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Service de la protection de l'environnement

Industrial Waste Characterization

For the Iron and Steel, Metal Recovery, Non-Ferrous Alloying, and Metal Finishing/Coating Industries

Solid Waste Management Branch
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October 1976

REPORT ON INDUSTRIAL WASTE CHARACTERIZATION FOR THE IRON AND STEEL, METAL RECOVERY AND NON-FERROUS ALLOYING, AND METAL FINISHING/COATING INDUSTRIES

by

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October 1975

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1. SUMMARY:

On behalf of the Solid Waste Management Branch of the Environmental Protection Services of Environment Canada, a study was undertaken to characterize the industrial wastes disposed of on land, which are generated by the Iron and Steel, Metal Recovery and Non-Ferrous Alloying, and Metal Finishing/Coating Industries. The basis for this study programme was a series of site visits to two integrated steel plants, two mini-steel plants, four foundries, seven metal recovery and non-ferrous alloying industries and nine metal finishing/coating industries. All these plants are located in southern Ontario.

The information and data provided by the participating industries showed a wide range of operating conditions, even for industries in the same category, resulting in widely varying quantities of waste per unit production, being disposed of on land. This made it rather difficult to prepare projections of total quantities of waste for land disposal for each category of industries.

Generally the effects of environmental control measures on solid wastes quantities could be assessed, as a number of the industries visited have air and/or water quality control systems in operation. It may be expected, that implementation of additional treatment facilities to comply with more stringent environmental standards would increase the quantity of wastes for disposal on land. However, this increase will be relatively small compared to the mass of wastes now being generated for disposal on land from the existing environmental control systems.

The recycling of waste materials is practiced by most industries to a substantial degree. In some cases this is done to maintain a profitable operation, or because the economics justify the installation of processing facilities for recovery of metals from specific wastes. In other cases some wastes are sold to outside contractors or to other companies, for metal recovery or material reuse. The direct benefit of recycle and processing for recovery is a significant reduction of wastes requiring disposal on land.

1. SUMMARY, Cont'd:

The following table presents a summary of the obtained data in terms of quantity of "land-disposed" wastes per unit production, e.g. per ton of coke, or iron, or steel for the integrated steel plant and per ton of finished casting for the foundries. This information illustrates the magnitude of the disposal of solid wastes in the Iron and Steel industry including the Foundries. By comparison, the quantities of wastes in the Non-Ferrous Metal Recovery and Alloying industries are much smaller, mainly because these are secondary producers of metal products, generally using a higher quality raw material. The data obtained for the Metal Finishing/Coating industries proved insufficient for inclusion in this summary table.

QUANTITIES OF WASTES DISPOSED OF ON LAND.

Area/Source	Range of Quantity lb/ton of Product
1. Integrated Steel Plant:	
Coke Oven	2 - 6
Blast Furnace	420 - 480
Basic Oxygen Furnace	380 - 500
Open Hearth Furnace	360
2. Mini-steel Plant	380 - 480
3. Foundries	745 - 1540
4. Aluminum Alloying (from scrap)	120 - 160
5. Lead Blast Furnace	40 - 100

At the present time most of the integrated and mini-steel plants have their own disposal site, either on the plant premises, or off-site a short distance away. Because of the large quantities of wastes, i.e. slags, oxides, dust and scrap refractories, on-site disposal has been the preferred method for the integrated steel plants. However, when present disposal areas will be full, off-site disposal will be the only alternative with its much increased cost.

1. SUMMARY, Cont'd:

Mini-steel plants and foundries usually operate their own landfill sites away from the plant premises, or have outside contractors haul their wastes to a private disposal site. In some instances solid wastes from the foundries are trucked to the municipal landfill site. Similarly, off-site disposal is generally used in the metal recovery and non-ferrous alloying and in the metal finishing/coating industries.

A major criterion in the disposal on land of these industrial wastes is the prevention of leaching of hazardous metals into ground water or surface waters, to ensure the safeguarding of a satisfactory water quality for the various public and agricultural uses.

More detailed information must be obtained, to develop the characteristics of wastes requiring disposal on land in the widely diverse group of metal finishing/ coating industries. Special attention should then be given to the effects of (eventual) compliance with the municipal sanitary sewer by-law, in so far as pretreatment of process waste waters might be required, which then would result in the production of sludges for disposal on land.

It is recommended that the present management of disposal sites be changed to a "stockpiling operation", where waste materials are involved which presently contain too low concentrations of valuable metals to warrant economical recovery. In the not too distant future such stockpiles of waste material might provide a welcome source of raw material, with the continuing depletion of metals for industrial production.

ACKNOWLEDGMENT.

This report is based on information and data received from the industries visited during this study programme and from the Federal and Ontario Environment Departments. Some published data has also been quoted. We wish to thank these individual groups for their willing cooperation and their patience in answering our many questions and further requests.

1.a RÉSUMÉ:

Ce document nous livre les résultats d'une étude effectuée pour le compte de la Direction des déchets solides du Service de la protection de l'environnement, à Environnement Canada. L'expérience visait à caractériser les déchets industriels rejetés sur le sol à divers stades d'activité de certaines industries, notamment la sidérurgie, la récupération des métaux, la production d'alliages non ferreux, le finissage et l'enduisage des métaux. Le programme comportait la visite de deux aciéries intégrées, de deux petites aciéries, de quatre fonderies, de sept usines de récupération des métaux et de production d'alliages non ferreux et de neuf industries de finissage et d'enduisage de produits métalliques, toutes situées dans le sud de l'Ontario.

Les données et renseignements fournis par les usines participantes reflètent des conditions de fonctionnement fort variables, même entre les industries d'une même catégorie; cela explique le dépôt, sur le sol, de quantités variables de résidus par unité produite. Il a donc été difficile de faire des projections des quantités globales de rebuts répandus sur le sol pour chacune des catégories.

En règle générale, il a été possible d'évaluer la répercussion des mesures de protection de l'environnement sur le volume des déchets. En effet, un certain nombre des usines visitées sont munies de systèmes de prévention de la pollution de l'air ou de l'eau. On peut prévoir que l'installation d'autres systèmes, de façon à respecter des normes environnementales plus strictes, augmenterait le volume de résidus déposés sur le sol. Néanmoins, cet accroissement serait relativement négligeable par rapport à la masse actuelle de rebuts ainsi rejetés par les appareils antipollution existants.

La plupart des établissements visités recyclent une bonne partie de leurs déchets. Dans certains cas, cette activité nouvelle est liée à la rentabilité de l'exploitation; en effet, cela semblerait rentable d'installer des appareils de recyclage

pour récupérer certains métaux contenus dans les rebuts. D'autres industries vendent leurs résidus à des entrepreneurs ou à des sociétés, qui en extraient les métaux ou les réutilisent. Le recyclage et la récupération réduisent considérablement le volume de déchets rejetés sur le sol.

Le tableau ci-dessous résume certaines données sur la quantité de rebuts répandus sur le sol par production unitaire, c'est-à-dire par tonne de coke, de fer ou d'acier pour l'aciérie intégrée et par tonne de pièces de fonte finies pour les fonderies. Ces statistiques donnent une idée de l'importance des déchets solides venant de la sidérurgie, les fonderies y comprises. Par ailleurs, les quantités de résidus résultant de la récupération des métaux non ferreux et la production d'alliages non ferreux sont, comparativement, beaucoup moins grandes; notons qu'il s'agit de producteurs secondaires de métaux, qui utilisent généralement des matières premières de qualité supérieure. Les données recueillies sur les industries de finissage et d'enduisage des métaux n'étaient pas assez représentatives pour les inclure dans le présent tableau.

QUANTITES DE DECHETS REJETES SUR LE SOL

Exploitation ou source	Quantité approximative (lb par tonne de production)
1. Aciéries intégrées:	
Fours à coke	2 - 6
Hauts fourneaux	420 - 480
Fours à oxygène (traitement basique)	380 - 500
Fours à sole	360
2. Petites aciéries	380 - 480
3. Fonderies	745 - 1540
4. Alliages d'aluminium (à partir de ferraille)	120 - 160
5. Hauts fourneaux à plomb	40 - 100

Aujourd'hui, la plupart des aciéries, petites ou intégrées, ont leur propre dépotoir industriel, soit sur les lieux de l'usine, soit à quelque distance de celle-ci. Etant donné le volume élevé des déchets, c'est-à-dire de scories, d'oxydes et de poussières et ferrailles réfractaires, le rejet sur place a été la méthode préférée des aciéries intégrées. Toutefois, lorque les dépotoirs actuels seront comblés, il faudra transporter les rebuts loin de l'usine, ce qui sera beaucoup plus coûteux.

Les petites aciéries et les fonderies ont habituellement leurs propres aires d'enfouissement, à quelque distance de l'usine, ou font appel à des entrepreneurs pour emporter leurs déchets sur des terrains privés réservés aux détritus. Dans certains cas, les rebuts solides des fonderies sont transportés par camions jusqu'aux dépotoirs municipaux. De même, le transport au loin a cours dans l'industrie de la récupération des métaux non ferreux et dans celle de la production d'alliages non ferreux ainsi que dans celles du finissage ou de l'enduisage des métaux.

Une réserve importante s'impose quand on considère la dispersion de ces déchets industriels: il faut à tout prix empêcher le lessivage de métaux toxiques, qui risque de contaminer les eaux souterraines ou de surface. Il faut préserver la qualité de l'eau destinée à la consommation et aux exploitations agricoles.

Pour mieux définir les déchets produits par les procédés si diversifiés de finissage et d'enduisage des métaux, il faudra plus de renseignements et de données. Il serait en outre opportun de bien considérer les effets que pourra éventuellement entraîner l'observation des règlements municipaux sur les égouts sanitaires; ils pourraient, en effet, exiger un prétraitement des eaux industrielles usées, ce qui produirait des boues qu'il faudrait ensuite répandre sur le sol.

Nous recommandons un changement dans la gestion des dépotoirs industriels. A notre avis, il vaudrait mieux entasser les déchets solides dont la teneur métallique est actuellement jugée trop faible pour en rentabiliser la récupération. Dans un avenir très rapproché, ces réserves de résidus pourraient, en effet, offrir une source inespérée de matières premières, les métaux se faisant rares pour l'exploitation industrielle.

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2. INTRODUCTION:

This study programme was undertaken by L.S. Love and Associates Ltd. for the Department of Supply and Services under Contract No. OSS4-0414 (DSS File No. SS02.KE204-4-EP102) dated March 26th, 1975, on behalf of the Solid Waste Management Branch, Environmental Protection Services, attention of Mr. H. Mooij, Environment Canada.

The objective of this study was to characterize the industrial wastes disposed of on land, which are generated by the Iron and Steel, Metal Recovery and Non-Ferrous Alloying, and Metal Finishing/Coating Industries. Thus the report will describe the current state of disposal on land of these industrial wastes and will indicate the effects of future application of environmental control measures.

During the study programme site visits were made to two integrated steel plants, one mini-steel plant, one speciality mini-steel plant, four foundries, seven metal recovery and non-ferrous alloying industries and nine metal finishing/coating industries. All of these are located in Southern Ontario.

Based on the confidential data provided by the participating industries a general range of waste characteristics was developed for each subcategory of industry and correlated where possible with the known production rates. Development and selection of a so called typical process for an industrial subcategory proved generally impractical in view of the relatively small number of individual industries that could be visited during the study, in relation to the large number of industries in those groups existing in the Province of Ontario. A complicating factor in this regard was also the wide variability of processes in use in industries within the same major grouping, as found during the site visits. This problem was illustrated particularly in the metal recovery and non-ferrous alloying and the metal finishing/coating industries.

To protect the confidential nature of the information provided by each participating industry, only the generalized data developed during this study programme have been presented in this report, and in such a way that any part of this information cannot be identified with any one of the specific industries visited throughout this study.

3. GROUP "A", IRON AND STEEL INDUSTRY:

3.1 Integrated Steel Plants:

The three integrated steel plants located in Ontario are listed in Table 1. For this study site visits were made to the Steel Company of Canada Ltd., Hilton Works, in Hamilton, and to Dominion Foundries and Steel Company Ltd., also located in Hamilton.

3.1.1 Process Description:

A general illustration of the unit processes involved in an integrated steel plant is given in Figure 1. This may serve as ready identification of the various production areas which are briefly described in this section. However, for more detailed descriptions of the various processes in the Iron and Steel Industry reference may be made to two reports prepared by LOVE for Environment Canada a) DSS Contract No. OSS4-029, State of the Art of Waste Waters and their Control in the Canadian Steel Industry, and b) DSS Contract No. OSS4-0375, Draft Industry Study Report for the Iron and Steel Industry for the Air Pollution Control Directorate.

Coke ovens are an essential part of the integrated steel plant, to provide a suitable fuel for use in the blast furnace. Coke is the residue from the destructive distillation of bituminous coal. The by-product process is commonly used in the three Ontario steel plants for the production of metallurgical coke. In this process air is excluded from the coking chamber and the heat required for distillation is supplied from external combustion using a part of the coke oven gas thus produced. During the heating process the volatiles are driven from the coal matrix and recovered. These various volatile products are collected and processed to reclaim chemicals, coal tar and coke oven gas. Figure No. 2 presents a materials flow diagram for the coke ovens and will be further described in the following Section 3.1.2.

