Lb/Hr	<0.01	Lb/Hr	<0.01	Lb/Hr
Chromium as Cr	0.0003	Lb/Hr	0.0002	Lb/Hr	0.0003	Lb/Hr
Mercury, thallium, and beryllium:	***NIF		***NIF		***NIF	

* Below Detectable Limit ** Insufficient data to estimate. *** Not known to be in feedstock to plant.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

Furnace:	Old (3.6-m)	Pb° in Bulln, mt		CHARGE		Bullion	Slag Only	Matte Only
Date:	24-Jul-91	Pb in Feed, mt	11.29	CYCLE	PbO			
EndOfPeriod, T	310 degC	Pb,Mat+Slag, mt		IS FIRST	Pb°, PbS			
Parameters		Pb in Dust, mt		**********	C°			
to Check		Pb,DrossFloat,mt		TIME IS	CO2			
Slag FeO =		Bullion, mt		DURING	FeS			
Target =	10 to 15%	PbRecToBulln		THE FIRST	FeO			
Basicity =		Balanced if small	9.98E-12	1.0	S			
Target =	1.1 to 1.4	Slag, mt		HRS AFTER	Na2S			
Viscosity =		Matte, mt		CHARGE DOOR	Na(K)2O			
Target =	10 to 40	Soda/hr to flue	0.045	IS CLOSED	SiO2			
Slag Ratio of		Dust, % of feed	2.9%	**********	Ca(Ba)O			
(Si+Al)/Na =	1.2	Molds Output-->			MgO			
					Cr2O3			
					Al2O3			
					NaCl			
					Sn°, SnO			
					Sb°,Sb2S3			
					Other			
					ZnO,ZnS			
					Other			
					Other			
					Cu,Cu2S			
					TOTAL	100.0%	100.0%	100.0%

Feed(Scoops)	WetFeed,lb	DryFeedMt/hr
P.CakeTEL(2)	4000.	1.39
MM Plate(6)	13600.	6.08
Dust In (2)	1000.	0.45
MM Dross(6)	13000.	5.78
Coke(1/2)	700.	0.31
FeChips(0.35)	500.	0.22
Total Air In	1842.	0.83
O2 to Burner	760.	0.34
Lenox(0)	0.	0.00
NiterDross(0)	0.	0.00
Glass Sand(2)	2000.	0.89
Anzon(0)	0.	0.0
Natural Gas	237.4	0.108
TOTAL	37639.	16.41

Flux Summary		
Soda(2+BH)	3500.	1.586
Sand (1.5)	2000.	0.907
FeChip(.25)	500.	0.227
Coke (0.5)	700.	0.317

Matte + Slag Emulsion,%	
Pb	
C°	
FeO	
S	
Na2O	
SiO2	
Ca(Ba)O	
MgO	
Cr2O3	
Al2O3	
NaCl	
SnO	
Sb2O3	
Other	
ZnO	
Other	
Other	
CuO	

MgCr Brick, kg/hr per mt Bullion	0.0	% of S fixed:	99.90%
Al2O3 Brick, Kg/hr per mt Bullion	0.00	Coke in matte + slag, %	
Mat.FeS/Na2S	0.50	"Slag" Basicity	
Mat.FeO Contr.	10	Distribution Factors	
% Excess Coke	20.0%	Sn(Bullion):	0.00
PbTo"slag"mt		Sb(Bullion):	0.00
		Cu(Bullion):	0.00
Viscosity of the silicate slag, Poise:		DrossRecycle:	0.00
		SO2 controller	

Comments: Moisture is evaporated from charge. The door is closed. There is no fusion or reduction. See Page 2 for gas analyses and data. Oxygen make-up is met with tonnage oxygen (to burner), plus tramp air.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

Gas firing rate:		**Summary of Heat Losses, Kcal/hr During 1st part of 1st charge cycle**		Approx. st SO2 vented from plant per yr	0.42	Estimated ΔT drop due to heat loss when gas passes through the knockout tanks prior to initial dilutn.	111 degC
Kcal/hr	1,427,348	Loss through furnace walls	96,507	SCFM to Stack:	17974.		
Btu/hr	5,663,719	Heat to refractory from system	108,086				
Kg Nat. Gas/hr	107.6	Radiant heat loss thru closed door	4,942	Gas Temp. exiting stack:	35 degC	ACFM from the furnace:	5,004
Lb NG/hr	237.4	Sum of heat losses:	209,535				
%TongeO2Use	**100.%**	Initial T°C of refractory (Ave.)	700 degC	Gas Temp. exiting convective cooler:	345 degC	SCFM from the furnace:	1,221
%Exc.O2->NG	**-20%**	Final T°C of refractory (Ave.)	725 degC				
Ave. Offgas T°C	**900 degC**	Coke Content of Oxide Component:		Gas Temp. exiting convective cooler:	195 degC	ACFM to BH:	6,708
P, inch H20	**0.25**	Furnace area in use, m2	**57.7**			SCFM to BH:	5,079
Shell, T°F	425 degF	Temperature of bag house:	**105 degC**	Matte/slag concentration ratio for coke:			**0.00**
Tramp Air in Through the Door, kg/hr:	835.	PbInSilicatePhaseOfEmulsion,mt		SCFM moisture to stack:	766		
		Pb inMatte phase of Emulsion, %:		Coke Calculated via total heat?	Indirectly.		**700.**
Percent of Dust Exiting Per Hour	**16.7%**	Hrs of 1st Cycle CycleDoorClosed	**6.0**	Portion of excess coke burned, %/hr?			**17.%**
Percent of Charge Fused Per Hour	**0.%**			Number of Hrs in this period:	**One**		**1.0**
Percent of Charge Reduced Per Hour	**0.%**	Total Hrs Burner	**15.0**	Soda ash CO2 still in solids?	**Yes**		**100.0%**
				Soda ash CO2 to gas vent?	**No**		**0.0%**
Stoic. Pure O2 for Natural Gas, kg/hr	430.4	% Dross Formed?	**0**	Coke heat input, Kcal/hr			
Stoic. Pure O2 for solid C-> CO2, Kg/hr	0.0			System's heat gain from refractory, Kcal/hr			
				Heat lost to furnace offgas & dust, Kcal/hr			
				Heat to furnace charge from burner, Kcal/hr			
				Heat lost from walls and door, Kcal/hr			
Initial Temperature of Charge:	**90 degC**	If >100°C, =0	**0**	Sum of heats of reaction and fusion:			
Final Temperature of Charge:	**310 degC**	If <100°C, =1		Air drawn into furnace via door, SCFM			382
Charge Moisture Removed:	**66.7%**			FurnaceGas,kg	2058.	Gas Volume to Baghouse, ACMH =	11,398
Offgas volume at average furnace temperature:	8,503 ACMH			" " ",kgMole	84.9		
				v/oCO2 diluted From Stack	0.86%	Sn(Bullion):	0.00
				v/oSO2 diluted	0.00029%	Sb(Bullion):	0.00
						Cu(Bullion):	0.00
Dilution air to cooler, kg/hr	3,215						
Dilutn. air to cooler, ACMH	5,885						
Total ACMH into cooler	14,388						

Furnace Offgas Volume% at 900 degC	
O2:	**2.1%**
N2:	**26.9%**
H20:	**58.5%**
CO2:	**12.6%**
CO:	**0.0%**
SO2:	**0.0042%**
sum=	100.00%

Furnace Offgas mt/hr	
O2:	**0.06**
N2:	**0.64**
H20:	**0.89**
CO2:	**0.47**
CO:	**0.0**
SO2:	**0.00023**
sum=	2.0584

Space between door and furnace, inches =	**0.39**		
Start-up Controller for Totals =	100		
EFFICIENCY OF HEAT UTILIZATION, %			
Calculated Eff.	46%		
Target effic.	45%		
SO2, %/hr	**60.0%**	BH, ACFM	6,708
Lb SO2/Hr	SO2evoln.,hrs	Press., mm:	**730**
0.506	1.0	Ambient, degC:	**7**

Comments: One third of charges H20 evaporated during charging process. Note that exit gas temperature is the average during the period.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

						Efficiency	
Kg moles of gas from furnace	84.9		Oxide Slag mt	5.93		Kcal from solids	598,155
Kg moles air cooler entry	111.5	345 degC	C with Oxide	0.67		Feed gases	-44,410
Kg moles gas into cooler	196.3	195 degC	%C in Oxide	11.3%		Kcal from H20 evaporation	0
Air to cooler exit, kg/hr	4518.	105 degC	C Burnt, mt	0.014		Kcal from coke excess	-108,579
Air to cooler exit, ACMH	5059.		C in dust, mt	0.00		Kcal from shell loss	204,593
Kg moles air to cooler exit	156.6		Dilution air to stack, kg/hr:		25450.	TOTAL	649,759
Kg moles, all gases, to BH	353.0		Total gas to stack, kgMoles/hr		1249.	Burner Kcal	1,427,348
ACMH to BH, TOTAL	11398.		Total ACFM into stack		19341.	Efficiency	45.5%

	Atomic Weight	Total Moles (inc. refractory)	Total mt
PbO	223	0.00811	1.809
Pb°	207	0.04642	9.608
C°, non-gas	12	0.05703	0.684
CO2	44	0.00190	0.083
Fe°	55.8	0.00337	0.188
FeO	71.8	0.00148	0.107
SO3	80	0.00237	0.190
S	32	0.00360	0.115
Na(K)2O	62	0.00466	0.289
SiO2	60	0.02006	1.204
Ca(Ba)O	56	0.00117	0.065
MgO	40.3	0.00263	0.106
Cr2O3	152	0.00011	0.017
Al2O3	102	0.00076	0.077
NaCl	58.5	0.00231	0.135
SnO	135	0.00039	0.052
Sb2O3	291	0.00074	0.216
H2OFrCb	18	0.03050	0.549
ZnO	81.4	0.00026	0.021
SO2	64.0	0.00000	0.000
O2	32.0	0.01678	0.537
CuO	79.5	0.00074	0.059
Sum:		0.20538	16.112

O2 released by redn., mt:	0.0000
SCFH air drawn into furnace:	22,924
SCFM air drawn into furnace:	382

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

Weight %	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas
PbO	35.5%	19.0%	35.3%	0.0%	0.0%	0.0%	0.00%	0.00%	34.9%	10.0%	0.00%	71.1%	0.0%
Pb°	8.0%	73.2%	0.0%	87.3%	0.0%	0.0%	0.00%	0.00%	0.0%	61.2%	0.0%	0.0%	0.00%
C°	12.00%	1.50%	0.00%	2.3%	92.2%	3.00%	0.00%	0.00%	0.0%	0.50%	0.00%	22.1%	75.00%
CO2	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0%	0.00%	0.00%	0.00%	0.00%
Fe°	0.00%	0.1%	0.00%	0.00%	0.00%	82.50%	0.00%	0.00%	0.0%	0.00%	0.00%	0.0%	0.00%
FeO	2.80%	0.1%	0.50%	0.50%	0.29%	12.00%	0.00%	0.00%	0.9%	0.50%	0.30%	0.0%	0.00%
SO3	1.00%	2.0%	12.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0%	0.00%	0.00%	4.0%	0.00%
S	0.00%	0.00%	0.00%	1.70%	5.50%	0.00%	0.00%	0.00%	0.3%	1.50%	0.00%	0.00%	0.00%
Na(K)2O	1.10%	0.00%	35.0%	2.00%	0.10%	0.00%	0.00%	0.00%	3.5%	7.30%	0.01%	0.00%	0.00%
SiO2	11.00%	1.00%	0.50%	1.50%	1.50%	2.50%	0.00%	0.00%	36.0%	0.50%	99.6%	0.99%	0.00%
Ca(Ba)O	1.50%	0.15%	0.10%	0.60%	0.09%	0.00%	0.00%	0.00%	0.90%	5.00%	0.00%	1.50%	0.00%
MgO	7.50%	0.00%	0.10%	0.02%	0.04%	0.00%	0.00%	0.00%	0.70%	0.10%	0.00%	0.00%	0.00%
Cr2O3	1.10%	0.00%	0.13%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Al2O3	5.00%	0.05%	0.10%	0.05%	0.18%	0.00%	0.00%	0.00%	16.1%	0.00%	0.10%	0.00%	0.00%
NaCl	0.06%	0.52%	10.0%	1.00%	0.10%	0.00%	0.00%	0.00%	0.26%	0.50%	0.00%	0.35%	0.00%
SnO	0.01%	0.10%	2.50%	0.60%	0.00%	0.00%	0.00%	0.00%	0.10%	6.00%	0.00%	0.00%	0.00%
Sb2O3	0.02%	2.30%	1.50%	1.20%	0.00%	0.00%	0.00%	0.00%	0.10%	6.50%	0.00%	0.00%	0.00%
Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ZnO	0.02%	0.00%	2.00%	0.20%	0.00%	0.00%	0.00%	0.00%	1.00%	0.20%	0.00%	0.00%	0.00%
SO2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	0.000%
O2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	23.20%	100.0%	0.000%	0.000%	0.000%	0.000%	0.000%
CuO	0.01%	0.00%	0.25%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.20%	0.00%	0.00%	0.00%
H2OXL	7.33%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.20%	0.00%	0.00%	0.00%	0.00%
CO	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	0.000%
H2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	25.0%
N2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	76.8%	0.0%	0.000%	0.000%	0.000%	0.000%	0.00%
Sum:	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
H2O Fr.	23.3%	1.3%	0.7%	2.0%	2.0%	1.2%	0.5%	0.0%	15.3%	2.0%	1.3%	0.0%	0.0%
	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas

Moisture contents of solid feeds are multiplied by 2/3 to reflect partial drying during the charging process.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

Moles	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas
PbO	0.0022	0.0052	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pb*	0.0005	0.0215	0.0000	0.0244	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C*	0.0139	0.0076	0.0000	0.0111	0.0239	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0067
CO2	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fe*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FeO	0.0005	0.0001	0.0000	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO3	0.0002	0.0015	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S	0.0000	0.0000	0.0000	0.0031	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Na(K)2O	0.0002	0.0000	0.0025	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SiO2	0.0025	0.0010	0.0000	0.0014	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0148	0.0000	0.0000
Ca(Ba)O	0.0004	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MgO	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cr2O3	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Al2O3	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NaCl	0.0000	0.0005	0.0008	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SnO	0.0000	0.0000	0.0001	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sb2O3	0.0000	0.0005	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2OFrCb	0.0180	0.0045	0.0002	0.0064	0.0003	0.0001	0.0002	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000
ZnO	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0060	0.0108	0.0000	0.0000	0.0000	0.0000	0.0000
CuO	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2OXL	0.0057	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0135
N2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0228	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum:													
H2O Fr.	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas

ESTIMATE OF STACK EMISSIONS (FROM NEW BAGHOUSE) WHEN OPERATING THE 3.6-M ROTARY FURNACE,

and Summary of Results of Furnace and Flue Calculations

	Drying		Melting		Reduction	
Operation time during each furnace charging cycle:	1.0	Hr		Hr		Hr
Initial temperature for drying, melting, or reduction:	194	°F		°F		°F
Temperature at finish of drying, melting, or reduction:	590	°F		°F		°F
Natural gas firing rate:	5.7 MM	Btu/Hr		Btu/Hr		Btu/Hr
Average off-gas temperature from the furnace:	1652	°F		°F		°F
Natural gas consumed by the furnace:	5260	Ft3/Hr		Ft3/Hr		Ft3/Hr
Oxygen consumed by the furnace:	8978	Ft3/Hr		Ft3/Hr		Ft3/Hr
Diluted flue gas to the stack						
Flow rate entering stack @ 95 °F :	19,341	ACFM		ACFM		ACFM
Flow, DSCFM = 77°F @ 1 atm.:	17,208	DSCFM		DSCFM		DSCFM
Moisture content of gas to stack:	4.3%	Vol%		Vol%		Vol%
Particulates to stack, grains/dscf:	0.0026	g/DSCF		g/DSCF		g/DSCF
SO2 to the stack:	0.51	Lb/Hr		Lb/Hr		Lb/Hr
Emissions from Stack (Lb/Hr)						
Tetraethyl lead:	*BDL	Lb/Hr	*BDL	Lb/Hr	*BDL	Lb/Hr
Total chlorine expressed as chloride:	0.023	Lb/Hr		Lb/Hr		Lb/Hr
Lead as Pb:	0.13	Lb/Hr		Lb/Hr		Lb/Hr
Antimony as Sb:	0.005	Lb/Hr		Lb/Hr		Lb/Hr
Arsenic as As:	**ID	Lb/Hr	**ID	Lb/Hr	**ID	Lb/Hr
Barium as Ba:	<0.01	Lb/Hr		Lb/Hr		Lb/Hr
Silver as Ag:	<0.01	Lb/Hr		Lb/Hr		Lb/Hr
Cadmium as Cd:	<0.01	Lb/Hr		Lb/Hr		Lb/Hr
Chromium as Cr	0.0003	Lb/Hr		Lb/Hr		Lb/Hr
Mercury, thallium, and beryllium:	***NIF		***NIF		***NIF	

* Below Detectable Limit ** Insufficient data to estimate. *** Not known to be in feedstock to plant.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

mt	Bullion	Mat+Slag	Dust Out	mt	All mt In	All mt Out	MoleChecks	At. Wt.	
PbO	0.00000	1.80894	*0.16011*	PbO	1.80894	1.96905	0.054529	223	PbO
Pb*	9.45964	0.00000	0.00000	Pb*	9.60826	9.45964	0.054529	207	Pb*
C*	0.00000	0.65924	0.00000	C*	0.76502	0.65924	0.967361	12	C*
CO2	0.00000	0.00000	*0.65849*	CO2	0.74190	1.12979	0.967361	44	CO2
Fe*	0.00000	0.00000	0.00000	Fe*	0.18779	0.00000	0.00485	55.8	Fe*
FeO	0.00000	0.34598	0.00224	FeO	0.10659	0.34823	0.00485	71.8	FeO
SO3	0.00000	0.00000	*0.05375*	SO3	0.18959	0.05375	0.005972	80	SO3
S	0.00000	0.16950	0.00000	S	0.11528	0.16950	0.005972	32	S
Na2O	0.00000	1.05978	0.15689	Na(K)2O	1.21667	1.21667	RefrConsum	62	Na(K)2O
SiO2	0.00000	1.20151	0.00224	SiO2	1.20375	1.20375	**0.00000**	60	SiO2
CaO	0.00000	0.06491	0.00045	Ca(Ba)O	0.06536	0.06536	0.00000	56	Ca(Ba)O
MgO	0.00000	0.10554	0.00045	MgO	0.10599	0.10599	0.00000	40.3	MgO
Cr2O3	0.00000	0.01645	0.00058	Cr2O3	0.01703	0.01703	0.00000	152	Cr2O3
Al2O3	0.00000	0.07689	0.00045	Al2O3	0.07734	0.07734	**0.00000**	102	Al2O3
NaCl	0.00000	0.09858	0.04483	NaCl	0.14340	0.14340	0.00000	58.5	NaCl
SnO	0.00000	0.04092	0.01121	SnO	0.05213	0.05213	Sulfide	135	SnO
Sb2O3	0.00000	0.20952	0.00672	Sb2O3	0.21624	0.21624	339.0	291	Sb2O3
H2OFrCb	0.00000	0.00000	0.00000	H2OFrCb	0.54897	0.79107	Atomic	18	H2OFrCb
ZnO	0.00000	0.01187	0.00897	ZnO	0.02083	0.02083	97.4	81.4	ZnO
SO2	0.00000	0.00000	*0.00023*	SO2	0.00000	0.00023	Weights	64	SO2
O2	0.00000	0.00000	*0.00006*	O2	0.53707	0.05582	86.9	32	O2
CuO	0.00000	0.05790	0.00112	CuO	0.05902	0.05902	159.0	79.5	CuO
H2OXL	0.00000	0.00000	0.00000	H2OXL	0.10194	0.10194		18	H2OXL
CO	0.00000	0.00000	0.00000	CO	0.00000	0.00000		28.00	CO
H2	0.00000	0.00000	0.00000	H2	0.02690	0.00000		2.00	H2
N2	0.00000	0.00000	0.00000	N2	0.63804	0.63804		28.00	N2
Sum:	9.4596	5.9275	1.108778	Sum:	18.55406	18.55407			
	Bullion	Mat+Slag	Dust Out		CHECK				
			1.108778				**O2Mole Σ**		
			Check				1.92252		
							1.92252		

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

Moles To Flux	
0.0074	PbO
0.0464	Pb*
0.0638	C*
0.0169	CO2
0.0034	Fe*
0.0015	FeO
0.0017	SO3
0.0036	S
0.0171	Na(K)2O
0.0200	SiO2
0.0012	Ca(Ba)O
0.0026	MgO
0.0001	Cr2O3
0.0008	Al2O3
0.0017	NaCl
0.0003	SnO
0.0007	Sb2O3
0.0439	H2OFrCb
0.0001	ZnO
0.0000	SO2
0.0168	O2
0.0007	CuO
0.0057	H2OXL
0.0000	CO
0.0135	H2
0.0228	N2
Moles To Flux	

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

mt	Total In	Total Out	mt	At. Wt.	m3/tmole	
PbO	1.8089	1.9691	PbMoleSum	223	25.93	PbO
Pb*	9.6083	9.4596	**11.2874**	207	32.34	Pb*
C*	0.7650	0.6592	**11.2874**	12	5.33	C*
CO2	0.7419	1.1298	Fe&S m.s.	44	0.00	CO2
Fe*	0.1878	0.0000	0.00485	55.8	14.68	Fe*
FeO	0.1066	0.3482	0.00485	71.8	15.28	FeO
SO3	0.1896	0.0537	**0.00597**	80		SO3
S	0.1153	0.1695	**0.00597**	32	16.00	S
Na(K)2O	1.2167	1.2167	Refractory	62	31.00	Na(K)2O
SiO2	1.2037	1.2037	**0.00000**	60	27.27	SiO2
Ca(Ba)O	0.0654	0.0654	0.00000	56	18.67	Ca(Ba)O
MgO	0.1060	0.1060	0.00000	40.3	12.21	MgO
Cr2O3	0.0170	0.0170	0.00000	152	34.55	Cr2O3
Al2O3	0.0773	0.0773	**0.00000**	102	31.88	Al2O3
NaCl	0.1434	0.1434	0.00000	58.5	34.41	NaCl
SnO	0.0521	0.0521	C moleSum	135	20.93	SnO
Sb2O3	0.2162	0.2162	**0.08061**	291	55.96	Sb2O3
H2OFrCb	0.5490	0.7911	**0.08061**	18	0.00	H2OFrCb
ZnO	0.0208	0.0208	H wt Sum	81.4	14.88	ZnO
SO2	0.0000	0.0002	**0.09922**	64		SO2
O2	0.5371	0.0558	**0.09922**	32		O2
CuO	0.0590	0.0590	O wt Sum	79.5	12.42	CuO
H2OXL	0.1019	0.1019	**1.92252**	18		H2OXL
CO	0.0000	0.0000	**1.92252**	28.0		CO
H2	0.0269	0.0000	**Check?**	2.0		H2
N2	0.6380	0.6380		28.0		N2
Sum:	18.5541	18.5541		At. Wt.	m3/tmole	
	mt In	mt Out				

g/cc-ft3/lb 62.42

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

Boundary Conditions for Operating the Short Rotary Furnace

Dust recycle rate, dry mt/hr	0.45
Calculated Natl. Gas Kcal/hr Input	1,427,349
Calculated Natl. Gas used, mt/hr	0.108
Calculated Natl. Gas used, kg/hr	107.60
Natl. Gas heat content (net), kcal/kg	13,265
Natl. Gas density, lb/ft3 @ STP	0.044
Fuel heat capacity, kgcal/kg°C	0.55
Natl. Gas density, kg/m3 @ STP	1.44
Fuel temperature, C	7
Air temperatures, C	7
Solids feed conc. temperature, C	7
Return dust temperature, C	7
Offgas temperature, C	310
Final solids temperature, °C	310
Stoic. oxygen for fuel, kg dry/kg fuel	4.00
% excess oxygen for natural gas	-0.20
Air inleakage to furnace, mt/hr	0.83
Atomizing steam, kcal/kg	0.00
Atomizing steam, kg/kg fuel	0.00
Sum H20 in furnace solids, mt/hr	0.65
Moisture in air&O2&Gas, mt /hr	0.00
Total moisture to plant, mt/hr	0.65
Furnace shell temperature, F	425
Furnace (small) shell area, m2	57.65
Heat loss, kiln shell & door, kcal/hr	96,507

	H fusion kcal/kgmole	Fusion Kcal/hr
PbO	6570	53294.9
Pb°	1150	53379.2
C		
CO2		
FeS	7730	26014.3
FeO	7500	11134.2
SO3		
Na(K)2O	11400	53101.2
SiO2	2600	52162.5
Ca(Ba)O	12200	14238.6
MgO	18500	48655.8
Cr2O3	4000	448.2
Al2O3	25700	19486.9
NaCl	6700	15497.4
SnO	6000	2316.9
Sb2O3	13300	9883.2
CuO	13580	10081.0
ZnO	4500	1151.8
Sum =	141430.	370,846

Chemical Reactions

	kcal/kg	of:
PbO + 1/2C = Pb° + 1/2CO2	24.5	Pb°
PbS + Na2O = Na2S + 1/2O2	139.3	PbS
Fe° + PbS = FeS + Pb°	21.3	Fe°
PbS + FeO = FeS + PbO	145.7	FeS
PbOSO3 + Na2O = Na2S + PbO + 2O2	2276.9	Na2S
Na2CO3 = Na2O + CO2	725.0	Na2CO3

Large= 69.08

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

DrssProdmt	Dross,%
0.00000	8.000%
0.00000	86.165%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	5.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.133%
0.00000	0.551%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.151%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	0.000%
0.00000	100.0%

Normalized Silicate Fraction i.e., Slag Assay	
3.5%	Al2O3+Cr2O3
10.9%	FeO
-	
-	
40.4%	Na2O
45.1%	SiO2
100.0%	TOTAL

Sulfur Balance(mt or %)	
Heat S In as S:	0.1911
Heat S Out as S	0.1911
Heat SO2 as S:	0.000191
SDross(Heat)	0.0000
Ssilicate(Heat)	0.1164
Smatte(Heat):	0.0532
S in dust=Heat	0.0217
S out by addn.	0.1914
FlueGasMt/hr	2.0584
Wt.% SO2	0.0000%
SO2 exit/hr, this furnace:	Short Tons 0.000253
SO2 exit/yr, all furnaces:	st/yr 0.42
%ofSasSilicate	60.9%
% of S asMatte	27.8%
% of S asDross	
% of S as Dust	11.3%
% of S as Gas	0.10%

PbO;PbS	
Pb*	
C*	
CO2	
Fe*;FeS	
FeO	
SO3	
S;Na2S	
Na(K)2O	
SiO2	
Ca(Ba)O	
MgO	
Cr2O3	
Al2O3	
NaCl	
SnO	
Sb2O3	
H2OFrCb	
ZnO	
SO2	
O2	
CuO	
H2OXL	
CO	
H2	
N2	
SUM	0
Total%=Check	100%

Sulfur Pool=	0.04379
Oxygen Pool=	-6.42337
FeSvsNa2Smat	50.0%
Na2O pool=	0.63503

mt of CO2=	0.658		
O from PbO=	0.000	but not dust.	
O for Fe=	0.000	but not dust.	
O form SO3=	0.000	but not dust.	
O from SnO=	0.0000	but not dust.	
O fromSb2O3=	0.0000	but not dust.	
O from ZnO=	0.0000	but not dust.	FeOMoleFract.
O from CuO=	0.0000	but not dust.	**0.07**
O for Si in Fe°	0.0000	CO2/COwt.=R	1000.00
mt eq CO2 in=	0.6585	1.27R + 1=	1271.0000

(CO2-x)/1.27x=CO2/CO wt=R

(CO2-x)=1.27Rx

CO2 decomposed =1.27Rx + x = x(1.27R+1))

x=	0.001	mt CO2 decomposed
1.27x=	0.001	mt CO evolved from melt.
CO2-x=	0.658	mt CO2 evolved from melt.
	0.000	mt Carbon needed for above.
	0.398	mt C
	0.659	mt carbon for slag; (inc. H2)
	0.37	
	mt	**20.% Excess Coke**

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

Density		mt O2 Out	m3 MatteSlag	mt O2 In	
11.30	PbO	0.14128	0.21034	0.12979	PbO
Pb°	Pb°	0.00000	0.00000	0.00000	Pb°
	C°	0.00000	0.29299	0.00000	C°
	CO2	0.82166	0.00000	0.53956	CO2
	Fe°	0.00000	0.00000	0.00000	Fe°
	FeO	0.07760	0.07361	0.02375	FeO
	SO3	0.03225	0.00000	0.11376	SO3
	S	0.00000	0.08475	0.00000	S
	Na(K)2O	0.31398	0.52989	0.31398	Na(K)2O
	SiO2	0.64200	0.54614	0.64200	SiO2
	Ca(Ba)O	0.01867	0.02164	0.01867	Ca(Ba)O
	MgO	0.04208	0.03198	0.04208	MgO
	Cr2O3	0.00538	0.00374	0.00538	Cr2O3
	Al2O3	0.03640	0.02403	0.03640	Al2O3
Sn°	NaCl	0.00000	0.05799	0.00000	NaCl
6.60	SnO	0.00618	0.00634	0.00618	SnO
6.40	Sb2O3	0.03567	0.04029	0.03567	Sb2O3
Sb°	H2OFrCb	0.21521	0.00000	0.00000	H2OFrCb
	ZnO	0.00410	0.00217	0.00410	ZnO
	SO2	0.00011	0.00000	0.00000	SO2
Cu°	O2	0.05582	0.00000	0.53707	O2
8.40	CuO	0.01188	0.00905	0.01188	CuO
	H2OXL	0.09062	0.00000	0.09062	H2OXL
	CO	0.00000	0.00000	0.00000	CO
	H2	0.00000	0.00000	0.00000	H2
	N2	0.00000	0.00000	0.00000	N2
Sum =	Oxygen Out=	2.55088	1.93496	2.55088	<- Oxygen In
			SUM OF M3	Oxygen In	

m3 of Bullion:	0.84
m3 of Slag:	1.93
m3 of Dross:	0.00
m3 in Charge:	2.77
FreshBrckM3	6.9
WornBrickM3	8.8