TABLE 1

LIST OF STEEL PLANTS IN ONTARIO

a) Integrated Steel Plants

The Steel Company of Canada Ltd., Hamilton

Dominion Foundries and Steel Co. Ltd., Hamilton

Algoma Steel Corporation Ltd., Sault Ste. Marie

b) Mini-Steel Plants*

Atlas Steels Limited, Welland.

Burlington Steel Co. Ltd., Hamilton.

Ivaco Industries Ltd., L'Orignal.

Lake Ontario Steel Co. Ltd., Whitby.

* Note:
All these mini-steel plants are electric furnace shops.

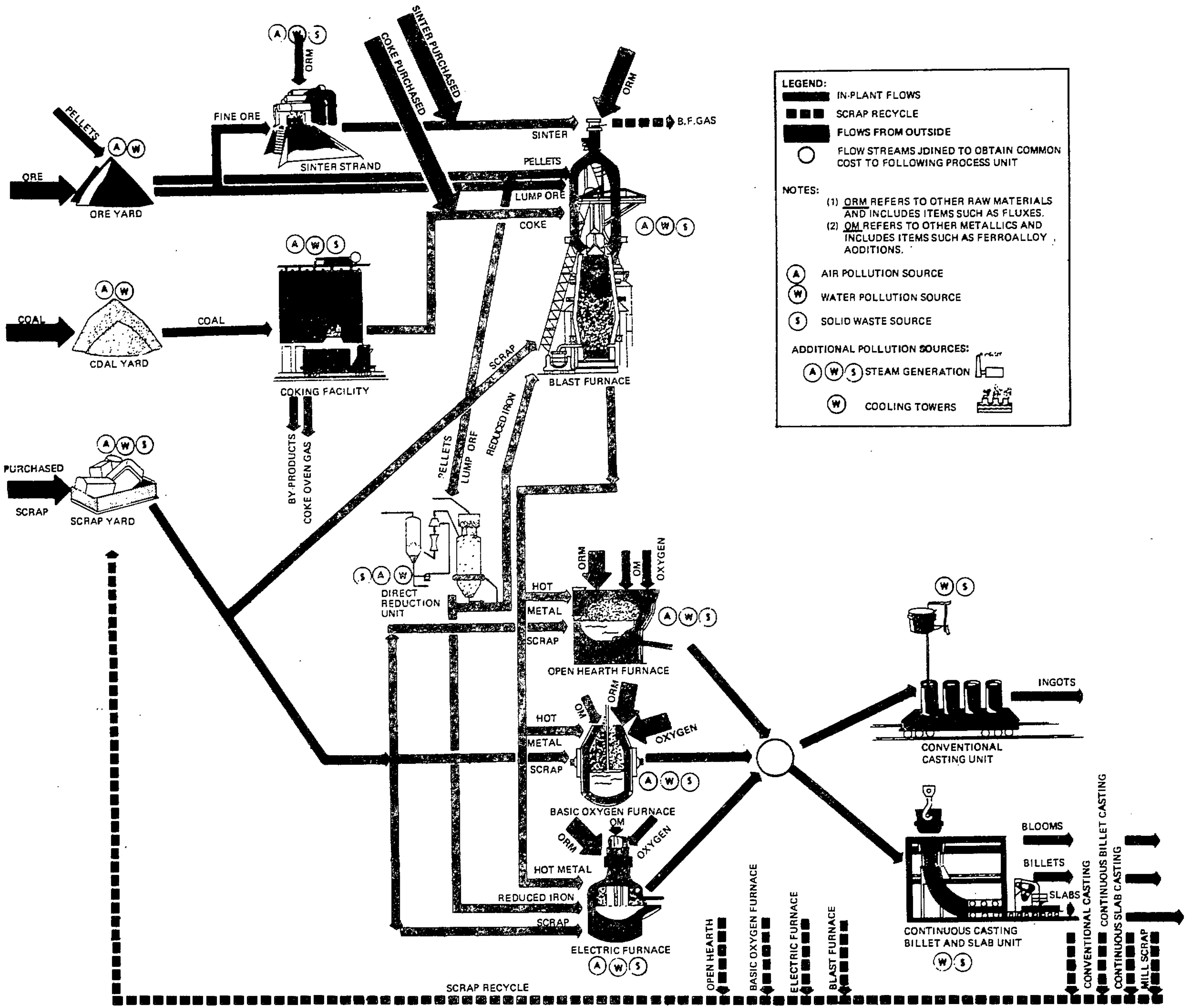


FIG. No. 1. **PROCESS UNIT INTERRELATIONSHIPS IN IRON AND STEELMAKING**

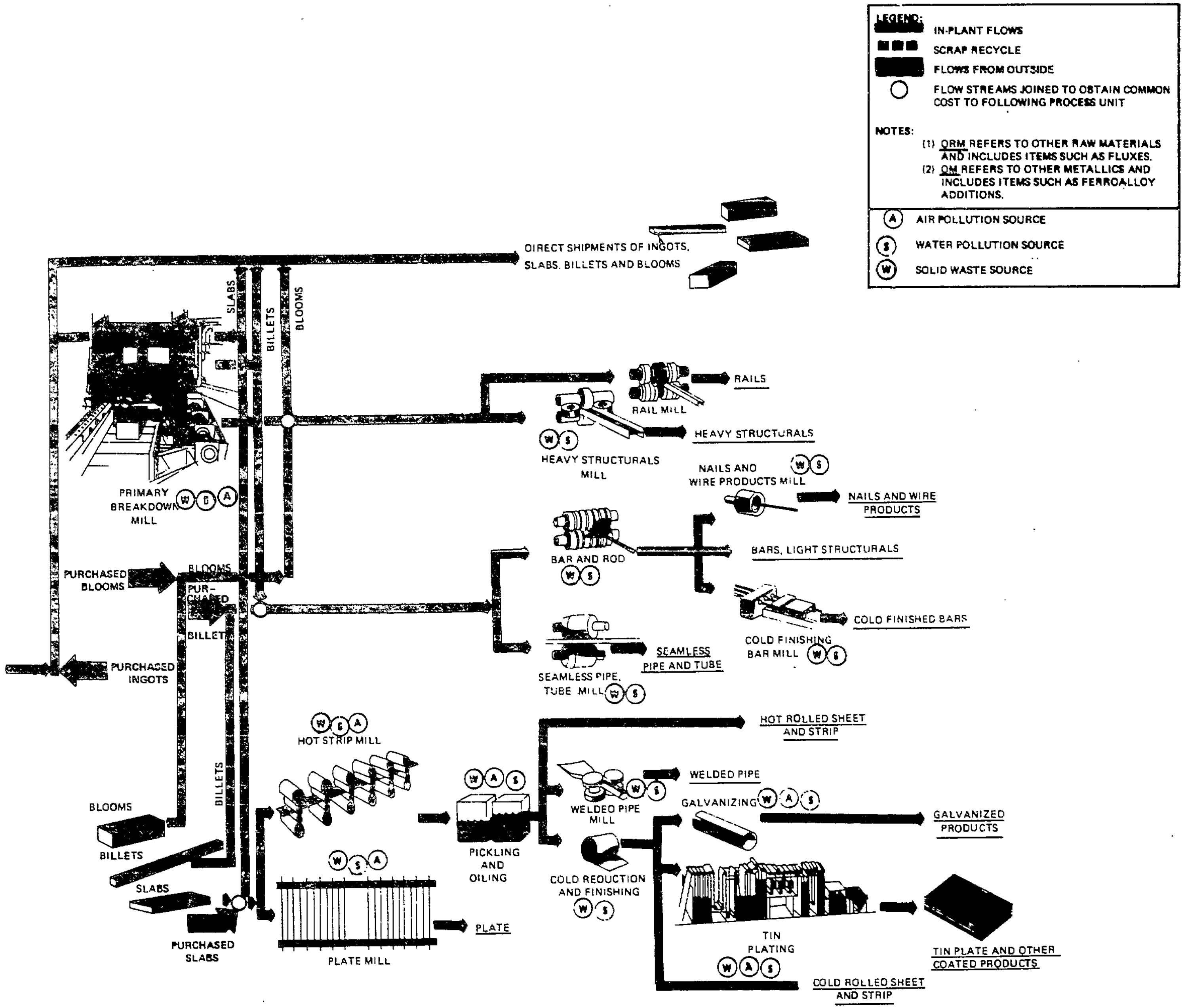


FIG. No. 1. Cont. **PROCESS UNIT INTERRELATIONSHIPS IN STEEL ROLLING AND FINISHING**

COKE OVENS

MATERIALS FLOW DIAGRAM

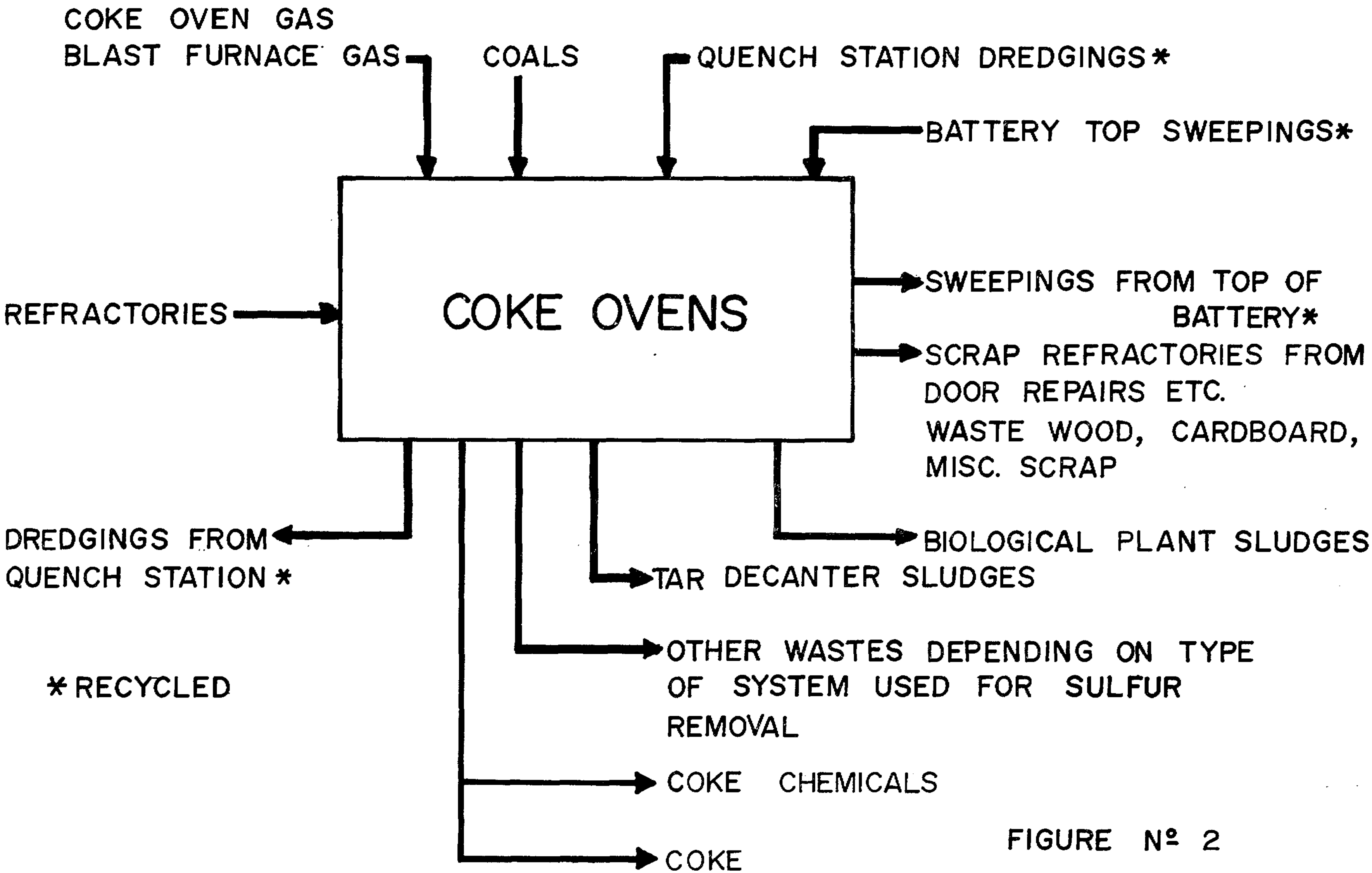


FIGURE Nº 2

3.1.1 Process Description Cont'd:

At the three integrated steel plants iron is produced by the blast furnace process. The iron bearing material could be crude iron ore, pellets, sinter, mill scale, cast iron and steel scrap. This material is charged into the top of the blast furnace together with limestone and coke. The passage of the hot blast air through the ore-coke limestone matrix causes the coke to burn and produce carbon monoxide gas, which combines with the ore to produce carbon dioxide gas and metallic iron. The heat generated by the burning coke supplies the necessary heat for the reaction to proceed, and also the heat required to melt the metallic iron as it is formed. The materials flow diagram shown in Figure No.3 will serve as further reference. The limestone aids the formation of a molton slag which contains all the impurities, and which floats on the molten iron.

The molten iron is tapped into large iron ladles, which convey it to the open hearth or basic oxygen furnaces to be processed into steel. Some of the molten iron may go to the "pig" machine, where it is poured into moving moulds to form pig iron. Special grades of "foundry iron" are usually pig-casted so that they can be conveniently handled and shipped to foundries.

Basic Oxygen Furnace (B.O.F.) shops are used for the production of steel at the three steel plants, while one of these steel plants still operates an open hearth furnace shop. Because of its greater efficiency, the trend is towards ultimate replacement of the open hearth furnaces by the basic oxygen furnace. Materials flow diagrams for the open hearth and basic oxygen furnaces respectively are presented in Figures No.4 and 5.

The addition of oxygen to the charge of scrap and molten iron in a basic oxygen furnace initiates chemical reactions which lead to the formation of iron oxide, while carbon monoxide is evolved giving rise to vigorous boiling action.

BLAST FURNACE

MATERIALS FLOW DIAGRAM

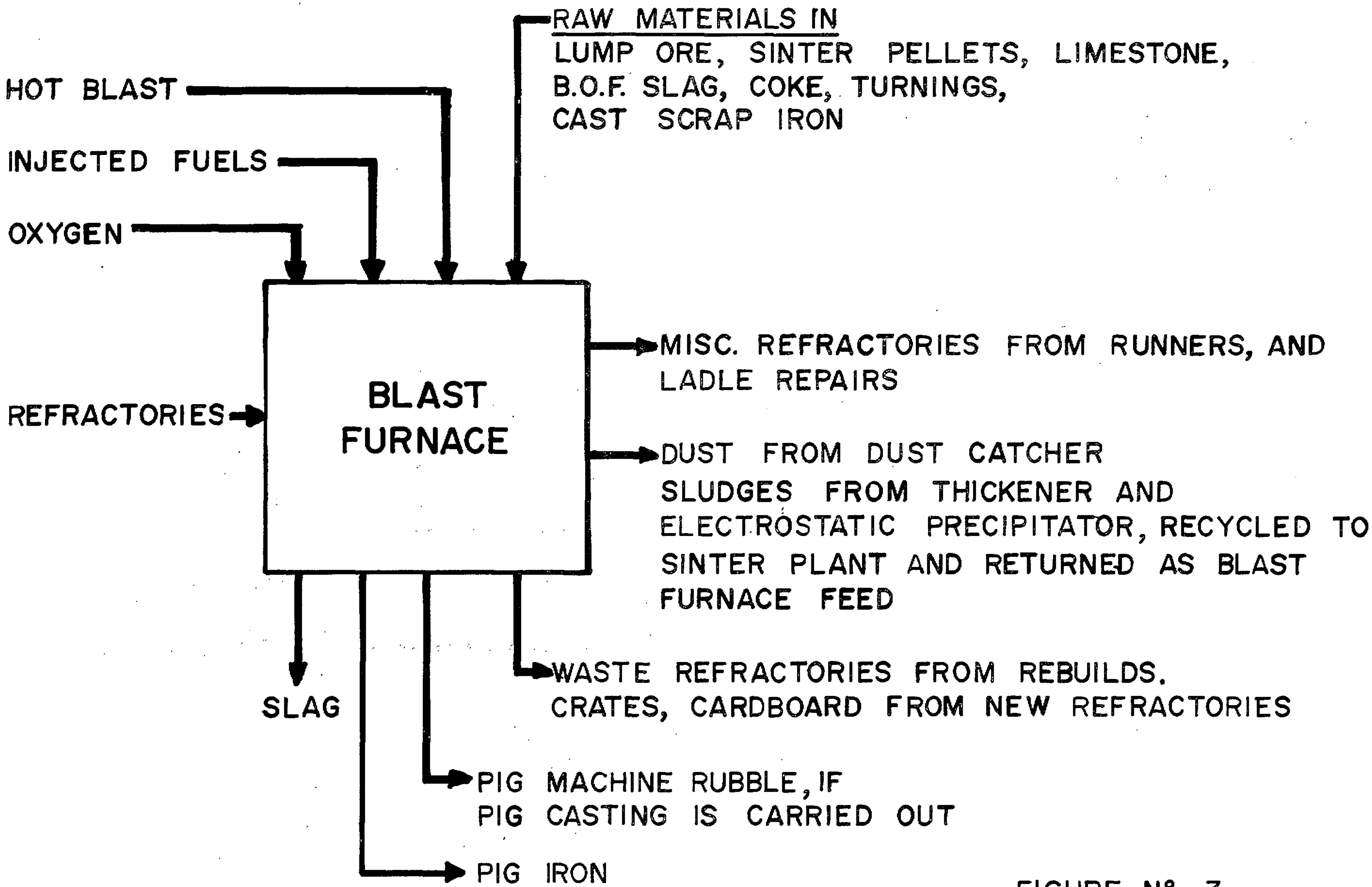


FIGURE Nº 3

STEEL MAKING
MATERIALS FLOW DIAGRAM

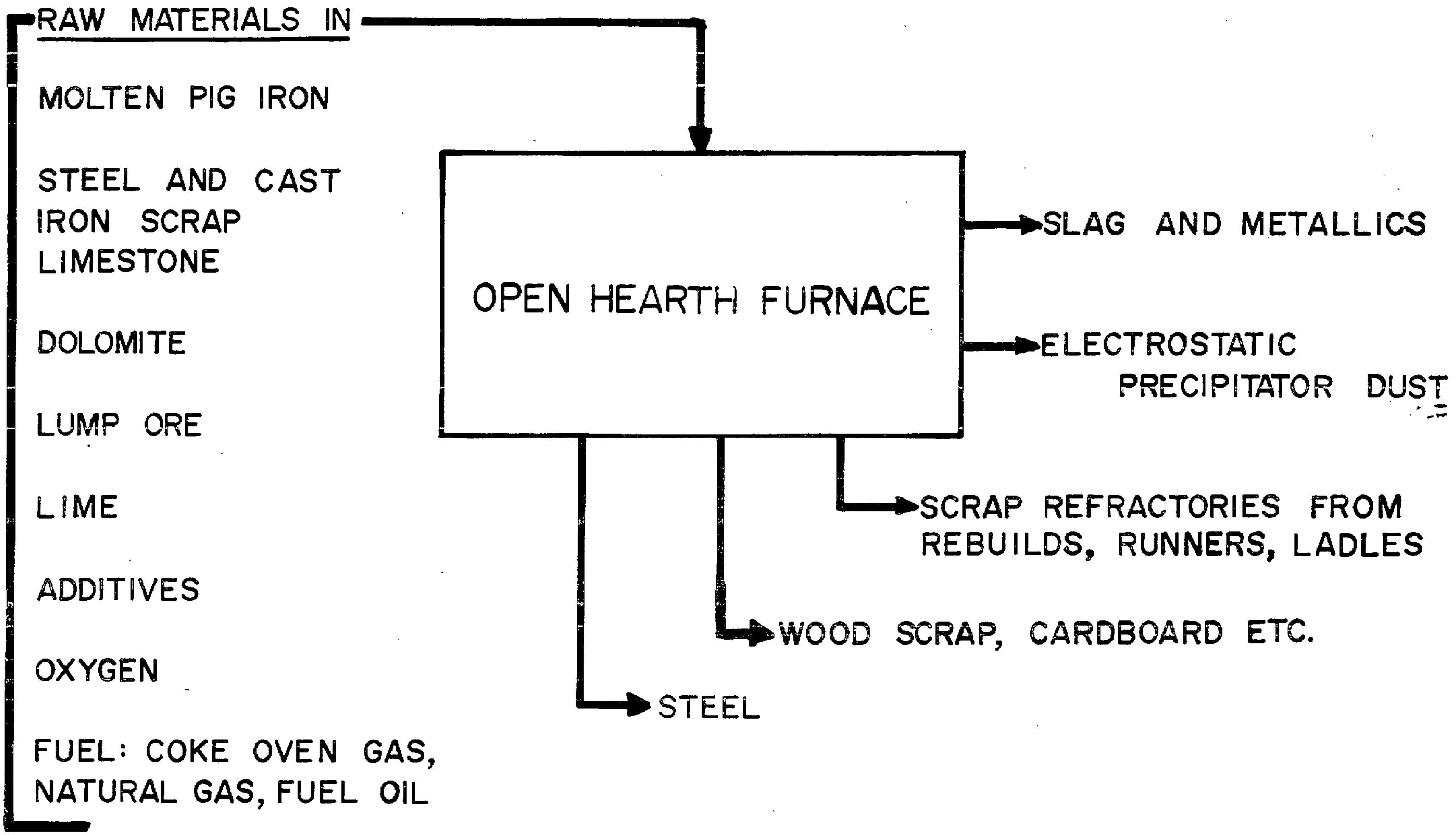


FIGURE Nº 4

STEEL MAKING

MATERIALS FLOW DIAGRAM

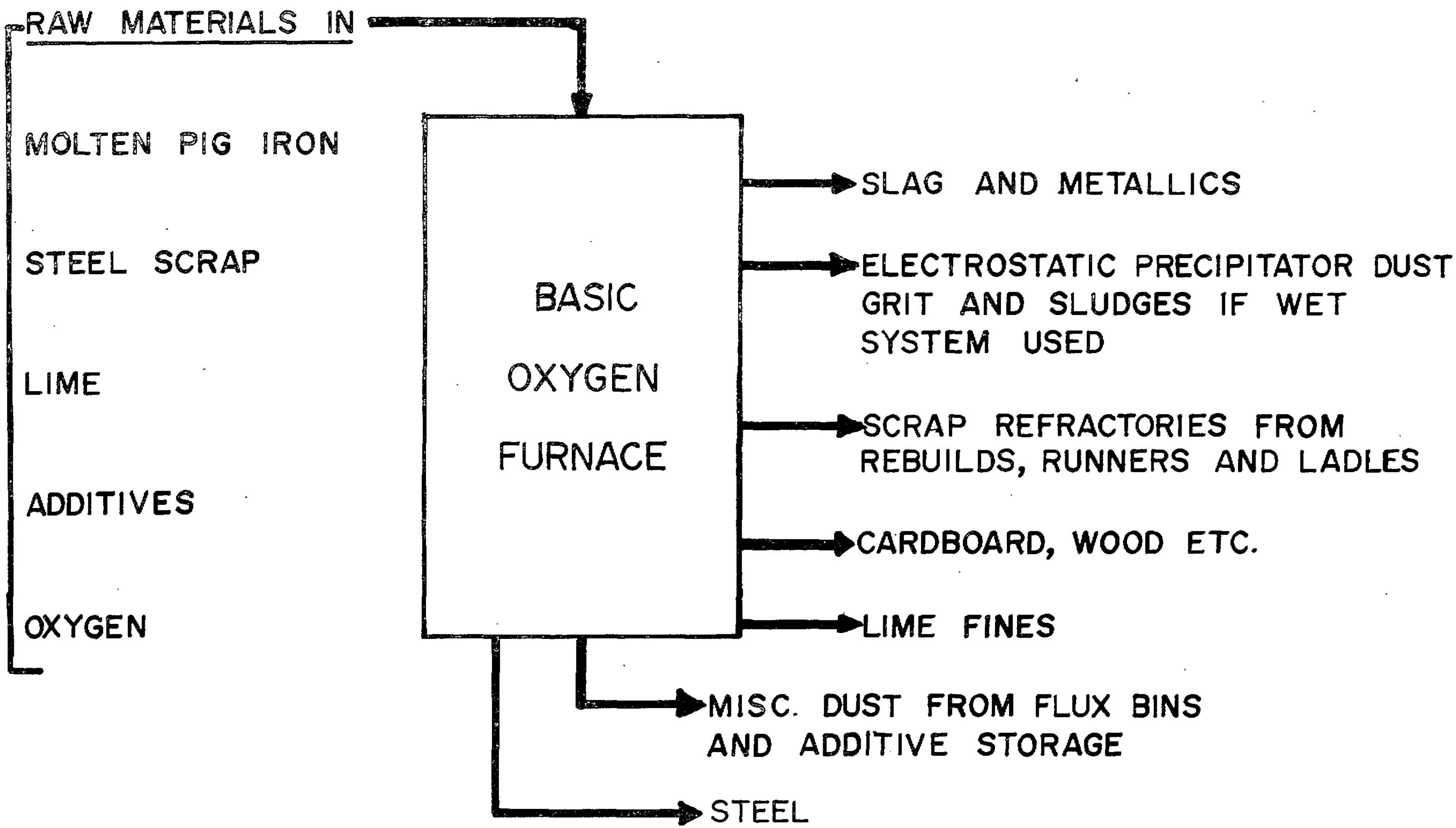


FIGURE Nº 5

3.1.1 Process Description, Cont'd:

Slag forming fluxes, mostly lime and fluorspar, are added in controlled amounts to produce a slag. When the carbon content of the molten metal has been reduced to the desired level, the steel is tapped into a teeming ladle.

From the steel making furnaces the molten steel is either poured into ingot moulds or cast into blooms, billets or slabs by the continuous casting method. This is shown schematically in Figure No. 1. A wide range of rolling mills further process the steel into finished products. The materials flow diagram shown in Figure No. 6 illustrates soaking pits and reheating furnaces, both of which are an essential part in the rolling operations.