Effective Furn. Volume with New Brick vs with Worn Brick.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

Heat Capacity Calc., kcal/kg		
T1, C=	90	for solids
T2, C=	310	for solids
Average Feed	0.180	4.3235E-05
CO2	229	
	kcal/kg	
CO	234	
Dust recy.	0.184	0.0000838
T1, C=	25.	for gases
T2, C=	900.	for gases
	kcal/kg	
O2	213	
SO2	163	
Air	0.234	0.0000173
H2O vapor	443	Sensible Heat
	kcal/kg	
N2	233	
H2O Vaporize	598	
	Heat of boiling	

	Mass Basis mt/hr	Heat Inputs kcal/hr
Fuel Combustion	0.108	1,427,349
Steam for Atomization	0.00	0
Coke Combustion:	0.0141	108,579
Sensible Heats:		
Dry furnace feedstocks	16.26	190,289
Dry dust recycle	0.45	5,385
Natural gas	0.108	417
Gas combustion oxygen	0.34	564
Total air into furnace	0.83	1,361
H2O in all input gases	0.004	29
Free H2O in solid feeds	0.65	42,039
FeS-Fe°&FeO Formation ΔH		0
Na2S from PbS "		0
Na2S from SO3 "		0
Na2O-Na2CO3 "		0
Pb° from PbO "		0
Refractory dissolved:	0.0000	0
Heats of fusion and vaporization:		
Fusion		0
Vaporization=already in ΔH		0
Total Heat Input, kcal/hr		1,776,012

	Mass Basis mt/hr	Heat Outputs kcal/hr
Sensible Heats:		
CO2 exhaust dry gas	0.47	108,019
CO exhaust dry gas	0.00	0
O2 exhaust dry gas	0.06	11,877
N2 exhaust dry gas	0.64	148,695
SO2 exhaust dry gas	0.00023	37
Solids in Charge (heated/hr)	16.26	891,459
Dry dust in offgas	0.18	10,949
Slag discharge is zero	0.00	0
H2O from all input gases	0.004	1,839
Free H2O in solid feeds	0.65	286,393
H2O from combustion	0.24	107,208
H2O from atomization steam	0.00	0
H2O from solid Rx product:	0.00	0
Shell+Door+Refr heat losses		209,535
Total Heat Out, kcal/hr:		1,776,012

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 1st Hour After Charge Door is Closed.

	Slag Wt,mt	Matte Wt,mt			
				11.3%	% fixed C in matte + slag.
PbO	1.80894	0.00000	-	0.0%	is PbS in Matte
-	0.00000	0.00000	PbS		is Matte + Slag factor kg Pb loss/mt bullion.
C	0.65924	0.00000	C	0.00	is (matte/slag) concentration ratio for coke
CO2	0.00000	0.00000	CO2	5.0%	is the % Na2S in slag
-	0.00000	0.06007	FeS	2.03%	is the percent sulfur in slag.
FeO	0.29085	0.00601	FeO		
	0.00000	0.00000	-		
Na2S	0.28361	0.05337	Na2S		
Na(K)2O	0.79192	0.00000	-		
SiO2	1.20133	0.00018	SiO2	0.005	is (matte/slag) concentration ratio for silica
Ca(Ba)O	0.06490	0.00001	Ca(Ba)O	0.005	is (matte/slag) concentration ratio for lime
MgO	0.10553	0.00002	MgO	0.005	is (matte/slag) concentration ratio for magnesia
Cr2O3	0.01645	0.00000	Cr2O3	0.005	is (matte/slag) concentration ratio for chromia
Al2O3	0.07688	0.00001	Al2O3	0.005	is (matte/slag) concentration ratio for alumina
NaCl	0.09809	0.00049	NaCl	0.17	is (matte/slag) concentration ratio for chloride
SnO	0.04033	0.00059	CdO	0.50	is (matte/slag) concentration ratio for tin
Sb2O3	0.20787	0.00192	Sb2S3	0.27	is (matte/slag) concentration ratio for antimony
H2OFrCb	0.00000	0.00000	H2OFrCb		
ZnO	0.01153	0.00040	ZnS	1.00	is (matte/slag) concentration ratio for Zn
SO2	0.00000	0.00000	SO2		
O2	0.00000	0.00000	O2		
CuO	0.01473	0.04317	Cu2S	100.00	is (matte/slag) concentration ratio for Cu
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
TOTAL SLAG	5.67221	0.16623	TOTAL Matte		
	Slag Wt,mt	Matte Wt,mt			

Calculation of Slag Viscosity

X'SiO2'=	Moles Si+P+Ti
X'CaO'=	Moles Ca+Mg+Mn+Pb+Zn+Fe
X'Al2O3'=	Moles Al2O3+Cr2O3
X'Na2O'=	Moles NaK2O+Na2S (non-mat
X'CaF2'=	Moles NaCl
A=	
B=	

	η in Poise	°K	°C
Viscosity=			
Viscosity=			
Viscosity=			
Viscosity=			
Viscosity=			

	Wt %	Weight	MoleFrac.Slag	MoleNonMatte
PbO	37.3%	1.81	0.1442	0.00811
Pb*	0.0%	0.00	0.0000	0.00000
C*	0.0%	0.00	0.0000	0.00000
CO2	0.0%	0.00	0.0000	0.00000
Fe*	0.0%	0.00	0.0000	0.00000
FeO	6.0%	0.29	0.0720	0.00405
SO3	0.0%	0.00	0.0000	0.00000
Na2S	2.4%	0.12	0.0646	0.00364
Na(K)2O	16.3%	0.79	0.2271	0.01277
SiO2	24.8%	1.20	0.3559	0.02002
Ca(Ba)O	1.3%	0.06	0.0206	0.00116
MgO	2.2%	0.11	0.0466	0.00262
Cr2O3	0.3%	0.02	0.0019	0.00011
Al2O3	1.6%	0.08	0.0134	0.00075
NaCl	2.0%	0.10	0.0298	0.00168
SnO	0.8%	0.04	0.0053	0.00030
Sb2O3	4.3%	0.21	0.0127	0.00071
Other	0.0%	0.00	0.0000	0.00000
ZnO	0.2%	0.01	0.0025	0.00014
SO2	0.0%	0.00	0.0000	0.00000
O2	0.0%	0.00	0.0000	0.00000
CuO	0.3%	0.01	0.0033	0.00019
H2OXL	0.0%	0.00	0.0000	0.00000
CO	0.0%	0.00	0.0000	0.00000
H2	0.0%	0.00	0.0000	0.00000
N2	0.0%	0.00	0.0000	0.00000
Sum:	100.00%	4.85	1.0000	0.05625

100 Start-up controler

Calculation of the low-temperature heat capacities

	A	T2 - T1	B	T2sq - T1sq	C	1/T2-1/T1
CO2	10.57	25	1.05E-03	1.43E+04	2.06E+05	-3.07E-04
CO	6.708	25	5.53E-04	1.43E+04	6.20E+03	-3.07E-04
Sb4O6 vap.	52.016	25	1.69E-03	1.43E+04	8.30E+05	-3.07E-04
O2	7.16	25	5.00E-04	1.43E+04	4.00E+04	-3.07E-04
SO2	11.04	25	9.40E-04	1.43E+04	1.84E+05	-3.07E-04
H2O vapor	7.3	25	1.23E-03	1.43E+04	0.00E+00	-3.07E-04
N2	6.83	25	4.50E-04	1.43E+04	1.20E+04	-3.07E-04

Calculation of high-temperature heat capacities, kcal/kg

	A	T2 - T1	B	T2sq - T1sq	C	1/T2-1/T1
CO2	10.57	875	1.05E-03	1.29E+06	2.06E+05	-2.5E-03
CO	6.708	875	5.53E-04	1.29E+06	6.20E+03	-2.5E-03
Σ mass for input heat calc:						
Σ mass for outputput heat calc						
Σ mass in from material bal:						
Sb406 vapor	52.016	875	1.69E-03	1.29E+06	8.30E+05	-2.5E-03
O2	7.16	875	5.00E-04	1.29E+06	4.00E+04	-2.5E-03
SO2	11.04	875	9.40E-04	1.29E+06	1.84E+05	-2.5E-03
H20 vapor	7.3	875	1.23E-03	1.29E+06	0.00E+00	-2.5E-03
N2	6.83	875	4.50E-04	1.29E+06	1.20E+04	-2.50E-03

Low-Temp. Heat Capacities:

T1, °C=	0
T2, °C=	25
	Heat Capac. Kcal/kg
CO2	4.91E+00
CO	6.20E+00
Sb203 vapor	1.83E+00
O2	5.43E+00
SO2	3.64E+00
H20 vapor	1.11E+01
N2	6.20E+00

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Furnace:	Old (3.6-m)	Pb° in Bulln, mt		CHARGE
Date:	23-Jul-91	Pb in Feed, mt	11.19	CYCLE
EndOfPeriod T°	785 degC	Pb,TotalSlag, mt		IS FIRST
Parameters		Pb in Dust, mt		**********
to Check		Pb,DrossFloat,mt		TIME IS
Slag FeO =		Bullion, mt		DURING
Target =	10 to 15%	**PbRecToBulln**		HRS 2-3
Basicity =		Balanced if small	9.47E-06	2.0 hr
Target =	1.1 to 1.4	SilicatePhase, mt		AFTER
Viscosity =		MattePhase, mt		CHARGE DOOR
Target =	10 to 40	Soda/hr to flue	0.045	IS CLOSED
Slag Ratio of		Dust, % of feed	3.0%	**********
(Si+Al)/Na =	1.2	Molds Output-->		

Feed(Scoops)	DryFeed,lb	DryFeedMt/hr
P.CakeTEL(2)	2600.	1.18
MM Plate(6)	13328.	6.04
Dust In (2)	990.	0.45
MM Dross(6)	12610.	5.72
Coke(1/2)	679.	0.31
FeChips(0.35)	491.	0.22
Total Air In	2078.	0.94
O2 to Burner	757.	0.34
Lenox(0)	0.	0.00
NiterDross(0)	0.	0.00
Glass Sand(2)	1960.	0.89
Anzon(0)	0.	0.0
Natural Gas	236.7	0.107
TOTAL	35730.	16.19
	Flux Summary	
Soda(2+BH)	3500.	1.586
Sand (1.5)	1960.	0.888
FeChip(.25)	491.	0.223
Coke (0.5)	679.	0.308

Total Slag, %	
Pb	
C°	
FeO	
S	
Na2O	
SiO2	
Ca(Ba)O	
MgO	
Cr2O3	
Al2O3	
NaCl	
SnO	
Sb2O3	
Other	
ZnO	
Other	
Other	
CuO	

	Bullion	SilicateOnly	Matte Only
PbO			
Pb°, PbS			
C°			
CO2			
FeS			
FeO			
S			
Na2S			
Na(K)2O			
SiO2			
Ca(Ba)O			
MgO			
Cr2O3			
Al2O3			
NaCl			
Sn°, SnO			
Sb°,Sb2S3			
Other			
ZnO,ZnS			
Other			
Other			
Cu,Cu2S			
TOTAL	100.0%	100.0%	100.0%

MgCr Brick, kg/hr per mt Bullion	0.0	% of S fixed:	99.90%
		Coke in matte + slag, %	
Al2O3 Brick, Kg/hr per mt Bullion	0.00	"Slag" Basicity	
Mat.FeS/Na2S	0.50	**Distribution Factors**	
Mat.FeO Contr.	10	Sn(Bullion):	0.00
% Excess Coke	20.0%	Sb(Bullion):	0.00
PbTo"slag"mt		Cu(Bullion):	0.00
Viscosity of the silicate slag, Poise:		DrossRecycle:	0.00
		SO2 controller	

Comments: Lead metallics are melted over a 1 hr period.
Oxide reduction is nil.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Gas firing rate:		**Summary of Heat Losses, Kcal/hr**		Approx. st SO2 vented from		Estimated ΔT drop due to heat	
Kcal/hr	1,423,334	**During 2nd part of 1st charge cycle**		plant per yr	0.42	loss when gas passes through	
Btu/hr	5,647,790	Loss through furnace walls	96,507	SCFM to Stack:	11977.	the knockout tanks prior to	
Kg Nat. Gas/hr	107.3	Heat to refractory from system	21,617			initial dilutn.	127 degC
Lb NG/hr	236.7	Radiant heat loss thru closed door	6,380	Gas Temp. exiting		ACFM from	
%TongeO2Use	**100.%**	Sum of heat losses:	124,504	stack:	35 degC	the furnace:	3,292
%Exc.O2->NG	**-20%**	Initial T°C of refractory (Ave.)	725 degC	Gas Temp. exiting convective		SCFM from	
Ave. Offgas T°C	**980 degC**	Final T°C of refractory (Ave.)	735 degC	cooler:	345 degC	the furnace:	752
P, inch H20	**0.25**	Coke Content of Oxide Component:		Gas Temp. exiting convective		ACFM to BH:	4,470
Shell, T°F	425 degF	Furnace area in use, m2	**57.7**	cooler:	195 degC	SCFM to BH:	3,385
Tramp Air in Through the		Temperature of bag house:	**105 degC**	Matte/slag concentration ratio for coke:			**0.00**
Door, kg/hr:	942.	PbInSilicatePhaseOfEmulsion,mt		SCFM moisture to stack:	232		
Percent of Dust Exiting		Pb inMatte phase of Emulsion, %:		Coke Calculated via total heat?	Indirectly.		**679.**
Per Hour	**16.7%**	Hrs of 1st Cycle	**Furnace Offgas**	Portion of excess coke burned, %/hr?			**17.%**
Percent of Charge Fused		CycleDoorClosed	**Volume% at 980 degC**				
Per Hour	**31.%**	**6.0**	**O2: 2.1%**	Number of Hrs in this period:			**2.0**
Percent of Charge Reduced		Total Hrs Burner	**N2: 49.2%**	Soda ash CO2 still in solids?	**Yes**		**100.0%**
Per Hour	**0.%**	**15.0**	**H20: 26.2%**	Soda ash CO2 to gas vent?	**No**		**0.0%**
Stoic. Pure O2 for Natural			**CO2: 22.6%**	Coke heat input, Kcal/hr			
Gas, kg/hr	429.2	% Dross Formed?	**CO: 0.0%**	System's heat gain from refractory, Kcal/hr			
Stoic. Pure O2 for solid C->		**0**	**SO2: 0.00169%**	Heat lost to furnace offgas & dust, Kcal/hr			
CO2, Kg/hr			sum= 100.00%	Heat to furnace charge from burner, Kcal/hr			
	35.0		**Furnace Offgas**	Heat lost from walls and door, Kcal/hr			
Initial Temperature		If >100°C, =0	**mt/hr**	Sum of heats of reaction and fusion:			
of Charge:	**310 degC**	0	**O2: 0.034**	Air drawn into furnace via door, SCFM			431
Final Temperature		If <100°C, =1	**N2: 0.72**	FurnaceGas,kg	1520.	Gas Volume to Baghouse,	
of Charge:	**785 degC**		**H20: 0.25**	" " ",kgMole	52.3	ACMH =	7,595
Charge Moisture Removed:		**0.0%**	**CO2: 0.52**	v/oCO2 diluted	1.42%	Sn(Bullion):	0.00
Offgas volume at average furnace temperature:			**CO: 0.0**	From Stack		Sb(Bullion):	0.00
	5,595	ACMH	**SO2: 0.000057**	v/oSO2 diluted	0.00011%	Cu(Bullion):	0.00
Dilution air to cooler, kg/hr		2,266	sum= 1.5201		**EFFICIENCY OF HEAT UTILIZATION, %**		
Dilutn. air to cooler, ACMH		4,148	Space between door and furnace, inches =		**0.44**	Calculated Eff.	46%
Total ACMH into cooler		9,742	Start-up Controller for Totals =		100	Target effic.	**47.5%**
Comments: Note that the exit gas temperature is the average during				SO2, %/hr	**15.0%**	BH, ACFM	4,470
the period.				Lb SO2/Hr	SO2evoln.,hrs	Press., mm:	**730**
				0.125	2.0	Ambient, degC:	**7**