As illustrated in Figure No. 1 various processes for chemical treatment and physical or chemical coating of the steel products are part of the finishing operations for an integrated steel plant.

3.1.2 Waste Sources and Characteristics:

Due to the types of manufacturing processes involved in the Iron and Steel Industry, large quantities of solid wastes are generated and handled in an integrated steel plant. As will be indicated in more detail below, most of the waste materials can be recycled to the respective production processes, or may be sold as by-products, or can be used as landfill material on the steel plant premises.

The materials flow diagram, presented in Figure No.2 for coke ovens, gives an indication of the range of waste materials generated in this process. It is noted that a direct recycle of the battery top sweepings and of the dredgings from the quench station is practised, with both waste materials being reintroduced into the top of the coke ovens with the normal charges of coal. A typical range of quantities for scrap refractories and for tar decanter sludges is given in Table No. 2. These quantities are expressed as lb/ton of product.

MILLS

MATERIALS FLOW DIAGRAM

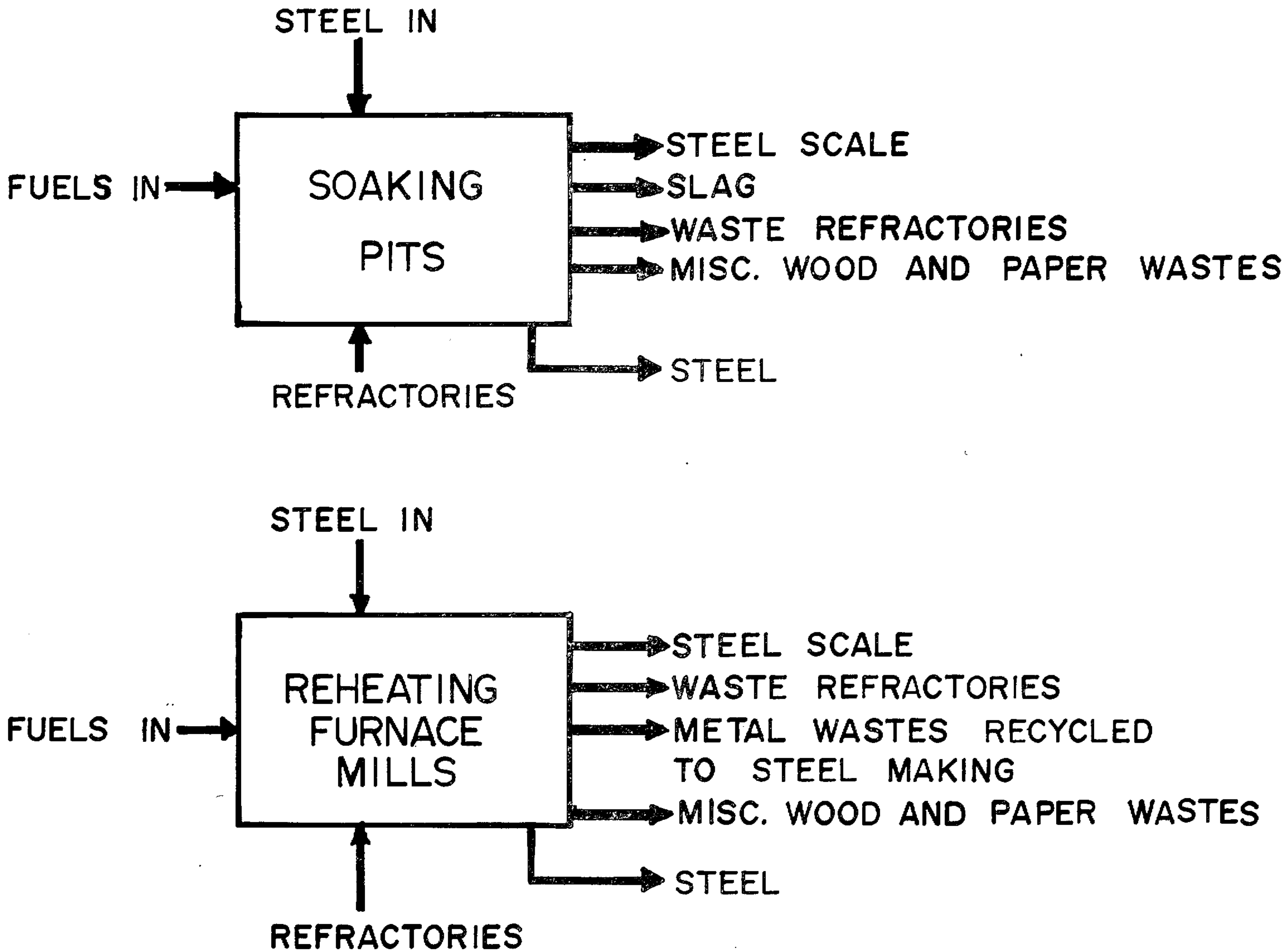


FIGURE Nº 6

TABLE 2

COKE OVEN AREA

Production of Solid and Liquid Wastes

Waste	Range of Quantities lb/ton of Product
Tar Decanter Sludges and Precipitator Sludges	1.3 - 2.7 (as coal) 1.6 - 3.9 (as coke)
Scrap Refractories (door repair etc).	0.007 - 0.04 (as coal) 0.009 - 0.058 (as coke)

Note:

Quantities of other wastes will depend on the specific plant processes, i.e. for H_2S removal, biological treatment and gas purification.

3.1.2 Waste Sources and Characteristics, Cont'd:

Depending on the type of hydrogen sulphide removal system which is in use, additional wastes can be generated. One process yields elemental sulphur as a by-product, at the rate of 1.6 lb/ton of coke produced, which may be sold if a market is available. If some form of biological treatment process is in operation, biological sludges will be produced which will require disposal. Other liquid wastes include the light oil muck from the light oil recovery process, and several concentrated liquid wastes from specific processes for hydrogen sulphide removal and other gas purification processes.

As shown by the data in Table 3, slags are a major waste material from the production of iron and steel, with quantities ranging typically from 290 to 425 lb/ton of product. The materials flow diagrams shown in Figures 3 through 5 respectively for the blast furnace, open hearth furnace and basic oxygen furnace show slag as a waste material for each of these processes.

The molten slag is derived from a mixture of fluxes, iron ore and pellets in the iron making process, and of pig iron or ferrous scrap metal in the steel making process. The chemical composition of slag varies with the impurities in the melted charge, the kinds of fluxes and other additives, and also depends on the type of melting furnace.

Blast furnace slag is fairly uniform in composition, depending on the type of ore already processed, whereas steel slag varies considerably, due primarily to the great variety of additive metals used in producing the many types of steel. Table 4 presents a range of chemical characteristics of blast furnace and steel slags, while Table 5 gives typical physical properties of the same two types of slag.

TABLE 3

Slag Production Data

Slag	Range of Quantities lb/ton of Product
Blast Furnace Slag	375 - 425 (as iron)
Basic Oxygen Furnace Slag	300 - 400 (as steel)
Open Hearth Furnace Slag	290 - 300 (as steel)

TABLE 4

CHEMICAL COMPOSITION OF BLAST FURNACES AND STEEL SLAGS

in terms of percentage concentration

Constituent	Blast Furnace Slag		Steel Slags	
	Usual Range	Typical	Open Hearth	Basic Oxygen Furnace
Calcium oxide (CaO)	36 - 45	38.6	25.8	41.3
Silicon Dioxide (SiO_2)	33 - 42	34.9	16.4	15.6
Aluminum Oxide (Al_2O_3)	10 - 16	10.0	2.4	2.2
Magnesium Oxide (MgO)	3 - 16	13.7	10.0	6.9
Iron (FeO or Fe_2O_3)	0.3 - 2	0.64	26.0	20.0
Sulfur (S)[5]	1 - 3	not determined	——	——
Manganese Oxide (MnO)	0.2 - 1.5	0.19	11.2	8.9
Titanium Dioxide (TiO_2)	——	——	0.8	0.5
Free Lime (free CaO)	——	——	2.1	3.3

TABLE 5

Typical Physical Properties of Air-cooled

Blast Furnaces and Steel Slags

Parameter	Blast Furnace Slag	Steel Slag
Specific Gravity	2.3 - 2.7	3.2 - 3.5
Unit Weight, Minus ½" Size (lb/cu.ft.)	70 - 90	110 - 130
Water Absorption (%)	1.5 - 5.0	0.2 - 2.0

TABLE 6

Summary of Solid Wastes

Requiring Disposal on Land.

Area	Quantities of Waste tons/ton of product	
	Range for Ontario	American Published Data
Coke Ovens	0.001 - 0.003	0.003
Blast Furnace	0.21 - 0.24	0.20
Basic Oxygen Furnace	0.19 - 0.25	0.15
Open Hearth Furnace	0.18	0.13

3.1.2 Waste Sources and Characteristics, Cont'd:

Data are presented in Table 6 giving an overall range of the quantities of solid wastes produced at the coke ovens and in the manufacture of iron and steel, which cannot be recycled to the processes and therefore must be disposed of continuously. These figures represent the totals of the various waste streams described in the materials flow diagrams presented in Figures No. 2 through 5.

Another major group of wastes generated in a steel plant are the waste oxides. The production of waste oxides can vary over a wide range depending on plant size, raw materials used, processes applied (i.e. whether pellets are screened or not), and even to some extent on how a waste oxide is defined.

The amount of mill scale formed depends on the time-temperature relationship for furnace operation, and the composition of the furnace atmosphere is critical (both for the soaking pits and the reheating furnaces). Figure No.6 illustrates the materials flow diagrams applicable to the operation of soaking pits and reheating furnaces. Table 7 presents the range of quantities of mill scale produced.

The characteristics of steel making dusts depend on the percentage of hot metal charged and on the volume of oxygen blown. The efficiency of the particular air quality control system installed will determine the total quantity of dust collected.

In the practice of blast furnace operation the amount of flue dust and filter cake will depend on a number of factors:

a) type of burden, i.e. lump ore, pellets and sinter;

b) whether the pellets are screened and hence free of dust. The efficiency of the dust collection system also has a great effect on the total amount of dust collected.

TABLE 7

Approximate Quantities of Waste Oxides
(Based on data obtained from two Steel Plants).

Description	Range of Quantities tons/ton of product
Mill Scale	0.025 - 0.062
Steel Making Dust	0.023 - 0.029
Blast Furnace Flue Dust & Filter Cake	0.019 - 0.054 **
Pellet Screening	0.037
Totals:	0.104* - 0.145

* This total includes the pellet screening value.
** This high value would decrease significantly with pellet screening.

TABLE 8

CHEMICAL COMPOSITION OF WASTE OXIDES

(expressed as percentage concentration)

Parameter	Mill Scale	Open Hearth Precipitator Dust	Blast Furnace Dust and Filter Cake	Basic Oxygen Furnace Dust
Fe_T	73.0	60.9	44.4	58.4
Fe^{++}	45.1	1.2	—	8.6
SiO_2	1.7	0.88	6.3	2.92
Al_2O_3	1.46	0.32	1.4	0.66
CaO	0.6	1.0	4.1	8.3
MgO	0.7	0.8	2.8	1.3
S	0.04	0.3	0.2	0.114
C	—	—	20.7	0.397
ZnO	—	9.7	—	0.15
Pb	—	0.13	—	—

3.1.2 Waste Sources and Characteristics, Cont'd:

Table 7 gives also total quantities of oxides produced in a steel plant in terms of tons of oxides per ton of steel produced.

Some chemical characteristics of waste oxides are presented in Table 8, which includes mill scale, open hearth precipitator dust (OHPD), blast furnace filter cake, and basic oxygen furnace dust (BOFD). These data show that mill scale has a high iron content (greater than 70 per cent) and that it contains very few impurities. Blast furnace filter cake represents the other extreme, a low iron content (less than 45 per cent) and a high level of impurities up to 20 per cent carbon and more than 10 per cent gangue, i.e. SiO_2, Al_2O_3, CaO and MgO. However, mill scale and blast furnace filter cake are not tradionally regarded as waste oxides, since they are chemically as well as physically suitable for recycling through the sinter plant.

The steel making dusts contain zinc (up to 10 per cent as ZnO) and as much as 0.5 per cent lead. OHPD has a high sulphur content of 0.3 to 0.6 per cent, compared to approximately 0.1 per cent for the typical BOFD. The two types of steel making dusts have different physical characteristics. OHPD is more reddish in colour and contains only trace amounts of coarse particles. BOF dusts on the other hand are darker in colour and contain shiny graphite flakes and white lime-based particles.

Since the steel making dusts contain zinc and traces of lead and tin, they are not suitable for recycling to the sinter plant, i.e. for use as blast furnace feed material. Considerable pilot plant work is in progress to find a suitable system for pelletizing these types of dust and for eliminating the trace elements.

3.1.2 Waste Sources and Characteristics, Cont'd:

Scrap refractories are another common waste material from many production areas in the steel plant complex. This is shown schematically on the materials flow diagrams referred to earlier. Large tonnages of refractory materials are required in a steel plant, as most processes for the production of steel require high temperatures. Some of the areas where large quantities of refractories are used are: coke ovens, blast furnaces, open hearth furnaces, basic oxygen vessels, soaking pits and reheating furnaces.