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Kg moles of gas from furnace	52.3		Oxide Slag mt	5.86	
Kg moles air cooler entry	78.6	345 degC	C with Oxide	0.63	
Kg moles gas into cooler	130.8	195 degC	%C in Oxide	10.7%	
Air to cooler exit, kg/hr	3010.	105 degC	C Burnt, mt	0.027	
Air to cooler exit, ACMH	3371.		C in dust, mt	0.00	
Kg moles air to cooler exit	104.4		Dilution air to stack, kg/hr:	16958.	
Kg moles, all gases, to BH	235.2		Total gas to stack, kgMoles/hr	832.	
ACMH to BH, TOTAL	7595.		Total ACFM into stack	12888.	

Efficiency

Kcal to solids	802,563
Kcal to redn. & fusion	55,134
Wall & door losses	-102,887
Feed gases	-2,514
Coke heat input, Kcal/hr	-100,980
TOTAL	651,316
Burner Kcal	1,423,334
Efficiency	45.8%

O2 released by redn., mt:	0.0000
SCFH air drawn into furnace:	25,863
SCFM air drawn into furnace:	431

	Atomic Weight	Total Moles (inc. refractory)	Total mt
PbO	223	0.00812	1.812
Pb°	207	0.04594	9.510
C°, non-gas	12	0.05450	0.654
CO2	44	0.00161	0.071
Fe°	55.8	0.00334	0.187
FeO	71.8	0.00139	0.100
SO3	80	0.00233	0.186
S	32	0.00357	0.114
Na(K)2O	62	0.00459	0.285
SiO2	60	0.01955	1.173
Ca(Ba)O	56	0.00110	0.062
MgO	40.3	0.00224	0.090
Cr2O3	152	0.00010	0.015
Al2O3	102	0.00065	0.067
NaCl	58.5	0.00229	0.134
SnO	135	0.00038	0.052
Sb2O3	291	0.00074	0.215
H2OFrCb	18	0.00026	0.005
ZnO	81.4	0.00025	0.021
SO2	64.0	0.00000	0.000
O2	32.0	0.01753	0.561
CuO	79.5	0.00073	0.058
Sum:		0.17123	15.370

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Weight %	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas
PbO	42.9%	19.0%	35.3%	0.0%	0.0%	0.0%	0.00%	0.00%	40.1%	10.0%	0.00%	71.1%	0.0%
Pb°	8.0%	73.2%	0.0%	87.3%	0.0%	0.0%	0.00%	0.00%	0.0%	61.2%	0.0%	0.0%	0.00%
C°	12.00%	1.50%	0.00%	2.3%	92.2%	3.00%	0.00%	0.00%	0.0%	0.50%	0.00%	22.1%	75.00%
CO2	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0%	0.00%	0.00%	0.00%	0.00%
Fe°	0.00%	0.1%	0.00%	0.00%	0.00%	82.50%	0.00%	0.00%	0.0%	0.00%	0.00%	0.0%	0.00%
FeO	2.80%	0.1%	0.50%	0.50%	0.29%	12.00%	0.00%	0.00%	0.9%	0.50%	0.30%	0.0%	0.00%
SO3	1.00%	2.0%	12.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0%	0.00%	0.00%	4.0%	0.00%
S	0.00%	0.00%	0.00%	1.70%	5.50%	0.00%	0.00%	0.00%	0.3%	1.50%	0.00%	0.00%	0.00%
Na(K)2O	1.10%	0.00%	35.0%	2.00%	0.10%	0.00%	0.00%	0.00%	3.5%	7.30%	0.01%	0.00%	0.00%
SiO2	11.00%	1.00%	0.50%	1.50%	1.50%	2.50%	0.00%	0.00%	36.0%	0.50%	99.6%	0.99%	0.00%
Ca(Ba)O	1.50%	0.15%	0.10%	0.60%	0.09%	0.00%	0.00%	0.00%	0.90%	5.00%	0.00%	1.50%	0.00%
MgO	7.50%	0.00%	0.10%	0.02%	0.04%	0.00%	0.00%	0.00%	0.70%	0.10%	0.00%	0.00%	0.00%
Cr2O3	1.10%	0.00%	0.13%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Al2O3	5.00%	0.05%	0.10%	0.05%	0.18%	0.00%	0.00%	0.00%	16.1%	0.00%	0.10%	0.00%	0.00%
NaCl	0.06%	0.52%	10.0%	1.00%	0.10%	0.00%	0.00%	0.00%	0.26%	0.50%	0.00%	0.35%	0.00%
SnO	0.01%	0.10%	2.50%	0.60%	0.00%	0.00%	0.00%	0.00%	0.10%	6.00%	0.00%	0.00%	0.00%
Sb2O3	0.02%	2.30%	1.50%	1.20%	0.00%	0.00%	0.00%	0.00%	0.10%	6.50%	0.00%	0.00%	0.00%
Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ZnO	0.02%	0.00%	2.00%	0.20%	0.00%	0.00%	0.00%	0.00%	1.00%	0.20%	0.00%	0.00%	0.00%
SO2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	0.000%
O2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	23.20%	100.0%	0.000%	0.000%	0.000%	0.000%	0.000%
CuO	0.01%	0.00%	0.25%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.20%	0.00%	0.00%	0.00%
H2OXL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	0.000%
H2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	25.0%
N2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	76.8%	0.0%	0.000%	0.000%	0.000%	0.000%	0.00%
Sum:	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
H2O Fr.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas
OrigH2O	35.0%	2.0%	1.0%	3.0%	3.0%	1.8%	0.5%	0.0%	23.0%	3.0%	2.0%	0.0%	0.0%

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Moles	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas
PbO	0.0023	0.0051	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pb°	0.0005	0.0214	0.0000	0.0241	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C°	0.0118	0.0076	0.0000	0.0110	0.0236	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0067
CO2	0.0016	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fe°	0.0000	0.0001	0.0000	0.0000	0.0000	0.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FeO	0.0005	0.0001	0.0000	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO3	0.0001	0.0015	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S	0.0000	0.0000	0.0000	0.0030	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Na(K)2O	0.0002	0.0000	0.0025	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SiO2	0.0022	0.0010	0.0000	0.0014	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0147	0.0000	0.0000
Ca(Ba)O	0.0003	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MgO	0.0022	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cr2O3	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Al2O3	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NaCl	0.0000	0.0005	0.0008	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SnO	0.0000	0.0000	0.0001	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sb2O3	0.0000	0.0005	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2OFrCb	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ZnO	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0068	0.0107	0.0000	0.0000	0.0000	0.0000	0.0000
CuO	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2OXL	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0134
N2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0257	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum:													
H2O Fr.	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas

ESTIMATE OF STACK EMISSIONS (FROM NEW BAGHOUSE) WHEN OPERATING THE 3.6-M ROTARY FURNACE,

and Summary of Results of Furnace and Flue Calculations

	Drying		Melting		Reduction	
Operation time during each furnace charging cycle:		Hr	2.0	Hr		Hr
Initial temparature for drying, melting, or reduction:		°F	590	°F		°F
Temperature at finish of drying, melting, or reduction:		°F	1445	°F		°F
Natural gas firing rate:		Btu/Hr	5.6 MM	Btu/Hr		Btu/Hr
Average off-gas temperature from the furnace:		°F	1796	°F		°F
Natural gas consumed by the furnace:		Ft3/Hr	5245	Ft3/Hr		Ft3/Hr
Oxygen consumed by the furnace:		Ft3/Hr	8953	Ft3/Hr		Ft3/Hr
Diluted flue gas to the stack						
Flow rate entering stack @ 95 °F :		ACFM	12,888	ACFM		ACFM
Flow, DSCFM = 77°F @ 1 atm.:		DSCFM	11,746	DSCFM		DSCFM
Moisture content of gas to stack:		Vol%	1.9%	Vol%		Vol%
Particulates to stack, grains/dscf:		g/DSCF	0.0026	g/DSCF		g/DSCF
SO2 to the stack:		Lb/Hr	0.12	Lb/Hr		Lb/Hr
Emissions from Stack (Lb/Hr)						
Tetraethyl lead:	*BDL	Lb/Hr	*BDL	Lb/Hr	*BDL	Lb/Hr
Total chlorine expressed as chloride:		Lb/Hr	0.016	Lb/Hr		Lb/Hr
Lead as Pb:		Lb/Hr	0.085	Lb/Hr		Lb/Hr
Antimony as Sb:		Lb/Hr	0.0032	Lb/Hr		Lb/Hr
Arsenic as As:	**ID	Lb/Hr	**ID	Lb/Hr	**ID	Lb/Hr
Barium as Ba:		Lb/Hr	<0.01	Lb/Hr		Lb/Hr
Silver as Ag:		Lb/Hr	<0.01	Lb/Hr		Lb/Hr
Cadmium as Cd:		Lb/Hr	<0.01	Lb/Hr		Lb/Hr
Chromium as Cr		Lb/Hr	0.0002	Lb/Hr		Lb/Hr
Mercury, thallium, and beryllium:	***NIF		***NIF		***NIF	

* Below Detectable Limit ** Insuficient date to estimate. *** Not known to be in feedstock to plant.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

mt	Bullion	Mat+Slag	Dust Out	mt	All mt In	All mt Out	MoleChecks	At. Wt.	
PbO	0.00000	1.81183	*0.15851*	PbO	1.81183	1.97034	0.054066	223	PbO
Pb*	9.36265	0.00000	0.00000	Pb*	9.50978	9.36265	0.054066	207	Pb*
C*	0.00000	0.61204	0.00000	C*	0.73447	0.61204	0.933348	12	C*
CO2	0.00000	0.00000	*0.65849*	CO2	0.72921	1.17814	0.933348	44	CO2
Fe*	0.00000	0.00000	0.00000	Fe*	0.18665	0.00000	0.00474	55.8	Fe*
FeO	0.00000	0.33805	0.00224	FeO	0.10013	0.34030	0.00474	71.8	FeO
SO3	0.00000	0.00000	*0.05378*	SO3	0.18648	0.05378	0.005897	80	SO3
S	0.00000	0.16715	0.00000	S	0.11410	0.16715	0.005897	32	S
Na2O	0.00000	1.05556	0.15707	Na(K)2O	1.21263	1.21263	RefrConsum	62	Na(K)2O
SiO2	0.00000	1.17083	0.00224	SiO2	1.17308	1.17308	**0.00000**	60	SiO2
CaO	0.00000	0.06132	0.00045	Ca(Ba)O	0.06176	0.06176	0.00000	56	Ca(Ba)O
MgO	0.00000	0.08966	0.00045	MgO	0.09011	0.09011	0.00000	40.3	MgO
Cr2O3	0.00000	0.01411	0.00058	Cr2O3	0.01469	0.01469	0.00000	152	Cr2O3
Al2O3	0.00000	0.06625	0.00045	Al2O3	0.06670	0.06670	**0.00000**	102	Al2O3
NaCl	0.00000	0.09744	0.04488	NaCl	0.14232	0.14232	0.00000	58.5	NaCl
SnO	0.00000	0.04046	0.01122	SnO	0.05168	0.05168	Sulfide	135	SnO
Sb2O3	0.00000	0.20779	0.00673	Sb2O3	0.21452	0.21452	339.0	291	Sb2O3
H2OFrCb	0.00000	0.00000	0.00000	H2OFrCb	0.00469	0.24611	Atomic	18	H2OFrCb
ZnO	0.00000	0.01167	0.00898	ZnO	0.02064	0.02064	97.4	81.4	ZnO
SO2	0.00000	0.00000	*0.00006*	SO2	0.00000	0.00006	Weights	64	SO2
O2	0.00000	0.00000	*0.00001*	O2	0.56081	0.03440	86.9	32	O2
CuO	0.00000	0.05728	0.00112	CuO	0.05840	0.05840	159.0	79.5	CuO
H2OXL	0.00000	0.00000	0.00000	H2OXL	0.00000	0.00000		18	H2OXL
CO	0.00000	0.00000	0.00000	CO	0.00000	0.00000		28.00	CO
H2	0.00000	0.00000	0.00000	H2	0.02682	0.00000		2.00	H2
N2	0.00000	0.00000	0.00000	N2	0.71984	0.71984		28.00	N2
Sum:	9.3626	5.8014	1.107267	Sum:	17.79136	17.79135			
	Bullion	Mat+Slag	Dust Out		CHECK				
			1.107267				**O2Mole Σ**		
			Check				1.35951		
							1.359499		

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Moles To Flux	
0.0074	PbO
0.0459	Pb°
0.0612	C°
0.0166	CO2
0.0033	Fe°
0.0014	FeO
0.0017	SO3
0.0036	S
0.0170	Na(K)2O
0.0195	SiO2
0.0011	Ca(Ba)O
0.0022	MgO
0.0001	Cr2O3
0.0006	Al2O3
0.0017	NaCl
0.0003	SnO
0.0007	Sb2O3
0.0137	H2OFrCb
0.0001	ZnO
0.0000	SO2
0.0175	O2
0.0007	CuO
0.0000	H2OXL
0.0000	CO
0.0134	H2
0.0257	N2
Moles To Flux	