For the basic oxygen and open hearth furnaces the period between rebuilds is fairly short, ranging from three or four weeks to six months. Refractories used in ladles and runners also have a short life cycle and usually considerable patching is done between complete relines.

By contrast coke oven refractories have a life of 20 to 25 years, while blast furnaces usually run 4 to 7 years between complete rebuilds and considerable patching may take place between rebuilds.

In many cases the "burnt" refractory forms part of the slag, especially in the blast furnaces, open hearth and basic oxygen furnaces.

Because of the varying length of time between rebuilds, it proved not possible to obtain a complete estimate of the amounts of waste refractory material discharged from an integrated steel plant.

Figure No.7 illustrates various miscellaneous solid wastes originating throughout a steel plant complex, including change house wastes, wood wastes and blocking, cardboard and paper wastes, miscellaneous chemical sludges, i.e. from tinning lines and pickling operations and main office refuse. Expressed in terms of tons/1,000 tons of steel produced, these miscellaneous wastes requiring disposal on land amount to a range of 2.1 - 6.9 tons.

MISCELLANEOUS WASTES

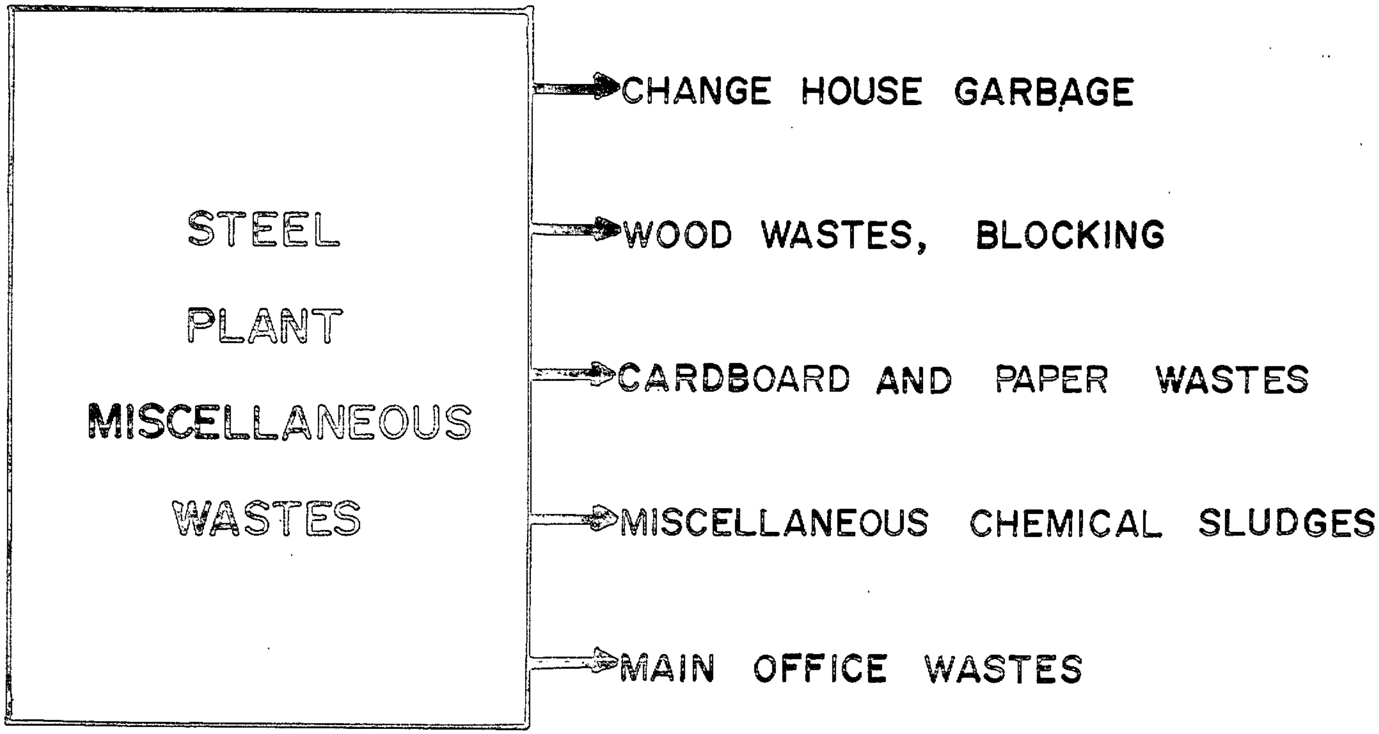


FIGURE Nº 7

3.1.3 Effects of Process Changes and Environmental Controls:

The current technology of iron and steel manufacturing has achieved a high degree of internal recycle of products recovered from waste materials. Examples are the recycle at the coke ovens of battery top sweepings and of quench tower dredgings, the recovery of mill scale via the sinter plant as feed to the blast furnace, and also the reuse of basic oxygen furnace slag as flux in the blast furnace due to its high lime content.

Environmental control measures effected so far have increased the total mass of waste materials, i.e. dust collected through scrubbers or bag-houses, or sludges from settling facilities or thickeners. Ideally these wastes are also recycled via the sinter plant when available, to minimize the disposal requirements. However, as noted earlier, the dusts from open hearth and basic oxygen furnaces cannot be recycled in this manner, due to the presence of zinc and also in smaller amounts of tin and lead. Thus steel making dusts must be disposed of, e.g. by landfill. If the current investigations on the removal of zinc, tin and lead from BOF dusts would prove successful, then reuse of these dusts would significantly reduce the present disposal requirements.

Another example of reuse of waste products due to environmental controls is the waste oils recovered from oily waste water treatment plants. The oil so recovered is used as fuel oil.

Implementation of additional environmental control measures will result in only marginal increases in the total amounts of waste materials generated, since relatively speaking the bulk of solids have already been removed from air and water flows using the environmental control systems so far installed. The waste materials collected from such new environmental control systems must as a first choice be recycled internally within the steel plant complex, rather than be sent to a waste disposal site.

3.1.4 By-Product Recovery:

In addition to internal recycle and reuse of waste products, a number of waste materials have commercial value outside of the steel plant premises and are sold on this basis.

The demand for blast furnace slag, mainly in the construction industry, generally results in a full utilization of the secondary products, such as fill aggregates, building materials and railway ballast, which outside contractors derive from blast furnace slag.

Since the slags from steel production are not as stable as blast furnace slag, they are of no use in the construction industry. After reclaiming of the so called "steel buttons", the open hearth (O.H.) slag is used for landfill on site, and BOF slag can be recycled to the blast furnace, due to its high lime content, where it takes the place of part of the necessary limestone charged as flux material.

Steel slags usually undergo little processing other than air or water cooling, crushing, sizing and magnetic separation of the free metal (steel buttons). Reclaiming of the steel takes place at nearly every stage in the processing cycle.

Usually the scrap refractories are carefully sorted over, so that any usable brick or special shapes can be recovered for reuse. Often scrap refractory is ground up, using mullers or drypans. This ground mixture is blended with new refractory cement and used as a plastic ramming material, e.g. in furnace doors and walls. In some cases the plastic material is used to line runners and ladles.

The ferric oxide resulting from the recovery processes for spent hydrochloride pickling acids can be sold outside to the pigment industry, or can be recycled to the blast furnace, depending on the specific recovery process in use and the corresponding quality of the ferric oxide produced.

3.1.4 By-Product Recovery, Cont'd:

Waste sludge from the tinning line is usually sold to outside contractors for reclaiming of the tin.

It must be realized that any recovered by-product for sale outside can only be sold successfully, if a market exists for that product. If at any time the market would disappear, the recovered by-product would revert to its original state of waste material and as such would require disposal. An illustration may be found in the currently available processes for recovery of elemental sulphur from H_2S removal systems for coke oven gas. This sulphur is of sufficient quality that it represents a useful raw material for the chemical process industry. However, if this demand for sulphur can be satisfied from other less costly sources, the sulphur recovered from coke oven gas will simply become a waste material requiring alternate disposal.

3.1.5 Disposal Methods:

The integrated steel plants are usually located on major waterways, providing easy access for transportation and a source of supply of the necessary large volumes of water. If water lots were acquired, these proved to be an ideal landfill site for the massive quantities of solid wastes generated in the steel plant on a daily basis.

Recently government regulatory agencies have become concerned about the adverse effects of the landfill operation and the encroaching land mass on the water quality, also in view of the possible leaching of hazardous chemicals from the waste materials into the water body. Curtailment of this operation as a disposal method for waste materials will increase the cost of solid waste disposal, as soon as the available sites on the plant premises are filled.

3.1.5 Disposal Methods, Cont'd:

The solid wastes resulting from iron and steel manufacture, which are not recycled in-plant or sold outside, are usually disposed of on landfill sites located on or near the plant premises. The costs of transportation and disposal of the slag, dry solids and sludges will vary significantly, depending on the specific plant.

American published data indicates the average cost of disposal of steel plant wastes to be in the range of $4.00/ton of solids. This cost may vary depending on the type of solid wastes. Some published data shows the following disposal costs per ton of product: blast furnace - 80¢, open hearth furnace - 52¢, basic oxygen - 60¢ (based on 1974 costs).

Disposal on land will continue to be the only economically acceptable alternative for the disposal of the bulk of the solid wastes generated in an integrated steel plant. Off-site disposal will require that the governments' waste management regulations are satisfied, with respect to the disposal site and the characteristics of the waste material to be disposed of. Any chemicals which would potentially contaminate the surface run-off water or the ground water through leaching must be excluded from the waste material. A permit for the waste disposal will be issued only when the government authority is satisfied that the geohydrologic aspects of the disposal area are acceptable and that proper controls can be provided to prevent leaching of chemicals into the ground water. Dust control can be prevented by providing a cover.

Miscellaneous wastes such as refuse, scrap wood, and office wastes are normally disposed of at the municipal landfill site.

3.1.5 Disposal Methods, Cont'd:

With the increasingly tightened environmental regulations, the steel industry will experience increasing difficulty in locating disposal areas for the large volumes of solid wastes from the production processes.

3.2 Mini-Steel Plants:

The four mini-steel plants located in Ontario are also listed in Table 1. (See page 6). For this study, site visits were made to Atlas Steels Ltd. in Welland, and Lake Ontario Steel Co. Ltd. in Whitby.

3.2.1 Process Description:

A mini-steel plant has no pig iron production facility (i.e. blast furnace) and uses as its raw materials scrap iron and ore pellets purchased from outside sources. An electric furnace is the steel making process, and from that point on the flow diagram shown in Figure No.1 (see pp. 7, 8) applies also to the mini-steel plants.

The electric furnace receives its energy from a 3-phase transformer equipped for varying the secondary voltage over a suitable range of power levels. Cylindrical solid graphite electrodes, suspended from above the shell and extending down through the ports in the roof, are used to conduct the electric current inside the furnace shell. Generally the pellet charge will not exceed 40 to 45% of the total charge, unless the electric furnace has a continuous pellet feed. Lime is used as a flux material and oxygen may be injected into the bath. Alloying metals are usually added in the pouring ladle.

3.2.1 Process Description, Cont'd:

Electric furnaces used by Ontario mini-steel plants are in the range of 10 - 125 ton capacity. The electric furnaces have the advantage of relatively low investment cost and the ability to:

a) produce steels of a wide range of composition, i.e. carbon, alloy, stainless;

b) make smaller heats than the full capacity of the furnace;

c) take advantage of the relative cost of cold scrap and pre-reduced pellets;

d) produce steel without a source of hot metal.

Some electric furnace shops use continuous casting exclusively, while many use a combination, i.e. ingot pours or continuous cast billets, blooms or slabs. If the steel is teemed into ingots, then the conventional stripping, soaking pit reheating route is used. If the continuous casting system is used, the soaking pit route is generally eliminated and the billets, blooms or slabs go after proper conditioning directly to the reheating furnaces.

The type of rolling mills used in mini-steel plant is determined by the range of finished products the plant wishes to make.

3.2.2 Waste Characteristics:

Since the mini-steel plant uses iron in various forms as a raw material, such as steel or cast iron scrap and reduced pellets, the total mass of waste materials will be substantially less than for an integrated steel plant. Figure No. 8 presents the materials flow diagram for the electric furnace process for steel making.