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

mt	Total In	Total Out	mt	At. Wt.	m3/tmole	
PbO	1.8118	1.9703	PbMoleSum	223	25.93	PbO
Pb*	9.5098	9.3626	**11.1916**	207	32.34	Pb*
C*	0.7345	0.6120	**11.1916**	12	5.33	C*
CO2	0.7292	1.1781	Fe&S m.s.	44	0.00	CO2
Fe*	0.1866	0.0000	0.00474	55.8	14.68	Fe*
FeO	0.1001	0.3403	0.00474	71.8	15.28	FeO
SO3	0.1865	0.0538	**0.00590**	80		SO3
S	0.1141	0.1672	**0.00590**	32	16.00	S
Na(K)2O	1.2126	1.2126	Refractory	62	31.00	Na(K)2O
SiO2	1.1731	1.1731	**0.00000**	60	27.27	SiO2
Ca(Ba)O	0.0618	0.0618	0.00000	56	18.67	Ca(Ba)O
MgO	0.0901	0.0901	0.00000	40.3	12.21	MgO
Cr2O3	0.0147	0.0147	0.00000	152	34.55	Cr2O3
Al2O3	0.0667	0.0667	**0.00000**	102	31.88	Al2O3
NaCl	0.1423	0.1423	0.00000	58.5	34.41	NaCl
SnO	0.0517	0.0517	C moleSum	135	20.93	SnO
Sb2O3	0.2145	0.2145	**0.07778**	291	55.96	Sb2O3
H2OFrCb	0.0047	0.2461	**0.07778**	18	0.00	H2OFrCb
ZnO	0.0206	0.0206	H wt Sum	81.4	14.88	ZnO
SO2	0.0000	0.0001	**0.02735**	64		SO2
O2	0.5608	0.0344	**0.02735**	32		O2
CuO	0.0584	0.0584	O wt Sum	79.5	12.42	CuO
H2OXL	0.0000	0.0000	**1.35950**	18		H2OXL
CO	0.0000	0.0000	**1.35951**	28.0		CO
H2	0.0268	0.0000	**Check?**	2.0		H2
N2	0.7198	0.7198		28.0		N2
Sum:	17.7914	17.7914		At. Wt.	m3/tmole	
	mt In	mt Out				

g/cc-ft3/lb 62.42

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Boundary Conditions for Operating the Short Rotary Furnace	
Dust recycle rate, dry mt/hr	0.45
Calculated Natl. Gas Kcal/hr Input	1,423,331
Calculated Natl. Gas used, mt/hr	0.107
Calculated Natl. Gas used, kg/hr	107.30
Natl. Gas heat content (net), kcal/kg	13,265
Natl. Gas density, lb/ft3 @ STP	0.044
Fuel heat capacity, kgcal/kg°C	0.55
Natl. Gas density, kg/m3 @ STP	1.44
Fuel temperature, C	7
Air temperatures, C	7
Solids feed conc. temperature, C	7
Return dust temperature, C	7
Offgas temperature, C	785
Final solids temperature,°C	785
Stoic. oxygen for fuel, kg dry/kg fuel	4.00
% excess oxygen for natural gas	-0.20
Air inleakage to furnace, mt/hr	0.94
Atomizing steam, kcal/kg	0.00
Atomizing steam, kg/kg fuel	0.00
Sum H20 in furnace solids, mt/hr	0.00
Moisture in air&02&Gas, mt /hr	0.00
Total moisture to plant, mt/hr	0.00
Furnace shell temperature, F	425
Furnace (small) shell area, m2	57.65
Heat loss, kiln shell & door, kcal/hr	96,507

	H fusion kcal/kgmole	Fusion Kcal/hr
PbO	6570	53380.0
Pb°	1150	52832.1
C		
CO2		
FeS	7730	25856.0
FeO	7500	10459.8
SO3		
Na(K)2O	11400	52358.7
SiO2	2600	50833.3
Ca(Ba)O	12200	13455.9
MgO	18500	41365.8
Cr2O3	4000	386.6
Al2O3	25700	16805.9
NaCl	6700	15373.4
SnO	6000	2296.7
Sb2O3	13300	9804.7
CuO	13580	9976.1
ZnO	4500	1141.2
Sum =	141430.	356,326

Chemical Reactions

	kcal/kg	of:
PbO + 1/2C = Pb° + 1/2CO2	24.5	Pb°
PbS + Na2O = Na2S + 1/2O2	139.3	PbS
Fe° + PbS = FeS + Pb°	21.3	Fe°
PbS + FeO = FeS + PbO	145.7	FeS
PbOSO3 + Na2O = Na2S + PbO + 2O2	2276.9	Na2S
Na2CO3 = Na2O + CO2	725.0	Na2CO3

Large= 6[illegible]

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

	DrssProdmt	Dross,%	Normalized Silicate Fraction i.e., Slag Assay				
	0.00000	8.000%			PbO;PbS		
	0.00000	86.118%			Pb*		
	0.00000	0.000%			C*		
	0.00000	0.000%			CO2		
	0.00000	0.000%	3.1%	Al2O3+Cr2O3	Fe*;FeS		
	0.00000	0.000%	10.9%	FeO	FeO		
	0.00000	0.000%	-		SO3		
	0.00000	5.000%	-		S;Na2S		
	0.00000	0.000%	41.1%	Na2O	Na(K)2O		
	0.00000	0.000%	45.0%	SiO2	SiO2		
	0.00000	0.000%	100.0%	TOTAL	Ca(Ba)O		
	0.00000	0.000%			MgO		
	0.00000	0.000%	**Sulfur Balance(mt or %)**		Cr2O3		
0.00233	0.00000	0.000%	Heat S In as S:	0.1887	Al2O3	Sulfur Pool=	0.04404
	0.00000	0.000%	Heat S Out as S	0.1887	NaCl	Oxygen Pool=	-6.29128
	0.00000	0.140%	Heat SO2 as S:	0.000189	SnO	FeSvsNa2Smat	50.0%
	0.00000	0.583%	SDross(Heat)	0.0000	Sb2O3	Na2O pool=	0.63538
	0.00000	0.000%	Ssilicate(Heat)	0.1138	H2OFrCb		
	0.00000	0.000%	Smatte(Heat):	0.0534	ZnO		
	0.00000	0.000%	S in dust=Heat	0.0216	SO2		
	0.00000	0.000%	S out by addn.	0.1889	O2		
	0.00000	0.159%			CuO		
	0.00000	0.000%			H2OXL		
	0.00000	0.000%	FlueGasMt/hr	1.5201	CO		
	0.00000	0.000%			H2		
	0.00000	0.000%	Wt.% SO2	0.0000%	N2		
	0.00000	100.0%	SO2 exit/hr,	Short Tons	SUM		0
			this furnace:	0.000062			
			SO2 exit/yr,	st/yr			
			all furnaces:	0.42			
			%ofSasSilicate	60.3%			
			% of S asMatte	28.3%			
			% of S asDross				
			% of S as Dust	11.5%	Total%=Check		
			% of S as Gas	0.10%	100%		

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

mt of CO2=	0.658		
O from PbO=	0.000	but not dust.	
O for Fe=	0.000	but not dust.	
O form SO3=	0.000	but not dust.	
O from SnO=	0.0000	but not dust.	
O fromSb2O3=	0.0000	but not dust.	
O from ZnO=	0.0000	but not dust.	FeOMoleFract.
O from CuO=	0.0000	but not dust.	**0.07**
O for Si in Fe°	0.0000	CO2/COwt.=R	1000.00
mt eq CO2 in=	0.6585	1.27R + 1=	1271.0000

(CO2-x)/1.27x=CO2/CO wt=R

(CO2-x)=1.27Rx

CO2 decomposed = 1.27Rx + x = x(1.27R+1))

x=	0.001	mt CO2 decomposed
1.27x=	0.001	mt CO evolved from melt.
CO2-x=	0.658	mt CO2 evolved from melt.
	0.000	mt Carbon needed for above.
	0.370	mt C
	0.612	mt carbon for slag; (inc. H2)
	0.34	
	mt	**20.% Excess Coke**

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Density		mt O2 Out	m3 MatteSlag	mt O2 In	
11.30	PbO	0.14137	0.21068	0.13000	PbO
Pb°	Pb°	0.00000	0.00000	0.00000	Pb°
	C°	0.00000	0.27202	0.00000	C°
	CO2	0.85683	0.00000	0.53033	CO2
	Fe°	0.00000	0.00000	0.00000	Fe°
	FeO	0.07583	0.07193	0.02231	FeO
	SO3	0.03227	0.00000	0.11189	SO3
	S	0.00000	0.08358	0.00000	S
	Na(K)2O	0.31294	0.52778	0.31294	Na(K)2O
	SiO2	0.62564	0.53220	0.62564	SiO2
	Ca(Ba)O	0.01765	0.02044	0.01765	Ca(Ba)O
	MgO	0.03578	0.02717	0.03578	MgO
	Cr2O3	0.00464	0.00321	0.00464	Cr2O3
	Al2O3	0.03139	0.02070	0.03139	Al2O3
Sn°	NaCl	0.00000	0.05732	0.00000	NaCl
6.60	SnO	0.00612	0.00627	0.00612	SnO
6.40	Sb2O3	0.03539	0.03996	0.03539	Sb2O3
Sb°	H2OFrCb	0.21460	0.00000	0.00000	H2OFrCb
	ZnO	0.00406	0.00213	0.00406	ZnO
	SO2	0.00003	0.00000	0.00000	SO2
Cu°	O2	0.03441	0.00000	0.56081	O2
8.40	CuO	0.01175	0.00895	0.01175	CuO
	H2OXL	0.00000	0.00000	0.00000	H2OXL
	CO	0.00000	0.00000	0.00000	CO
	H2	0.00000	0.00000	0.00000	H2
	N2	0.00000	0.00000	0.00000	N2
Sum =	Oxygen Out=	2.44069	1.88433	2.44069	<- Oxygen In
			SUM OF M3	Oxygen In	

m3 of Bullion:	0.83
m3 of Slag:	1.88
m3 of Dross:	0.00
m3 in Charge:	2.71
FreshBrckM3	6.9
WornBrickM3	8.8

Effective Furn. Volume with New Brick vs with Worn Brick.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

Heat Capacity Calc., kcal/kg		
T1, C=	310	for solids
T2, C=	785	for solids
Average Feed	0.180	4.3235E-05
CO2	253	
	kcal/kg	
CO	257	
Dust recy.	0.184	0.0000838
T1, C=	25.	for gases
T2, C=	980.	for gases
	kcal/kg	
O2	234	
SO2	179	
Air	0.234	0.0000173
H2O vapor	489	Sensible Heat
	kcal/kg	
N2	256	
H2O Vaporize	598	
	Heat of boiling	

	Mass Basis mt/hr	Heat Inputs kcal/hr
Fuel Combustion	0.107	1,423,331
Steam for Atomization	0.00	0
Coke Combustion:	0.0131	100,980
Sensible Heats:		
Dry furnace feedstocks	7.97	408,909
Dry dust recycle	0.22	11,767
Natural gas	0.107	416
Gas combustion oxygen	0.34	562
Total air into furnace	0.94	1,535
H2O in all input gases	0.005	33
Free H2O in solid feeds	0.00	0
FeS-Fe°&FeO Formation ΔH		0
Na2S from PbS "		0
Na2S from SO3 "		0
Na2O-Na2CO3 "		0
Pb° from PbO "		0
Refractory dissolved:	0.0000	0
Heats of fusion and vaporization:		
Fusion		-55,134
Vaporization=already in ΔH		0
Total Heat Input, kcal/hr		1,892,399

	Mass Basis mt/hr	Heat Outputs kcal/hr
Sensible Heats:		
CO2 exhaust dry gas	0.52	131,363
CO exhaust dry gas	0.00	0
O2 exhaust dry gas	0.03	8,039
N2 exhaust dry gas	0.72	184,035
SO2 exhaust dry gas	0.00006	10
Solids in Charge (heated/hr)	7.97	1,289,479
Dry dust in offgas	0.18	34,739
Slag discharge is zero	0.00	0
H2O from all input gases	0.005	2,289
Free H2O in solid feeds	0.00	0
H2O from combustion	0.24	117,941
H2O from atomization steam	0.00	0
H2O from solid Rx product:	0.00	0
Shell+Door+Refr heat losses		124,504
Total Heat Out, kcal/hr:		1,892,399

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulates 2nd and 3rd Hr After Charge Door is Closed.

	Slag Wt,mt	Matte Wt,mt			
				10.7%	% fixed C in matte + slag.
PbO	1.81183	0.00000	-	0.0%	is PbS in Matte
-	0.00000	0.00000	PbS		is Matte + Slag factor kg Pb loss/mt bullion.
C	0.61204	0.00000	C	0.00	is (matte/slag) concentration ratio for coke
CO2	0.00000	0.00000	CO2	5.0%	is the % Na2S in slag
-	0.00000	0.06041	FeS	2.03%	is the percent sulfur in slag.
FeO	0.28261	0.00604	FeO		
	0.00000	0.00000	-		
Na2S	0.27734	0.05367	Na2S		
Na(K)2O	0.79245	0.00000	-		
SiO2	1.17066	0.00018	SiO2	0.005	is (matte/slag) concentration ratio for silica
Ca(Ba)O	0.06131	0.00001	Ca(Ba)O	0.005	is (matte/slag) concentration ratio for lime
MgO	0.08965	0.00001	MgO	0.005	is (matte/slag) concentration ratio for magnesia
Cr2O3	0.01411	0.00000	Cr2O3	0.005	is (matte/slag) concentration ratio for chromia
Al2O3	0.06624	0.00001	Al2O3	0.005	is (matte/slag) concentration ratio for alumina
NaCl	0.09695	0.00050	NaCl	0.17	is (matte/slag) concentration ratio for chloride
SnO	0.03986	0.00060	CdO	0.50	is (matte/slag) concentration ratio for tin
Sb2O3	0.20612	0.00195	Sb2S3	0.27	is (matte/slag) concentration ratio for antimony
H2OFrCb	0.00000	0.00000	H2OFrCb		
ZnO	0.01133	0.00041	ZnS	1.00	is (matte/slag) concentration ratio for Zn
SO2	0.00000	0.00000	SO2		
O2	0.00000	0.00000	O2		
CuO	0.01430	0.04298	Cu2S	100.00	is (matte/slag) concentration ratio for Cu
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
TOTAL SLAG	5.54678	0.16677	TOTAL Matte		
	Slag Wt,mt	Matte Wt,mt			

Calculation of Slag Viscosity

X"SiO2"=	Moles Si+P+Ti
X"CaO"=	Moles Ca+Mg+Mn+Pb+Zn+Fe
X"Al2O3"=	Moles Al2O3+Cr2O3
X"Na2O"=	Moles NaK2O+Na2S (non-mat
X"CaF2"=	Moles NaCl
A=	
B=	

Y in Poise	°K	°C
Viscosity=		
Viscosity=		
Viscosity=		
Viscosity=		
Viscosity=		

	Wt %	Weight	MoleFrac.Slag	MoleNonMatte
PbO	38.0%	1.81	0.1479	0.00812
Pb°	0.0%	0.00	0.0000	0.00000
C°	0.0%	0.00	0.0000	0.00000
CO2	0.0%	0.00	0.0000	0.00000
Fe°	0.0%	0.00	0.0000	0.00000
FeO	5.9%	0.28	0.0716	0.00394
SO3	0.0%	0.00	0.0000	0.00000
Na2S	2.4%	0.11	0.0647	0.00356
Na(K)2O	16.6%	0.79	0.2326	0.01278
SiO2	24.5%	1.17	0.3551	0.01951
Ca(Ba)O	1.3%	0.06	0.0199	0.00109
MgO	1.9%	0.09	0.0405	0.00222
Cr2O3	0.3%	0.01	0.0017	0.00009
Al2O3	1.4%	0.07	0.0118	0.00065
NaCl	2.0%	0.10	0.0302	0.00166
SnO	0.8%	0.04	0.0054	0.00030
Sb2O3	4.3%	0.21	0.0129	0.00071
Other	0.0%	0.00	0.0000	0.00000
ZnO	0.2%	0.01	0.0025	0.00014
SO2	0.0%	0.00	0.0000	0.00000
O2	0.0%	0.00	0.0000	0.00000
CuO	0.3%	0.01	0.0033	0.00018
H2OXL	0.0%	0.00	0.0000	0.00000
CO	0.0%	0.00	0.0000	0.00000
H2	0.0%	0.00	0.0000	0.00000
N2	0.0%	0.00	0.0000	0.00000
Sum:	100.00%	4.77	1.0000	0.05495

100 Start-up controller

Calculation of the low-temperature heat capacities

	A	T2 - T1	B	T2sq - T1sq	C	1/T2-1/T1
CO2	10.57	25	1.05E-03	1.43E+04	2.06E+05	-3.07E-04
CO	6.708	25	5.53E-04	1.43E+04	6.20E+03	-3.07E-04
Sb4O6 vap.	52.016	25	1.69E-03	1.43E+04	8.30E+05	-3.07E-04
O2	7.16	25	5.00E-04	1.43E+04	4.00E+04	-3.07E-04
SO2	11.04	25	9.40E-04	1.43E+04	1.84E+05	-3.07E-04
H2O vapor	7.3	25	1.23E-03	1.43E+04	0.00E+00	-3.07E-04
N2	6.83	25	4.50E-04	1.43E+04	1.20E+04	-3.07E-04

Calculation of high-temperature heat capacities, kcal/kg

	A	T2 - T1	B	T2sq - T1sq	C	1/T2-1/T1
CO2	10.57	955	1.05E-03	1.48E+06	2.06E+05	-2.6E-03
CO	6.708	955	5.53E-04	1.48E+06	6.20E+03	-2.6E-03
Σ mass for input heat calc:						
Σ mass for outputput heat calc						
Σ mass in from material bal:						
Sb4O6 vapor	52.016	955	1.69E-03	1.48E+06	8.30E+05	-2.6E-03
O2	7.16	955	5.00E-04	1.48E+06	4.00E+04	-2.6E-03
SO2	11.04	955	9.40E-04	1.48E+06	1.84E+05	-2.6E-03
H2O vapor	7.3	955	1.23E-03	1.48E+06	0.00E+00	-2.6E-03
N2	6.83	955	4.50E-04	1.48E+06	1.20E+04	-2.56E-03

Low-Temp. Heat Capacities:

T1, °C=	0
T2, °C=	25
	Heat Capac. Kcal/kg
CO2	4.91E+00
CO	6.20E+00
Sb2O3 vapor	1.83E+00
O2	5.43E+00
SO2	3.64E+00
H2O vapor	1.11E+01
N2	6.20E+00

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

Furnace:	Old (3.6-m)	Pb° in Bulln, mt	11.55	*CHARGE*
Date:	23-Jul-91	Pb in Feed, mt	11.76	*CYCLE*
FinalChargeT°	**925 degC**	Pb in slag, mt	0.065	*IS FIRST*
Parameters		Pb in Dust, mt	0.15	**********
to Check		Pb,DrossFloat,mt	0.00	***TIME IS***
Slag FeO =	**9.5%**	Bullion, mt	11.55	***DURING***
Target =	**10 to 15%**	PbToBulln&Dross	98.2%	***HRS 4-5-6***
Basicity =	**1.13**	Balanced if small	-5.80E-08	*3*
Target =	**1.1 to 1.4**	SilicatePhase, mt	3.44	*TO*
Viscosity =	**30**	Matte Phase, mt	0.36	*COMPLETE*
Target =	**10 to 40**	Soda/hr to flue	0.045	*REDUCTION*
Slag Ratio of		Dust, % of feed	2.9%	**********
(Si+Al)/Na =	1.4	Molds Output-->	8.2	6.3

Feed(Scoops)	DryFeed,lb	DryFeedMt/hr
P.CakeTEL(2)	**4000.**	1.81
MM Plate(6)	**13600.**	6.17
Dust In (2)	**1000.**	0.45
MM Dross(6)	**13000.**	5.89
Coke(1/2)	**700.**	0.32
FeChips(0.35)	**500.**	0.23
Total Air In	**1842.**	0.83
O2 to Burner	**751.**	0.34
Lenox(0)	**0.**	0.00
NiterDross(0)	**0.**	0.00
Glass Sand(2)	**2000.**	0.91
Anzon(0)	**0.**	0.0
Natural Gas	**234.7**	0.106
TOTAL	**37628.**	17.05

Flux Summary		
Soda(2+BH)	**3500.**	**1.586**
Sand (1.5)	**2000.**	**0.907**
FeChip(.25)	**500.**	**0.227**
Coke (0.5)	**700.**	**0.317**

Assay of Slag, %	
Pb	**2.3%**
C°	**4.5%**
FeO	**9.5%**
S	**4.5%**
Na2O	**28.1%**
SiO2	**33.3%**
Ca(Ba)O	**1.9%**
MgO	**3.6%**
Cr2O3	**0.6%**
Al2O3	**2.6%**
NaCl	**2.6%**
SnO	**1.0%**
Sb2O3	**4.2%**
Other	**0.0%**
ZnO	**0.3%**
Other	**0.0%**
Other	**0.0%**
CuO	**1.6%**

	Bullion	Slag Only	Matte Only
PbO		2.0%	
Pb°, PbS	**100.0%**		7.0%
C°		4.1%	8.2%
CO2		0.0%	0.0%
FeS			33.3%
FeO		7.3%	3.3%
S			
Na2S		5.0%	29.6%
Na(K)2O		24.6%	
SiO2		36.8%	0.2%
Ca(Ba)O		2.1%	0.01%
MgO		4.0%	0.02%
Cr2O3		0.6%	0.00%
Al2O3		2.9%	0.01%
NaCl		2.9%	0.5%
Sn°, SnO	**0.0%**	1.2%	0.6%
Sb°,Sb2S3	**0.0%**	6.0%	1.9%
Other		0.0%	0.0%
ZnO,ZnS		0.3%	0.4%
Other		0.0%	0.0%
Other		0.0%	0.0%
Cu,Cu2S	**0.0%**	0.2%	15.0%
TOTAL	100.0%	100.0%	100.0%

MgCr Brick, kg/hr per mt Bullion	0.0
Al2O3 Brick, Kg/hr per mt Bullion	0.3
Mat.FeS/Na2S	0.50
Mat.FeO Contr.	10
% Excess Coke	20.0%
PbToSilic., mt	0.070
Viscosity of the silicate slag, Poise:	30

% of S fixed:	99.90%
Coke in matte + slag, %	4.5%
"Slag" Basicity	1.13
Distribution Factors	
Sn(Bullion):	0.00
Sb(Bullion):	0.00
Cu(Bullion):	0.00
DrossRecycle:	0.00
SO2 controller	

Comments: Reduction is completed over a 2-hr period.
The decomposition of soda ash is very endothermic.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

Gas firing rate:		**Summary of Heat Losses, Kcal/hr**		Approx. st SO2 vented from		Estimated ΔT drop due to heat	
Kcal/hr	1,411,292	**During 3rd part of 1st charge cycle**		plant per yr	0.43	loss when gas passes through	
Btu/hr	5,600,008	Loss through furnace walls	127,638	SCFM to Stack:	16064.	the knockout tanks prior to	
Kg Nat. Gas/hr	106.4	Heat to refractory from system	21,617			initial dilutn.	167 degC
Lb NG/hr	234.7	Radiant heat loss thru closed door	7,704	Gas Temp. exiting		ACFM from	
%TongeO2Use	**100.%**	Sum of heat losses:	156,960	stack:	35 degC	the furnace:	4,306
%Exc.O2->NG	**-20%**	Initial T°C of refractory (Ave.)	735 degC	Gas Temp. exiting convective		SCFM from	
Ave. Offgas T°C	**1180 degC**	Final T°C of refractory (Ave.)	750 degC	cooler:	345 degC	the furnace:	848
P, inch H20	0.25	Coke Content of Oxide Component:	4.5%	Gas Temp. exiting convective		ACFM to BH:	5,995
Shell, T°F	500 degF	Furnace area in use, m2	57.7	cooler:	195 degC	SCFM to BH:	4,539
Tramp Air in Through the		Temperature of bag house:	105 degC	Matte/slag concentration ratio for coke:			**2.00**
Door, kg/hr:	835.	PbInSilicatePhaseOfEmulsion,mt	0.070	SCFM moisture to stack:	242		
Percent of Dust Exiting		Pb inMatte phase of Emulsion, %:	7.0%	Coke Calculated via total heat?	Indirectly.		**700.**
Per Hour	**16.7%**	Hrs of 1st Cycle	**Furnace Offgas**	Portion of excess coke burned, %/hr?			**17.%**
Percent of Charge Fused		CycleDoorClosed	**Volume % Undiluted**				
Per Hour	**12.%**	**6.0**	**O2: 3.5%**	Number of Hrs in this period:			**3.00**
Percent of Charge Reduced		Total Hrs Burner	**N2: 38.7%**	Soda ash CO2 still in solids?	**No**		**0.0%**
Per Hour	**25.%**	**15.0**	**H20: 23.0%**	Soda ash CO2 to gas vent?	**Yes**		**100.0%**
Stoic. Pure O2 for Natural			**CO2: 34.9%**	Coke heat input, Kcal/hr			
Gas, kg/hr	425.6	% Dross Formed?	**CO: 0.0%**	System's heat gain from refractory, Kcal/hr			
Stoic. Pure O2 for solid C->		0	**SO2: 0.000346%**	Heat lost to furnace offgas & dust, Kcal/hr			
CO2, Kg/hr			sum= 100.00%	Heat to furnace charge from burner, Kcal/hr			
	361.4		**Furnace Offgas**	Heat lost from walls and door, Kcal/hr			
Initial Temperature		If <100°C, =0	**mt/hr**	Sum of heats of reaction and fusion:			
of Charge:	**785 degC**	**0**	**O2: 0.07**	Air drawn into furnace via door, SCFM			382
Final Temperature		If <100°C, =1	**N2: 0.64**	FurnaceGas,kg	1853.	Gas Volume to Baghouse,	
of Charge:	**925 degC**		**H20: 0.24**	" " ",kgMole	59.0	ACMH =	10,186
Charge Moisture Removed:		**0.0%**	**CO2: 0.91**	v/oCO2 diluted	1.84%	Sn(Bullion):	0.00
Offgas volume at average furnace temperature:			**CO: 0.0000**	From Stack		Sb(Bullion):	0.00
	7,317 ACMH		**SO2: 0.0000**	v/oSO2 diluted	0.00002%	Cu(Bullion):	0.00
Dilution air to cooler, kg/hr		3,360	sum= 1.8528			**EFFICIENCY OF HEAT UTILIZATION, %**	
Dilutn. air to cooler, ACMH		6,152	Space between door and furnace, inches =		**0.39**	Calculated Eff.	42%
Total ACMH into cooler		13,469	Start-up Controller for Totals =		100	Target effic.	**40%**
Comments:				SO2, %/hr	**3.3%**	BH, ACFM	5,995
Note that the exit gas temperature is the average during the period.				Lb SO2/Hr	SO2evoln.,hrs	Press., mm:	**730**
Apparent offgas temperature is low, due to large endothermic reactions				0.029	**3.0**	Ambient, degC:	**7**

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

(reduction & Na2CO3 decomposition) depressing rate of charge temperature increase.

						Efficiency	
Kg moles of gas from furnace	59.0		Oxide Slag mt	6.399		Kcal to solids	275,034
Kg moles air cooler entry	116.5	345 degC	C with Oxide	0.696		Kcal to redn. & fusion	439,718
Kg moles gas into cooler	175.5	195 degC	%C in Oxide	0.109		Kcal to H2O evaporation	0
Air to cooler exit, kg/hr	4038.	105 degC	C Burnt, mt	0.049		Kcal from coke excess	-125,666
Air to cooler exit, ACMH	4521.		C in dust, mt	0.000			
Kg moles air to cooler exit	140.0		Dilution air to stack, kg/hr:	22745.		TOTAL	589,086
Kg moles, all gases, to BH	315.5		Total gas to stack, kgMoles/hr	1116.		Burner Kcal	1,411,292
ACMH to BH, TOTAL	10186.		Total ACFM into stack	17285.		Efficiency	41.7%

	Atomic Weight	Total Moles (inc. refractory)	Total mt
PbO	223	0.00946	2.109
Pb°	207	0.04737	9.805
C°, non-gas	12	0.06208	0.745
CO2	44	0.00247	0.109
Fe°	55.8	0.00341	0.190
FeO	71.8	0.00166	0.120
SO3	80	0.00245	0.196
S	32	0.00368	0.118
Na(K)2O	62	0.00479	0.297
SiO2	60	0.02111	1.267
Ca(Ba)O	56	0.00130	0.073
MgO	40.3	0.00342	0.138
Cr2O3	152	0.00014	0.022
Al2O3	102	0.00099	0.101
NaCl	58.5	0.00235	0.137
SnO	135	0.00039	0.053
Sb2O3	291	0.00075	0.220
H2OFrCb	18	0.00023	0.004
ZnO	81.4	0.00026	0.021
SO2	64.0	0.00000	0.000
O2	32.0	0.01666	0.533
CuO	79.5	0.00076	0.060
Sum:		0.18573	16.316

O2 released by redn., mt:	0.1461
SCFH air drawn into furnace:	22,924
SCFM air drawn into furnace:	382