STEEL MAKING

MATERIALS FLOW DIAGRAM

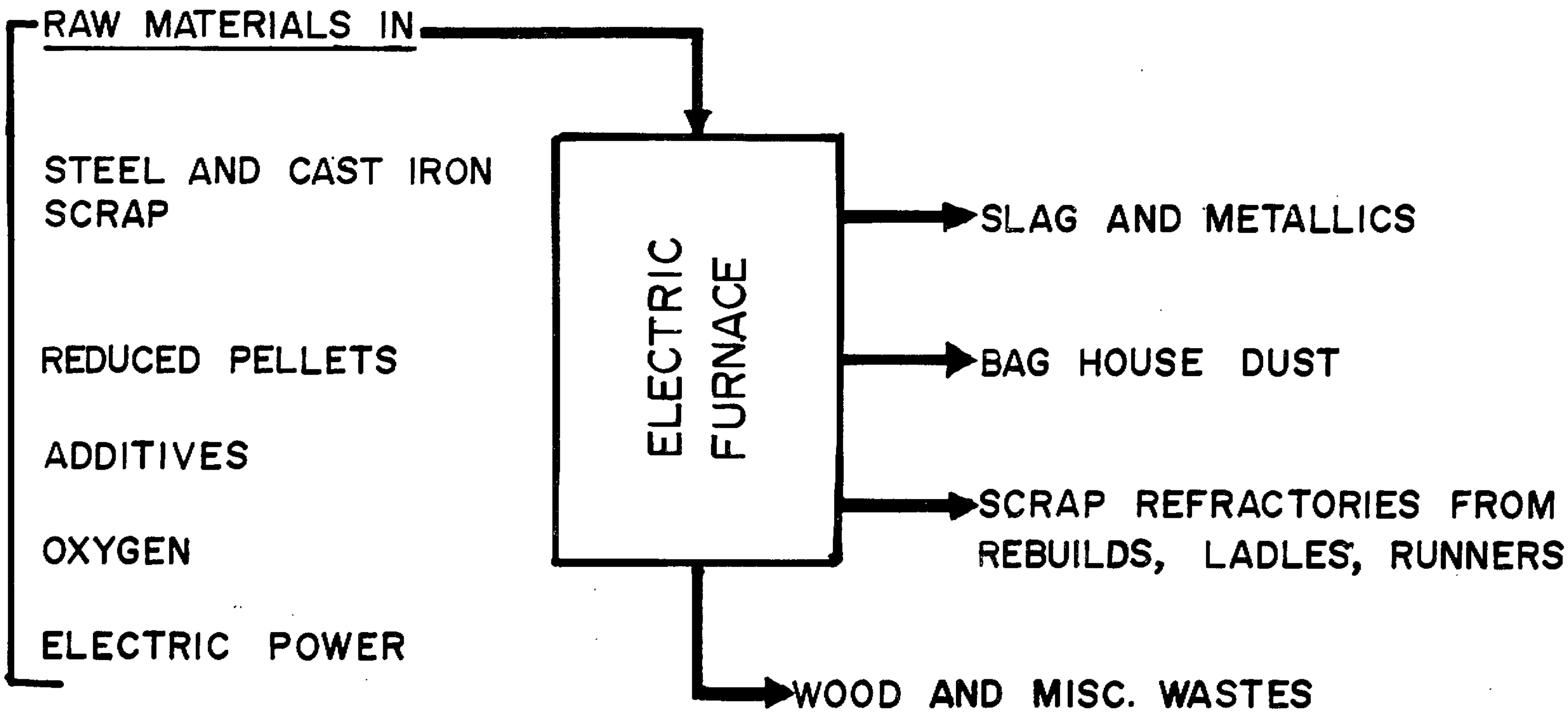


FIGURE Nº 8

3.2.2 Waste Characteristics, Cont'd:

The ranges of quantities of solid wastes produced in the mini-steel plant are shown in Table 9. The wide range for the quantities of slag, from less than 100 to 340 lb/ton of steel, indicates the variation of plant operating conditions, including quality of scrap charged to the electric furnace. Experience suggests a slag production rate in the range of 100-200 lb/ton as average for the industry.

Where possible reusable waste materials, such as mill scale or grinding dust, are recycled to the electric furnace, thus minimizing the total amount of solid wastes requiring disposal on a landfill site. These wastes will include slag, scrap refractories, electric furnace dust and miscellaneous wastes as, grinding wheels and belts, refuse, change house wastes, wood wastes, cardboard and paper bags.

3.2.3 Effects of Process Changes and Environmental Control Measures:

The installation of a new melt shop will require provision of adequate dust collection facilities, and it was estimated that the collected dust would amount to 20 lb/ton of hot metal produced. One possibility would be to pelletize the dust and to stockpile it on the plant premises for future recovery.

3.2.4 Disposal Methods:

The commonly used disposal method is by landfill, and generally off-site since the plant premises are fully occupied or allocated. In some cases a portion of the wastes may be used on-site for special purposes such as railway ballast.

Some companies operate their own private off-site disposal areas. Others have outside contractors hauling the wastes to a disposal area. Miscellaneous refuse is usually trucked to the municipal landfill site.

TABLE 9

MINI-STEEL PLANTS

DATA ON WASTE QUANTITIES

Solid Wastes	Range of Quantities lb/ton of Product
Electric Furnace Slag	95 - 340
Electric Furnace Refractories	55 - 73
Electric Furnace Dust	20 - 26
Mill Scale	45 - 100
Miscellaneous Wastes	15 - 22
Total Solid Wastes	485 - 530
Total Solid Wastes, excluding recycled material	380 - 480

3.3 Foundries:

Based on information obtained from the Ontario Ministry of the Environment (MOE), a listing was prepared of the 85 foundries in operation in Ontario, as shown in Appendix I. However, within the scope of the study programme, only a comparatively small number of foundries could be visited, i.e. Canron Ltd., Stuart Street, at Hamilton, Dorr-Oliver Long Ltd. and Fahralloy Canada Ltd., both at Orillia, and General Motors of Canada Ltd., at St. Catherines. In addition some information was obtained from Dominion Foundries and Steel Ltd., at Hamilton, on the operation of their foundry.

3.3.1 Process Description:

Foundries range in size from small operations to the large production type which turn out tonnage castings. The majority of foundries fall in the small to medium size range. Some are specialty plants, producing special wear and heat resisting castings, which are usually high alloy. Other plants produce the normal gray iron and ductile iron castings. The castings may weigh from a few ounces to several tons.

The melting process normally employed in the gray iron foundries consists of one or more cupolas. This may be supplemented by small electric furnaces and small induction units. The high alloy foundries generally use electric furnaces of 1 - 5 tons capacity and in some cases induction type furnaces. The air to the cupolas is supplied by a 16 oz blower and most cupolas use cold blasts. The blower capacity depends on the size and the capacity of the cupola.

The charge to a cupola consists of scrap iron and scrap steel, lump coke, limestone and the various additives necessary to give the required composition. In most cases recycled scrap from the pouring floor is also used, while new pig iron may also be included in the charge. The grade of scrap used will depend on the specific types of casting to be produced. The cupolas are charged by means of a hoist bucket or small skip hoist mechanisms.

3.3.1 Process Description, Cont'd:

The main types of moulding process are:

a) Green sand,

b) dry sand i.e. the "air-set" process,

c) shell type moulding, and

d) centrifugal casting, which is used to produce tube or pipe-type castings. Generally sand imported from Michigan is used, but in some cases local sand is also used.

After pouring the castings are allowed to cool and then taken to the "shake-out", which separates the castings from the mould and the core. The "burnt-out" sand is separated from the good sand, which is then returned to the sand reclaimer and mixed with new sand and the necessary moulding additives.

The "fillers" are then removed from the castings either by oxygen-gas torch or by diamond cutting wheel. The castings are rough ground and sand blasted if required, and then sent to the machine shop or directly to the customer.

3.3.2 Waste Characteristics:

Materials flow diagrams are presented in Figures No. 9 and 10 respectively for the cupola and electric furnace systems.

In terms of the total quantities of waste materials, the burnt-out sand and slag represent by far the largest proportion of waste materials ranging from 85 - 95% of the total. (See Table 10).

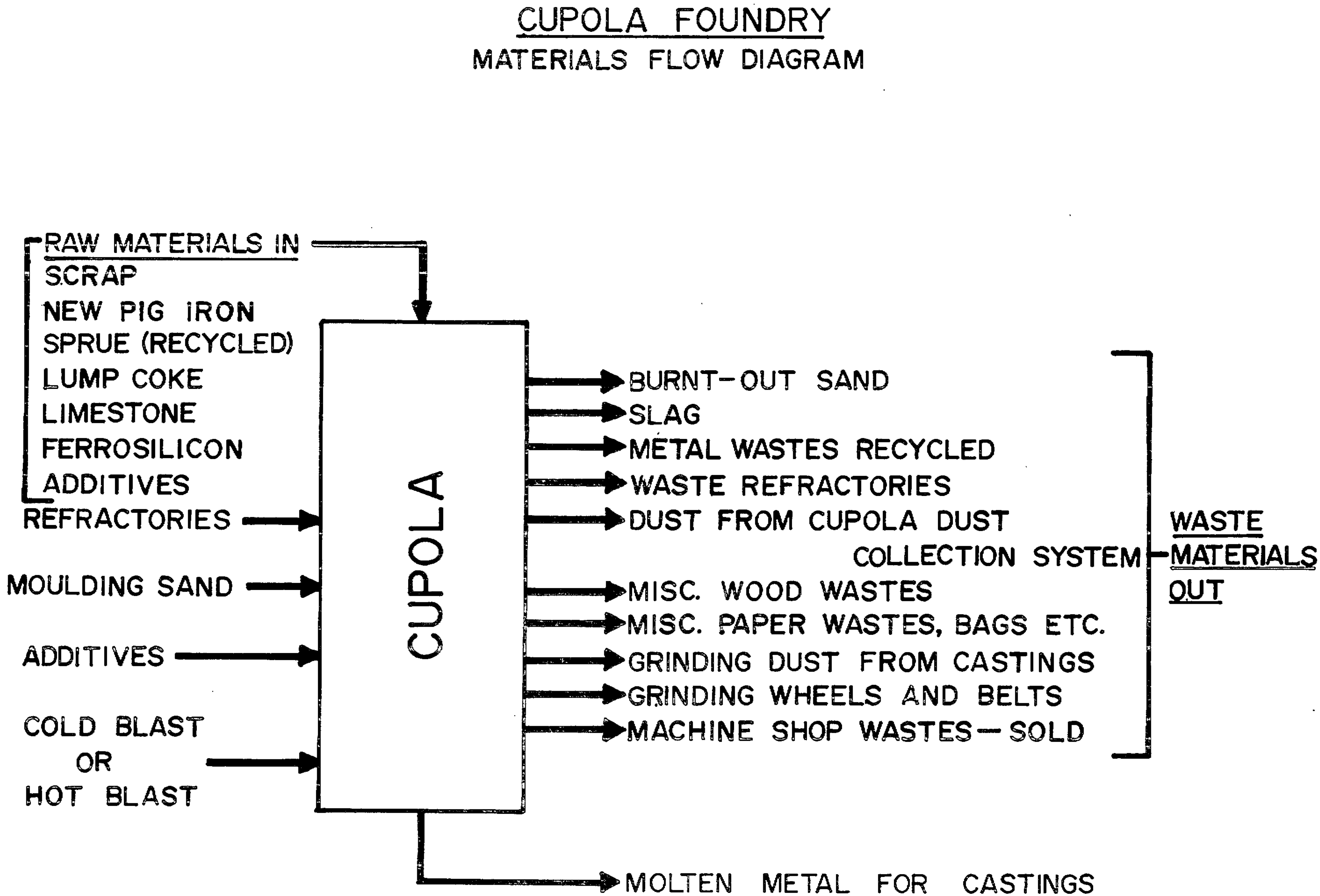

CUPOLA FOUNDRY
MATERIALS FLOW DIAGRAM
RAW MATERIALS IN
SCRAP
NEW PIG IRON
SPRUE (RECYCLED)
LUMP COKE
LIMESTONE
FERROSILICON
ADDITIVES
REFRACTORIES
MOULDING SAND
ADDITIVES
COLD BLAST
OR
HOT BLAST
CUPOLA
BURNT-OUT SAND
SLAG
METAL WASTES RECYCLED
WASTE REFRACTORIES
DUST FROM CUPOLA DUST
COLLECTION SYSTEM
MISC. WOOD WASTES
MISC. PAPER WASTES, BAGS ETC.
GRINDING DUST FROM CASTINGS
GRINDING WHEELS AND BELTS
MACHINE SHOP WASTES—SOLD
WASTE
MATERIALS
OUT
MOLTEN METAL FOR CASTINGS