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

Weight %	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas
PbO	42.9%	19.0%	35.3%	0.0%	0.0%	0.0%	0.00%	0.00%	40.1%	10.0%	0.00%	71.1%	0.0%
Pb°	8.0%	73.2%	0.0%	87.3%	0.0%	0.0%	0.00%	0.00%	0.0%	61.2%	0.0%	0.0%	0.00%
C°	12.00%	1.50%	0.00%	2.3%	92.2%	3.00%	0.00%	0.00%	0.0%	0.50%	0.00%	22.1%	75.00%
CO2	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0%	0.00%	0.00%	0.00%	0.00%
Fe°	0.00%	0.1%	0.00%	0.00%	0.00%	82.50%	0.00%	0.00%	0.0%	0.00%	0.00%	0.0%	0.00%
FeO	2.80%	0.1%	0.50%	0.50%	0.29%	12.00%	0.00%	0.00%	0.9%	0.50%	0.30%	0.0%	0.00%
SO3	1.00%	2.0%	12.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0%	0.00%	0.00%	4.0%	0.00%
S	0.00%	0.00%	0.00%	1.70%	5.50%	0.00%	0.00%	0.00%	0.3%	1.50%	0.00%	0.00%	0.00%
Na(K)2O	1.10%	0.00%	35.0%	2.00%	0.10%	0.00%	0.00%	0.00%	3.5%	7.30%	0.01%	0.00%	0.00%
SiO2	11.00%	1.00%	0.50%	1.50%	1.50%	2.50%	0.00%	0.00%	36.0%	0.50%	99.6%	0.99%	0.00%
Ca(Ba)O	1.50%	0.15%	0.10%	0.60%	0.09%	0.00%	0.00%	0.00%	0.90%	5.00%	0.00%	1.50%	0.00%
MgO	7.50%	0.00%	0.10%	0.02%	0.04%	0.00%	0.00%	0.00%	0.70%	0.10%	0.00%	0.00%	0.00%
Cr2O3	1.10%	0.00%	0.13%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Al2O3	5.00%	0.05%	0.10%	0.05%	0.18%	0.00%	0.00%	0.00%	16.1%	0.00%	0.10%	0.00%	0.00%
NaCl	0.06%	0.52%	10.0%	1.00%	0.10%	0.00%	0.00%	0.00%	0.26%	0.50%	0.00%	0.35%	0.00%
SnO	0.01%	0.10%	2.50%	0.60%	0.00%	0.00%	0.00%	0.00%	0.10%	6.00%	0.00%	0.00%	0.00%
Sb2O3	0.02%	2.30%	1.50%	1.20%	0.00%	0.00%	0.00%	0.00%	0.10%	6.50%	0.00%	0.00%	0.00%
Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ZnO	0.02%	0.00%	2.00%	0.20%	0.00%	0.00%	0.00%	0.00%	1.00%	0.20%	0.00%	0.00%	0.00%
SO2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	0.000%
O2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	23.20%	100.0%	0.000%	0.000%	0.000%	0.000%	0.000%
CuO	0.01%	0.00%	0.25%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.20%	0.00%	0.00%	0.00%
H2OXL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	0.000%
H2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.00%	0.00%	0.000%	0.000%	0.000%	0.000%	25.0%
N2	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	76.8%	0.0%	0.000%	0.000%	0.000%	0.000%	0.00%
Sum:	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
H2O Fr.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas
OrigH2O	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

Moles	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas
PbO	0.0035	0.0053	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pb°	0.0007	0.0218	0.0000	0.0249	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C°	0.0181	0.0077	0.0000	0.0113	0.0244	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0066
CO2	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fe°	0.0000	0.0001	0.0000	0.0000	0.0000	0.0034	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FeO	0.0007	0.0001	0.0000	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO3	0.0002	0.0015	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S	0.0000	0.0000	0.0000	0.0031	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Na(K)2O	0.0003	0.0000	0.0026	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SiO2	0.0033	0.0010	0.0000	0.0015	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0150	0.0000	0.0000
Ca(Ba)O	0.0005	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MgO	0.0034	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cr2O3	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Al2O3	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NaCl	0.0000	0.0005	0.0008	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SnO	0.0000	0.0000	0.0001	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sb2O3	0.0000	0.0005	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2OFrCb	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ZnO	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0060	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000
CuO	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2OXL	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0133
N2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0228	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum:													
H2O Fr.	P. Cake	Plates	MMdust	MMDrs	Coke	Fe Chip	Air	Oxygen	Lenox	NiterDs	Silica	Anzon	NatGas

ESTIMATE OF STACK EMISSIONS (FROM NEW BAGHOUSE) WHEN OPERATING THE 3.6-M ROTARY FURNACE,

and Summary of Results of Furnace and Flue Calculations

	Drying		Melting		Reduction	
Operation time during each furnace charging cycle:		Hr		Hr	3.0	Hr
Initial temparature for drying, melting, or reduction:		°F		°F	1445	°F
Temperature at finish of drying, melting, or reduction:		°F		°F	1697	°F
Natural gas firing rate:		Btu/Hr		Btu/Hr	5.6 MM	Btu/Hr
Average off-gas temperature from the furnace:		°F		°F	2156	°F
Natural gas consumed by the furnace:		Ft3/Hr		Ft3/Hr	5201	Ft3/Hr
Oxygen consumed by the furnace:		Ft3/Hr		Ft3/Hr	8877	Ft3/Hr
Diluted flue gas to the stack						
Flow rate entering stack @ 95 °F :		ACFM		ACFM	17,285	ACFM
Flow, DSCFM = 77°F @ 1 atm.:		DSCFM		DSCFM	15,822	DSCFM
Moisture content of gas to stack:		Vol%		Vol%	1.5%	Vol%
Particulates to stack, grains/dscf:		g/DSCF		g/DSCF	0.0025	g/DSCF
SO2 to the stack:		Lb/Hr		Lb/Hr	0.029	Lb/Hr
Emissions from Stack (Lb/Hr)						
Tetraethyl lead:	*BDL	Lb/Hr	*BDL	Lb/Hr	*BDL	Lb/Hr
Total chlorine expressed as chloride:		Lb/Hr		Lb/Hr	0.021	Lb/Hr
Lead as Pb:		Lb/Hr		Lb/Hr	0.11	Lb/Hr
Antimony as Sb:		Lb/Hr		Lb/Hr	0.0043	Lb/Hr
Arsenic as As:	**ID	Lb/Hr	**ID	Lb/Hr	**ID	Lb/Hr
Barium as Ba:		Lb/Hr		Lb/Hr	<0.01	Lb/Hr
Silver as Ag:		Lb/Hr		Lb/Hr	<0.01	Lb/Hr
Cadmium as Cd:		Lb/Hr		Lb/Hr	<0.01	Lb/Hr
Chromium as Cr		Lb/Hr		Lb/Hr	0.0003	Lb/Hr
Mercury, thallium, and beryllium:	***NIF		***NIF		***NIF	

* Below Detectable Limit ** Insuficient date to estimate. *** Not known to be in feedstock to plant.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

mt	Bullion	Mat+Slag	Dust Out
PbO	0.00000	0.07000	0.16011
Pb*	11.54928	0.00000	0.00000
C*	0.00000	0.17079	0.00000
CO2	0.00000	0.00000	0.00000
Fe*	0.00000	0.00000	0.00000
FeO	0.00000	0.36181	0.00227
SO3	0.00000	0.00000	0.05438
S	0.00000	0.17421	0.00000
Na2O	0.00000	1.06609	0.15866
SiO2	0.00000	1.26437	0.00227
CaO	0.00000	0.07209	0.00045
MgO	0.00000	0.13730	0.00045
Cr2O3	0.00000	0.02112	0.00059
Al2O3	0.00000	0.10048	0.00045
NaCl	0.00000	0.10024	0.04533
SnO	0.00000	0.04170	0.01133
Sb2O3	0.00000	0.21288	0.00680
H2OFrCb	0.00000	0.00000	0.00000
ZnO	0.00000	0.01215	0.00907
SO2	0.00000	0.00000	0.00001
O2	0.00000	0.00000	0.00000
CuO	0.00000	0.05911	0.00113
H2OXL	0.00000	0.00000	0.00000
CO	0.00000	0.00000	0.00000
H2	0.00000	0.00000	0.00000
N2	0.00000	0.00000	0.00000
Sum:	11.5493	3.8643	0.453309
	Bullion	Mat+Slag	Dust Out
			0.453309
			Check

mt	All mt In	All mt Out	MoleChecks	At. Wt.	
PbO	2.10899	0.23011	0.056826	223	PbO
Pb*	9.80521	11.54928	0.056826	207	Pb*
C*	0.32812	0.17079	0.417651	12	C*
CO2	0.32829	0.90517	0.417651	44	CO2
Fe*	0.19007	0.00000	0.005071	55.8	Fe*
FeO	0.11951	0.36408	0.005071	71.8	FeO
SO3	0.19583	0.05438	0.006124	80	SO3
S	0.11763	0.17421	0.006124	32	S
Na(K)2O	1.22475	1.22475	RefrConsum	62	Na(K)2O
SiO2	1.26664	1.26664	**0.00154**	60	SiO2
Ca(Ba)O	0.07254	0.07254	0.00000	56	Ca(Ba)O
MgO	0.13775	0.13775	0.00000	40.3	MgO
Cr2O3	0.02171	0.02171	0.00000	152	Cr2O3
Al2O3	0.10093	0.10093	**0.00231**	102	Al2O3
NaCl	0.14557	0.14557	0.00000	58.5	NaCl
SnO	0.05304	0.05304	Sulfide	135	SnO
Sb2O3	0.21968	0.21968	339.0	291	Sb2O3
H2OFrCb	0.00415	0.24354	Atomic	18	H2OFrCb
ZnO	0.02121	0.02121	97.4	81.4	ZnO
SO2	0.00000	0.00001	Weights	64	SO2
O2	0.53320	0.06603	86.9	32	O2
CuO	0.06024	0.06024	159.0	79.5	CuO
H2OXL	0.00000	0.00000		18	H2OXL
CO	0.00000	0.00000		28.00	CO
H2	0.02660	0.00000		2.00	H2
N2	0.63804	0.63804		28.00	N2
Sum:	17.71970	17.71970			
	CHECK				
			O2Mole Σ		
			1.071093		
			1.071093		

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

Moles To Flux	
0.0087	PbO
0.0474	Pb°
0.0687	C°
0.0174	CO2
0.0034	Fe°
0.0016	FeO
0.002	SO3
0.0037	S
0.0172	Na(K)2O
0.0211	SiO2
0.0013	Ca(Ba)O
0.0034	MgO
0.0001	Cr2O3
0.0010	Al2O3
0.0017	NaCl
0.0003	SnO
0.0007	Sb2O3
0.0135	H2OFrCb
0.0001	ZnO
0.0000	SO2
0.0167	O2
0.0007	CuO
0.0000	H2OXL
0.0000	CO
0.0133	H2
0.0228	N2
Moles To Flux	

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

mt	Total In	Total Out	mt	At. Wt.	m3/tmole	
PbO	2.1090	0.2301	PbMoleSum	223	25.93	PbO
Pb*	9.8052	11.5493	11.7629	207	32.34	Pb*
C*	0.3281	0.1708	11.7629	12	5.33	C*
CO2	0.3283	0.9052	Fe&S m.s.	44	0.00	CO2
Fe*	0.1901	0.0000	0.00507	55.8	14.68	Fe*
FeO	0.1195	0.3641	0.00507	71.8	15.28	FeO
SO3	0.1958	0.0544	0.00612	80		SO3
S	0.1176	0.1742	0.00612	32	16.00	S
Na(K)2O	1.2247	1.2247	Refractory	62	31.00	Na(K)2O
SiO2	1.2666	1.2666	0.00154	60	27.27	SiO2
Ca(Ba)O	0.0725	0.0725	0.00000	56	18.67	Ca(Ba)O
MgO	0.1378	0.1378	0.00000	40.3	12.21	MgO
Cr2O3	0.0217	0.0217	0.00000	152	34.55	Cr2O3
Al2O3	0.1009	0.1009	0.00231	102	31.88	Al2O3
NaCl	0.1456	0.1456	0.00000	58.5	34.41	NaCl
SnO	0.0530	0.0530	C moleSum	135	20.93	SnO
Sb2O3	0.2197	0.2197	0.03480	291	55.96	Sb2O3
H2OFrCb	0.0042	0.2435	0.03480	18	0.00	H2OFrCb
ZnO	0.0212	0.0212	H wt Sum	81.4	14.88	ZnO
SO2	0.0000	0.0000	0.02706	64		SO2
O2	0.5332	0.0660	0.02706	32		O2
CuO	0.0602	0.0602	O wt Sum	79.5	12.42	CuO
H2OXL	0.0000	0.0000	1.07109	18		H2OXL
CO	0.0000	0.0000	1.07109	28.0		CO
H2	0.0266	0.0000	Check?	2.0		H2
N2	0.6380	0.6380		28.0		N2
Sum:	17.7197	17.7197		At. Wt.	m3/tmole	
	mt In	mt Out				

g/cc-ft3/lb 62.42

Boundary Conditions for Operating the Short Rotary Furnace

Dust recycle rate, dry mt/hr	0.45
Calculated Natl. Gas Kcal/hr Input	1,411,292
Calculated Natl. Gas used, mt/hr	0.106
Calculated Natl. Gas used, kg/hr	106.39
Natl. Gas heat content (net), kcal/kg	13,265
Natl. Gas density, lb/ft3 @ STP	0.044
Fuel heat capacity, kgcal/kg°C	0.55
Natl. Gas density, kg/m3 @ STP	1.44
Fuel temperature, C	7
Air temperatures, C	7
Solids feed conc. temperature, C	7
Return dust temperature, C	7
Offgas temperature, C	925
Final solids temperature,°C	925
Stoic. oxygen for fuel, kg dry/kg fuel	4.00
% excess oxygen for natural gas	-0.20
Air inleakage to furnace, mt/hr	0.83
Atomizing steam, kcal/kg	0.00
Atomizing steam, kg/kg fuel	0.00
Sum H2O in furnace solids, mt/hr	0.00
Moisture in air&O2&Gas, mt /hr	0.00
Total moisture to plant, mt/hr	0.00
Furnace shell temperature, F	500
Furnace (small) shell area, m2	57.65
Heat loss, kiln shell & door, kcal/hr	127,638

	H fusion kcal/kgmole	Fusion Kcal/hr
PbO	6570	62134.9
Pb°	1150	54473.4
C		
CO2		
FeS	7730	26330.8
FeO	7500	12483.2
SO3		
Na(K)2O	11400	54586.2
SiO2	2600	54820.8
Ca(Ba)O	12200	15804.1
MgO	18500	63235.8
Cr2O3	4000	571.4
Al2O3	25700	24848.9
NaCl	6700	15745.4
SnO	6000	2357.2
Sb2O3	13300	10040.2
CuO	13580	10290.9
ZnO	4500	1172.8
Sum =	141430.	408,896

Chemical Reactions

	kcal/kg	of:
PbO + 1/2C = Pb° + 1/2CO2	24.5	Pb°
PbS + Na2O = Na2S + 1/2O2	139.3	PbS
Fe° + PbS = FeS + Pb°	21.3	Fe°
PbS + FeO = FeS + PbO	145.7	FeS
PbOSO3 + Na2O = Na2S + PbO + 2O2	2276.9	Na2S
Na2CO3 = Na2O + CO2	725.0	Na2CO3

Large= 69.08

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

	DrssProdmt	Dross,%					
	0.00000	8.000%	Normalized Silicate Fraction i.e., Slag Assay			PbO;PbS	
	0.00000	86.151%				Pb*	
	0.00000	0.000%				C*	
	0.00000	0.000%				CO2	
	0.00000	0.000%	4.6%	Al2O3+Cr2O3		Fe*;FeS	
	0.00000	0.000%	9.5%	FeO		FeO	
	0.00000	0.000%	-			SO3	
	0.00000	5.000%	-			S;Na2S	
	0.00000	0.000%	38.3%	Na2O		Na(K)2O	
	0.00000	0.000%	47.6%	SiO2		SiO2	
	0.00000	0.000%	100.0%	TOTAL		Ca(Ba)O	
	0.00000	0.000%				MgO	
	0.00000	0.000%	Sulfur Balance(mt or %)			Cr2O3	
0.00245	0.00000	0.000%	Heat S In as S:	0.1960		Al2O3	Sulfur Pool= 0.08712
	0.00000	0.000%	Heat S Out as S	0.1960		NaCl	Oxygen Pool= -6.27638
	0.00000	0.135%	Heat SO2 as S:	0.000196		SnO	FeSvsNa2Smat 50.0%
	0.00000	0.560%	SDross(Heat)	0.0000		Sb2O3	Na2O pool= 0.68647
	0.00000	0.000%	Ssilicate(Heat)	0.0705		H2OFrCb	
	0.00000	0.000%	Smatte(Heat):	0.1037		ZnO	
	0.00000	0.000%	S in dust=Heat	0.0218		SO2	
	0.00000	0.000%	S out by addn.	0.1962		O2	
	0.00000	0.154%				CuO	
	0.00000	0.000%				H2OXL	
	0.00000	0.000%	FlueGasMt/hr	1.8528		CO	
	0.00000	0.000%				H2	
	0.00000	0.000%	Wt.% SO2	0.0000%		N2	
	0.00000	100.0%	SO2 exit/hr, this furnace:	Short Tons 0.000014		SUM	0
			SO2 exit/yr, all furnaces:	st/yr 0.43			
			%ofSasSilicate	36.0%			
			% of S asMatte	52.9%			
			% of S asDross				
			% of S as Dust	11.1%		Total%=Check	
			% of S as Gas	0.10%		100%	

mt of CO_2=	0.219		
O from PbO=	0.135	but not dust.	
O for Fe=	-0.050	but not dust.	
O form SO_3=	0.085	but not dust.	
O from SnO=	0.0013	but not dust.	
O from Sb_2O_3=	-0.0224	but not dust.	
O from ZnO=	0.0002	but not dust.	FeO Mole Fract.
O from CuO=	0.0000	but not dust.	0.07
O for Si in Fe*	-0.0030	CO_2/CO wt.=R	0.0904
mt eq CO_2 in=	0.4204	1.27R + 1=	1.1148

$(CO_2-x)/1.27x = CO_2/CO$ wt=R

$(CO_2-x) = 1.27Rx$

CO_2 decomposed $= 1.27Rx + x = x(1.27R+1))$

x=	0.377	mt CO_2 decomposed
1.27x=	0.479	mt CO evolved from melt.
CO_2-x=	0.043	mt CO_2 evolved from melt.
	0.217	mt Carbon needed for above.
	0.452	mt C
	0.171	mt carbon for slag; (inc. H_2)
	0.027	**Wet stoic. Coke**
	mt	**20.% Excess Coke**

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

Density		mt O2 Out	m3 Matte/Slag	mt O2 In	
11.30	PbO	0.01651	0.00814	0.15132	PbO
Pb°	Pb°	0.00000	0.00000	0.00000	Pb°
	C°	0.00000	0.07591	0.00000	C°
	CO2	0.65831	0.00000	0.23876	CO2
	Fe°	0.00000	0.00000	0.00000	Fe°
	FeO	0.08113	0.07698	0.02663	FeO
	SO3	0.03263	0.00000	0.11750	SO3
	S	0.00000	0.08710	0.00000	S
	Na(K)2O	0.31606	0.53304	0.31606	Na(K)2O
	SiO2	0.67554	0.57471	0.67554	SiO2
	Ca(Ba)O	0.02073	0.02403	0.02073	Ca(Ba)O
	MgO	0.05469	0.04161	0.05469	MgO
	Cr2O3	0.00686	0.00480	0.00686	Cr2O3
	Al2O3	0.04750	0.03140	0.04750	Al2O3
Sn°	NaCl	0.00000	0.05896	0.00000	NaCl
6.60	SnO	0.00629	0.00647	0.00629	SnO
6.40	Sb2O3	0.03624	0.04094	0.03624	Sb2O3
Sb°	H2OFrCb	0.21278	0.00000	0.00000	H2OFrCb
	ZnO	0.00417	0.00222	0.00417	ZnO
	SO2	0.00001	0.00000	0.00000	SO2
Cu°	O2	0.06603	0.00000	0.53320	O2
8.40	CuO	0.01212	0.00924	0.01212	CuO
	H2OXL	0.00000	0.00000	0.00000	H2OXL
	CO	0.00000	0.00000	0.00000	CO
	H2	0.00000	0.00000	0.00000	H2
	N2	0.00000	0.00000	0.00000	N2
Sum =	Oxygen Out=	2.24759	1.57555	2.24759	<- Oxygen In
			SUM OF M3	Oxygen In	

m3 of Bullion:	1.02
m3 of Slag:	1.58
m3 of Dross:	0.00
m3 in Charge:	2.60
FreshBrckM3	6.9
WornBrickM3	8.8

Effective Furn. Volume with New Brick vs with Worn Brick.

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

Heat Capacity Calc., kcal/kg		
T1, C=	785	for solids
T2, C=	925	for solids
Average Feed	0.180	4.3235E-05
CO2	313	
	kcal/kg	
CO	316	
Dust recy.	0.184	0.0000838
T1, C=	25.	for gases
T2, C=	1180.	for gases
	kcal/kg	
O2	287	
SO2	221	
Air	0.234	0.0000173
H20 vapor	607	Sensible Heat
	kcal/kg	
N2	313	
H20 Vaporize	598	
	Heat of boiling	

	Mass Basis mt/hr	Heat Inputs kcal/hr
Fuel Combustion	0.106	1,411,292
Steam for Atomization	0.00	0
Coke Combustion:	0.0164	125,666
Sensible Heats:		
Dry furnace feedstocks	5.64	771,019
Dry dust recycle	0.15	21,130
Natural gas	0.106	413
Gas combustion oxygen	0.34	558
Total air into furnace	0.83	1,361
H20 in all input gases	0.004	29
Free H20 in solid feeds	0.00	0
FeS-Fe°&FeO Formation ΔH		-2,711
Na2S from PbS "		-7,323
Na2S from SO3 "		-26,839
Na2O-Na2CO3 "		-383,372
Pb° from PbO "		-3,563
Refractory dissolved:	0.0003	-8
Heats of fusion and vaporization:		
Fusion		-15,902
Vaporization=already in ΔH		0
Total Heat Input, kcal/hr		1,891,750

	Mass Basis mt/hr	Heat Outputs kcal/hr
Sensible Heats:		
CO2 exhaust dry gas	0.91	283,532
CO exhaust dry gas	0.00	0
O2 exhaust dry gas	0.07	18,931
N2 exhaust dry gas	0.64	199,768
SO2 exhaust dry gas	0.00001	3
Solids in Charge (heated/hr)	5.42	1,067,183
Dry dust in offgas	0.08	17,640
Slag discharge is zero	0.00	0
H20 from all input gases	0.004	2,520
Free H20 in solid feeds	0.00	0
H20 from combustion	0.24	145,213
H20 from atomization steam	0.00	0
H20 from solid Rx product:	0.00	0
Shell+Door+Refr heat losses		156,960
Total Heat Out, kcal/hr:		1,891,750

Master Metal's 3.6-m SRF Using 100% O2 to Burner: Simulate Hrs 4 to 6 After Charge Door is Closed (Complete the Reduction)

	Slag Wt,mt	Matte Wt,mt			
				4.5%	% fixed C in matte + slag.
PbO	0.07000	0.00000	-	7.0%	is PbS in Matte
-	0.00000	0.02514	PbS		is Matte + Slag factor kg Pb loss/mt bullion.
C	0.14126	0.02952	C	2.00	is (matte/slag) concentration ratio for coke
CO2	0.00000	0.00000	CO2	5.0%	is the % Na2S in slag
-	0.00000	0.11952	FeS	2.03%	is the percent sulfur in slag.
FeO	0.25212	0.01195	FeO		
	0.00000	0.00000	-		
Na2S	0.17181	0.10618	Na2S		
Na(K)2O	0.84513	0.00000	-		
SiO2	1.26371	0.00066	SiO2	0.005	is (matte/slag) concentration ratio for silica
Ca(Ba)O	0.07205	0.00004	Ca(Ba)O	0.005	is (matte/slag) concentration ratio for lime
MgO	0.13723	0.00007	MgO	0.005	is (matte/slag) concentration ratio for magnesia
Cr2O3	0.02111	0.00001	Cr2O3	0.005	is (matte/slag) concentration ratio for chromia
Al2O3	0.10043	0.00005	Al2O3	0.005	is (matte/slag) concentration ratio for alumina
NaCl	0.09849	0.00175	NaCl	0.17	is (matte/slag) concentration ratio for chloride
SnO	0.03963	0.00207	CdO	0.50	is (matte/slag) concentration ratio for tin
Sb2O3	0.20703	0.00681	Sb2S3	0.27	is (matte/slag) concentration ratio for antimony
H2OFrCb	0.00000	0.00000	H2OFrCb		
ZnO	0.01100	0.00138	ZnS	1.00	is (matte/slag) concentration ratio for Zn
SO2	0.00000	0.00000	SO2		
O2	0.00000	0.00000	O2		
CuO	0.00516	0.05395	Cu2S	100.00	is (matte/slag) concentration ratio for Cu
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
-	0.00000	0.00000	-		
TOTAL SLAG	3.43616	0.35909	TOTAL Matte		
	Slag Wt,mt	Matte Wt,mt			

Calculation of Slag Viscosity

X"SiO2"=	0.43	Moles Si+P+Ti
X"CaO"=	0.18	Moles Ca+Mg+Mn+Pb+Zn+Fe
X"Al2O3"=	0.02	Moles Al2O3+Cr2O3
X"Na2O"=	0.32	Moles NaK2O+Na2S (non-mat
X"CaF2"=	0.03	Moles NaCl
A=	1.73E-07	
B=	1.43E+04	

	V in Poise	°K	°C
Viscosity=	**30.4**	1198	925
Viscosity=	**108.7**	1073	800
Viscosity=	**38.3**	1173	900
Viscosity=	**16.0**	1273	1000
Viscosity=	**7.6**	1373	1100

	Wt %	Weight	MoleFrac.Slag	MoleNonMatte
PbO	2.2%	0.07	0.0064	0.00031
Pb°	0.0%	0.00	0.0000	0.00000
C°	0.0%	0.00	0.0000	0.00000
CO2	0.0%	0.00	0.0000	0.00000
Fe°	0.0%	0.00	0.0000	0.00000
FeO	7.9%	0.25	0.0710	0.00351
SO3	0.0%	0.00	0.0000	0.00000
Na2S	2.2%	0.07	0.0446	0.00220
Na(K)2O	26.5%	0.85	0.2758	0.01363
SiO2	39.6%	1.26	0.4261	0.02106
Ca(Ba)O	2.3%	0.07	0.0260	0.00129
MgO	4.3%	0.14	0.0689	0.00341
Cr2O3	0.7%	0.02	0.0028	0.00014
Al2O3	3.1%	0.10	0.0199	0.00098
NaCl	3.1%	0.10	0.0341	0.00168
SnO	1.2%	0.04	0.0059	0.00029
Sb2O3	6.5%	0.21	0.0144	0.00071
Other	0.0%	0.00	0.0000	0.00000
ZnO	0.3%	0.01	0.0027	0.00014
SO2	0.0%	0.00	0.0000	0.00000
O2	0.0%	0.00	0.0000	0.00000
CuO	0.2%	0.01	0.0013	0.00006
H2OXL	0.0%	0.00	0.0000	0.00000
CO	0.0%	0.00	0.0000	0.00000
H2	0.0%	0.00	0.0000	0.00000
N2	0.0%	0.00	0.0000	0.00000
Sum:	100.00%	3.19	1.0000	0.04942

100 Start-up controller

Calculation of the low-temperature heat capacities

	A	T2 - T1	B	T2sq - T1sq	C	1/T2-1/T1
CO2	10.57	25	1.05E-03	1.43E+04	2.06E+05	-3.07E-04
CO	6.708	25	5.53E-04	1.43E+04	6.20E+03	-3.07E-04
Sb4O6 vap.	52.016	25	1.69E-03	1.43E+04	8.30E+05	-3.07E-04
O2	7.16	25	5.00E-04	1.43E+04	4.00E+04	-3.07E-04
SO2	11.04	25	9.40E-04	1.43E+04	1.84E+05	-3.07E-04
H2O vapor	7.3	25	1.23E-03	1.43E+04	0.00E+00	-3.07E-04
N2	6.83	25	4.50E-04	1.43E+04	1.20E+04	-3.07E-04

Calculation of high-temperature heat capacities, kcal/kg

	A	T2 - T1	B	T2sq - T1sq	C	1/T2-1/T1
CO2	10.57	1155	1.05E-03	2.02E+06	2.06E+05	-2.7E-03
CO	6.708	1155	5.53E-04	2.02E+06	6.20E+03	-2.7E-03
Σ mass for input heat calc:						
Σ mass for outputput heat calc						
Σ mass in from material bal:						
Sb406 vapor	52.016	1155	1.69E-03	2.02E+06	8.30E+05	-2.7E-03
O2	7.16	1155	5.00E-04	2.02E+06	4.00E+04	-2.7E-03
SO2	11.04	1155	9.40E-04	2.02E+06	1.84E+05	-2.7E-03
H2O vapor	7.3	1155	1.23E-03	2.02E+06	0.00E+00	-2.7E-03
N2	6.83	1155	4.50E-04	2.02E+06	1.20E+04	-2.67E-03

Low-Temp. Heat Capacities:

T1, °C=	0
T2, °C=	25
	Heat Capac. Kcal/kg
CO2	4.91E+00
CO	6.20E+00
Sb2O3 vapor	1.83E+00
O2	5.43E+00
SO2	3.64E+00
H2O vapor	1.11E+01
N2	6.20E+00