FIGURE Nº 9

ELECTRIC FURNACE FOUNDRY

MATERIALS FLOW DIAGRAM

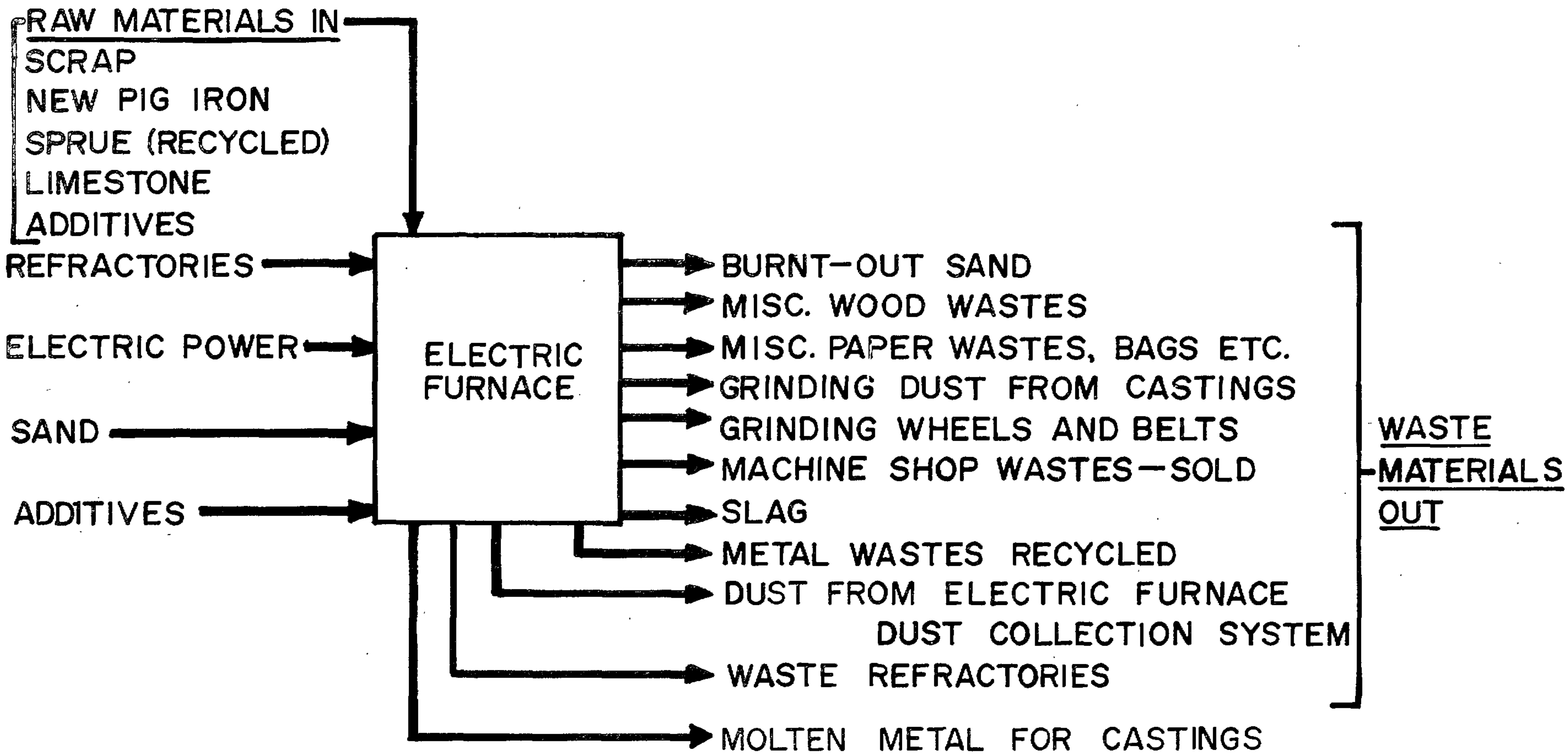


FIGURE Nº 10

TABLE 10

QUANTITIES OF WASTE MATERIALS

FROM FOUNDRIES

Descriptions	Range of Quantities lb/ton of castings
Slag	100 - 625
Burnt-out Sand	500 - 950
Refractories	1 - 25
Misc. Wastes	70 - 180
Total Solid Wastes	745 - 1540

3.3.2 Waste Characteristics, Cont'd:

If a dust collection system is in use on the cupolas or grinding operations, the dust so collected may amount to between 1 and 10% of the total mass of waste materials, depending on the specific plant operations.

Waste refractories and miscellaneous wood and paper wastes plus plant refuse are the remaining portion of the total plant solid wastes.

3.3.3 By-Product Recovery:

Within the foundry industry a limited degree of by-product recovery is practiced, mainly consisting of internal recycle of scrap metal within the foundry, i.e. the "filler" removed from the castings.

Any good sand is segregated from the burnt-out sand and returned to the sand reclaimer, where it is mixed with new sand and the necessary moulding additives. Generally most of the "air set" sand can be reclaimed.

Machine shop wastes consisting of steel turnings and cast iron turnings are sold to scrap collectors and recycled to steel mills. The total quantity amounts to approximately 3% of the annual production of waste materials.

In one instance a private contractor was producing a granular fill material by combining cupola slag and burnt-out sand. The economic feasibility of such an operation would depend entirely on the local conditions.

3.3.4 Disposal Methods:

The general practice for disposal of solid wastes in the foundry industry is by disposal on land, which may include using Company trucks to haul the waste to the local municipal landfill site, and using an outside contractor to collect the wastes for disposal at an MOE-approved landfill site.

The premises of individual plants are usually well utilized, leaving no space for disposal of solid wastes. Therefore all waste materials have to be disposed of off-site.

4. GROUP "B", METAL RECOVERY AND NON-FERROUS ALLOYING:

The list of industries in this general category, which are located in Ontario, is presented in Appendix I (P. 79). During the study programme site visits were made to seven of these: Alcan Canada Products Ltd., at Kingston; Anaconda Canada Ltd. and Canada Metal Co. Ltd. both at Toronto; Hudson Bay Diecastings Ltd., in Brampton; Metals and Alloys Co. Ltd., at Toronto; Federated Genco Ltd., at Burlington and Ratcliff's (Canada) Ltd., at Richmond Hill.

To satisfy the requirements of the study programme, it was decided to select three subcategories within this main grouping of industries. These subcategories were based on the various products made by the industry:

a) aluminum and aluminum alloys,
b) copper and copper alloys,
c) lead, tin and zinc alloys.

This particular division cuts across many of the companies in group "B", which have several operations in two or all three of the above mentioned subcategories. It appears that in this way sufficient information can be obtained, to provide a basis for a projection of the generalized waste production for each subcategory.

4.1 Aluminum and Aluminum Alloying:

4.1.1 Process Description:

The specific equipment and procedures employed by the industries for aluminum recovery and alloying will depend on the quality of raw materials used, i.e. characteristics of primary metal or different grades of scrap, and will also depend on the production capacity.

Several different types of furnaces are used to melt the metal charge. The reverberatory furnace is the most common among the large processors. This furnace consists of a charging well, where most of the impurities are removed, and of a holding section in which some additional fluxing may be performed and alloying metals are added.

4.1.1 Process Description, Cont'd:

When scrap is the main raw material, much alloying can be achieved by varying the ratios of different qualities of scrap.

The holding capacity of the larger and more common size of reverberatory furnace is usually in the range of 20-60 tons. The furnace may be operated with either oil or natural gas, requiring careful temperature control, depending on the quality of scrap and raw material processed. The finished product is tapped from the holding section, followed by batch or continuous casting.

Furnace cycles are normally in the range of 22-30 hr, depending on the characteristics of scrap metal charged. A typical cycle comprises (a) 12-24 hr charging, (b) 2-4 hr fluxing, chlorinating and skimming, (c) 4-6 hr tapping. If the company uses clean scrap or primary metal as raw material, the furnace cycle can be considerably reduced to the order of 2 hr.

Fluxing is done mainly in the charging well, and numerous compounds are used for this purpose including sodium chloride, potassium chloride and fluoride compounds. Removal of magnesium is generally accomplished by addition of chlorine, either to the charging well or more commonly to the holding section. The specific types and dosage of fluxing chemicals to be used will depend directly on the quality of the scrap. If clean scrap or primary metal is used, a mixture of chlorine and nitrogen will provide adequate fluxing.

The aluminum content of the scrap fed to the furnaces is generally in the range of 85-95% of the total metals present. This scrap is normally obtained from numerous sources, i.e. painted sidings, extrusions, pans, sheet stock, foil, turnings, scrap ingot and cans. Aluminum turnings obtained from the automotive industry will contain substantial concentrations of moisture and oil, and must therefore be processed in a rotary dryer before addition to the reverberatory furnace.

4.1.1 Process Description, Cont'd:

When scrap has a high ferrous content, i.e. from the automotive industry, the aluminum must first be separated in a sweat furnace, before it can be fed to the reverberatory furnace. Aluminum recovery of up to 60% has been found in the sweat furnace, depending on scrap source, while the remaining material can be sold to a scrap dealer.

For the usual grade of scrap charged to the reverberatory furnace, the recovery of finished product (aluminum or aluminum alloys) is in the range of 70-80% by weight of the scrap fed. When clean scrap or primary metal are used, this recovery is increased to the range of 90% and higher.

The usage of alloying metals and additives will depend entirely on the nature of the finished product manufactured in a specific plant. The range of alloying metals includes silicon, titanium, magnesium, manganese, copper and zinc, while other metals such as chromium, beryllium, and sodium may be added to improve the grain structure.

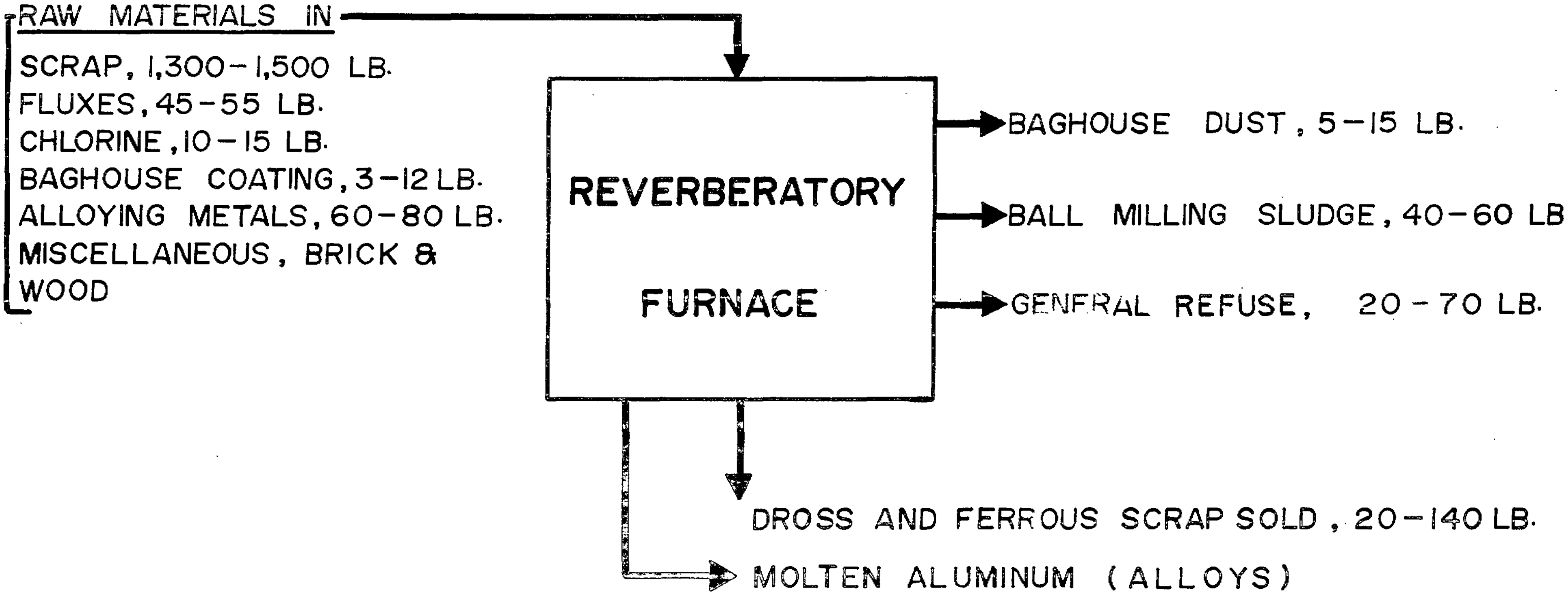
The finished product from the melt shop, i.e. ingots of aluminum or aluminum alloy, is further processed in a number of operations which include milling, extruding, hot rolling, cold rolling and annealing. Some of these operations are done on-site in other departments of the company, or they are undertaken by outside firms. Again depending on the range of consumer products manufactured, complete finishing operations may also include cleaning, coating and painting.

4.1.2 Waste Characteristics:

The range of consumption of the various raw materials and the production of wastes are presented in Figure No.11, for aluminum and aluminum alloying based on an average grade of scrap as source of aluminum, rather than clean scrap or primary metal.

ALUMINUM AND ALUMINUM ALLOYING

MATERIALS FLOW DIAGRAM PER
1,000 LB. OF FINISHED PRODUCT



* PLANTS EQUIPPED WITH BALL MILL PROCESS FOR DROSS RECOVERY AND RECYCLE HAVE MUCH REDUCED MASS OF DROSS FOR OUTSIDE SALE.

FIGURE № 11

4.1.2 Waste Characteristics, Cont'd:

The dross or skimmings from the furnace constitute the single largest source of waste material from this operation ranging from 4-10% of the total weight of scrap charged. Because of its high metal content, this material is normally sold to an outside contractor, or it is processed on the premises for metal recovery.

Most furnaces are equipped with baghouses for control of particulate emissions. However, a major problem is posed by the presence of the halogens in the exhaust gases resulting from the fluxing chemicals used. For this reason the bags are coated with nepheline syenite, which is a natural silica material, to protect against the halogens. Operating data indicate that in the range of 1-3 lb dust is collected per 1,000 lb finished product, while the baghouse coating amounts to approximately 3-12 lb per 1,000 lb finished product. The total mass of material removed from the baghouse is disposed of by landfill, and consists of approximately 20% carbonaceous material and the remainder inert compounds which include silica and some chlorides and alumina.

The item shown in Figure No.11 as general refuse will include waste lining material from the furnaces, floor sweepings, and miscellaneous wood boxes, old skids and general office refuse. The quantity range of 22-70 lb/1000 lb of finished product has been prorated on the basis of general plant data and the proportion of the total production represented by the aluminum and aluminum alloying operation.

4.1.3 By-Product Recovery:

Because of its relatively large volume and high metal content, the dross is a valuable waste material for by-product recovery. As such it may be sold to an outside contractor, or an industry may operate its own recovery process. The trend appears to be that larger companies will install their own recovery systems.

4.1.3 By-Product Recovery, Cont'd:

A wet milling process for metal recovery achieves a recycle of 30-40% of the dross, to be added to the charge to the reverberatory furnace. The resulting sludge cake is approximately 60-70% by weight total solids and contains in the range of 80% aluminum oxides and up to 20% aluminum. The sludge cake is disposed of by landfill. However, because of its high aluminum content, it could form the basis for the production of alum, which is used in waste water treatment for phosphorus removal and as primary coagulant chemical. It is noted that the presence of trace concentrations of heavy metals may pose a problem.

Another example of material recovery for reuse are the oil systems in aluminum rolling mills. Mineral oil is continuously filtered and any resulting waste oil is burned in their boiler. The spent filter medium is disposed of at a municipal landfill site. The contaminated emulsified oils are treated in the oily water treatment plant and the oil so recovered is also burned in the boiler.

It may be expected that further attempts will be made to recover valuable by-products from any remaining waste materials, as economics may justify or as environmental requirements dictate.

4.1.4 Disposal Methods:

The commonly used methods of disposal of the waste materials is by disposal on landfill sites. This would include the municipal landfill site, or disposal at an industrial landfill site. Particular attention must be given to ensure that the waste materials deposited will not cause any contamination of ground water through leaching or of surface waters through leaching and run-off.

In most cases industries employ outside contractors for haulage of the waste materials from their premises. If some room is still available on the local plant premises, the industry may wish to dispose of some inert solids, such as waste linings from the furnace. Generally, however, there is no space available on the plant premises for on-site disposal of wastes.

4.2 Copper and Copper Alloying:

4.2.1 Process Description:

A range of different types of furnace are used in the secondary melting processes for the production of copper and copper alloys, brass and bronze. This range includes oil-fired rotary furnaces, electric induction furnaces, oil-fired cylindrical reverberatory furnaces, and gas-fired crucible furnaces. Small shops will use indirectly heated crucible furnaces for the production of small heats of copper alloys. Larger producers will use electric induction furnaces, having capacities in the range of 4,000 - 14,000 lb.

These types of furnaces are generally used for the production of copper alloys, using clean copper scrap and refinery grade metal as the raw materials. Alloying metals include among others zinc, lead and tin. Using a charcoal cover, no fluxes will be added to the bath, because of the purity of the raw materials used. The melt cycle of a production furnace is in the range of 3-4 hr, and includes charging, melting, and addition of alloying metals. At the end of the melt cycle the molten product is poured into moulds using a continuous or semi-continuous method and the metal may also be cast into static moulds. Before the metal is poured, the static moulds are coated with a mould dressing, which includes a range of formulations, such as carbon black, or a mixture of oil, charcoal and proprietary additives.

The degree of further processing of the castings will depend on the overall range of products made by each company. In some cases the castings will constitute the finished product and will be sold to other companies for processing. If the manufactured products include wire, rod, tube, sheet or strip products, the industry will require different mills on the premises for the production of these materials. In addition the castings must be reheated prior to rolling and further processing. Annealing may also be required at various stages of the processing operations. When copper is annealed in a reduced atmosphere, chemical cleaning will not be necessary for scale removal. Brass must be pickled after annealing to remove the scale so formed.

4.2.1 Process Description, Cont'd:

For the reclaiming and refining of scrap metal, gas-and oil-fired furnaces of the reverberatory type are normally used, with the purified metal being cast into billets and cakes.

4.2.2 Waste Characteristics:

The materials flow diagram presented in Figure No. 12 shows the various raw materials used in the production of copper alloys and the resulting waste products. The copper scrap fed to the furnace may include reject castings and miscellaneous other scrap from the further processing of the finished castings on the plant premises. Individual plants will have variable ratios of scrap to refinery grade copper charged, and for this reason the respective ranges of quantities have been omitted from Figure No. 12.

Available data indicates the usage of clean scrap and a substantial proportion of refinery grade metal, with the total charge of copper and alloying metals to the furnace ranging from 1025-1050 lb per 1000 lb of castings. As a direct result the quantity of skimmings removed from the furnace is in the range of 2-3% of the total weight of metal fed to the furnace. The skimmings are sold to an outside contractor for metal recovery. This quantity of skimmings is substantially less than the 4-10% range of dross resulting from the production of aluminum alloys from an average grade of scrap. (See section 4.1.2, page 45).

Emission controls are now required for the exhaust gases from the furnaces and the casting shop, and these may consist of a baghouse or a venturi scrubber. The sludge removed from a scrubber system must be further concentrated, e.g. using a centrifuge, followed by air drying, before the waste material can be trucked to a landfill site. The solids removed from a baghouse can be collected and trucked away directly. Quantities in the range of 4-20 lb solids per 1000 lb castings have been reported. This waste material will contain in the range of 15-40% carbon, 20-40% zinc and trace concentrations of other alloying metals plus silica. The copper content will be low because of the very low volatility of this metal under furnace conditions.

COPPER AND COPPER ALLOYING

MATERIAL FLOW DIAGRAM

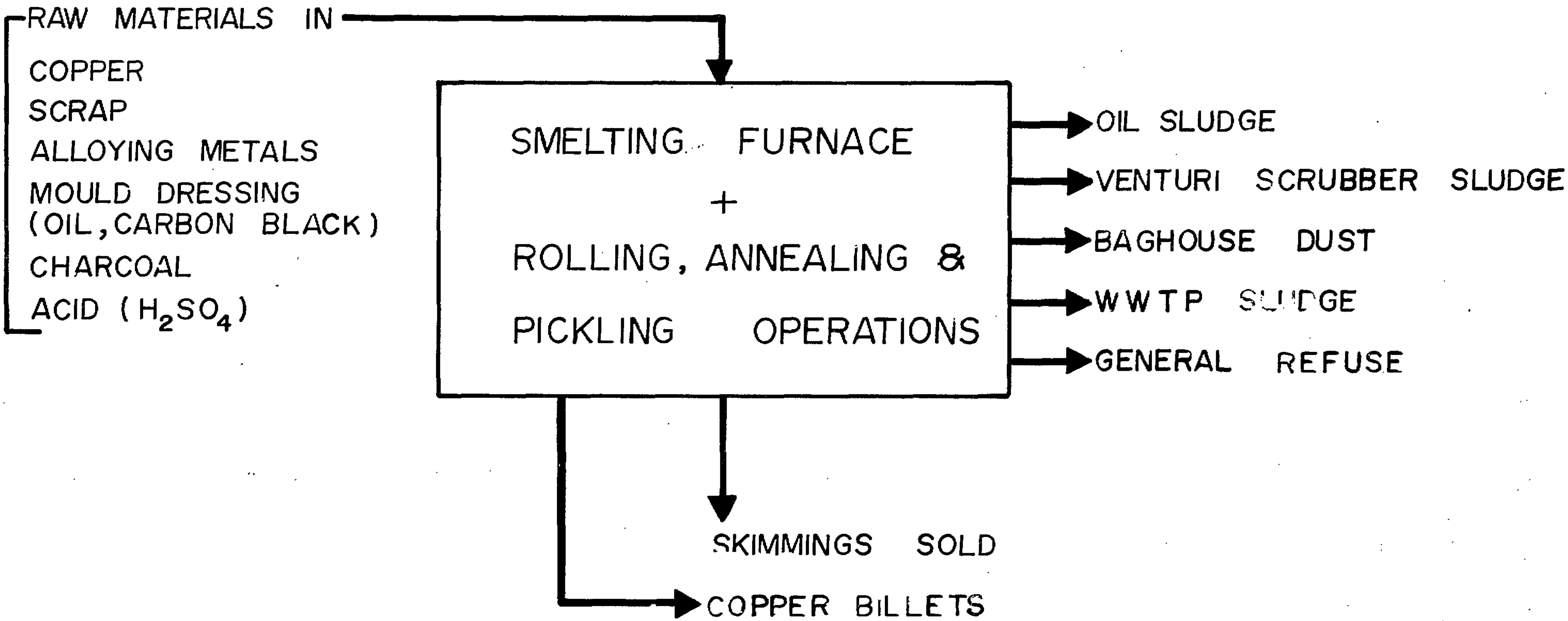


FIGURE Nº 12

4.2.2 Waste Characteristics,Cont'd:

An intermittent source of waste, which is not shown in Figure No. 12, is the insulating brick and ceramics used for the furnace lining. A melting furnace has a limited life, with 5000 hr given as a typical example. Between rebuilds small quantities of lining are wasted from the system as patching is required on a more or less continuous basis. A medium size furnace may require 2000 lb ceramics and 400 lb insulating brick as complete refractory lining.

If the plant includes hot and/or cold rolling mills, the lubricating oils will contaminate the process water and must be separated. This is normally achieved in an oil recovery plant, with the treated water being discharged to the sanitary sewer and the recovered oil being available for use as fuel. Any unusable oily sludge will require disposal.

When a pickling line is in operation, adequate treatment must be provided to meet the sanitary sewer by-laws, including control of pH and removal of heavy metals. Depending on the total flow of pickling waste water including spent acids, and the corresponding size of the treatment facilities, the process may include sludge dewatering, i.e. by vacuum filter. This would minimize the total volume of sludge to be disposed of. Available data indicates a range of 3-7 lb sludge per 1000 lb finished product. Gravity thickening of the liquid sludge may achieve solids concentrations as high as 9%, while vacuum filtration may increase that to the order of 40%. The sludge will contain significant quantities of zinc and copper hydroxides and traces of a number of other metals such as chromium and iron, depending on the nature of the finishing processes and the required waste treatment facilities.

General refuse will include wood, paper, steel strapping, floor sweepings and general office refuse and garbage, however, insufficient data was obtained to provide a realistic estimate of this waste item as a percentage pf the overall production.

4.2.3 Effects of Process Changes and Environmental Control Measures:

Under certain conditions of casting shop operation, it may be possible to minimize particulate emissions into the plant atmosphere. However, with the current trend to better environmental controls, both in-plant and exterior, all plants will require dust collection facilities if they are not already installed. As indicated in the foregoing section, the operation of a scrubber or baghouse will result in an increase in the total mass of waste solids for disposal in the range of 5-20 lb per 1000 lb of castings.

The requirement for treatment of contaminated process waste waters from rolling mills or a pickling line will depend on the implementation of municipal sewer by-laws for controlling waste water discharge to the sanitary sewer. It is likely that most plants located in major urban centres have already complied with such by-law limits, i.e. for pH, oil and heavy metals, by installing the necessary treatment facilities. If such treatment has yet to be provided, the data presented in the previous section will give an indication of the increased volumes of waste sludges requiring disposal, resulting from the operation of such treatment facilities. Referring to section 4.2.1, page 47. it may be noted that the total amount of waste sludge from the treatment of pickling waste water will be much reduced, if not completely eliminated, by using a controlled atmosphere on the annealing process. Thus the operating cost of the treatment plant and the cost of waste disposal will be much decreased.

4.2.4 By-Product Recovery:

Normal operating economics dictate recycle to the melt shop of all scrap metal originating in the various processing areas of the plant, including reject castings and any scrap from the hot and/or cold rolling mills.

4.2.4 By-Product Recovery, Cont'd:

The skimmings removed from the furnaces, amounting to 2-3% of the charge, are usually sold to an outside company for metal recovery and refining. Available information indicates that the skimmings contain up to 55% free metallics, and in the order of 35% metal oxides. In the recovery process about 35% of the metal oxides are recovered as pure metallics.

Waste oils are generally treated, either by filtration or by removal through an oil recovery plant, to utilize their fuel value and at the same time to eliminate a waste disposal problem.

The waste products presently hauled to a disposal site, including scrubber sludge, baghouse dust or waste treatment plant sludge, should possibly be stockpiled in a specific location, to facilitate retrieval of this material at a future date, for recovery of the metals contained in these waste materials. Current economics certainly do not justify recovery of these metals present in relatively small concentrations. However, as availability of raw materials may decrease in the future, present disposal sites should be well managed to serve as potential sources of raw material in the future. At that time, necessity may prompt the development of suitable process technology for the economical recovery of the metals contained in the waste materials.

4.2.5 Disposal Methods:

In most cases the industries employ outside contractors for trucking the waste materials to a landfill site. These will include the various waste sludges resulting from dust collection and waste water treatment facilities as well as general refuse including brick from furnace patching or relining.

Again because of the heavy metals present in the waste sludges, particular attention must be given to ensure that no contamination of ground water or of surface waters can possibly result from the waste disposal at the landfill site.

4.2.5 Disposal Methods, Cont'd:

Ideally the operation of the disposal site is managed in such a way that future access may be provided for potential retrieval of the waste materials for recovery of the heavy metals (see the comment under section 4.2.4).

4.3 Lead, Tin and Zinc Alloying:

4.3.1 Process Description:

The refining of lead and the production of lead alloys require different types of furnace, depending on the quality of raw materials used (i.e. various grades of scrap v. refinery metal) and the range of finished products desired.

The lead blast furnace or cupola is similar to those used in the iron foundry operations. The blast furnace is used primarily for the initial reclamation of lead from a wide range of scrap and in this capacity serves also as a convenient recycling facility for drosses and miscellaneous waste products originating in other areas of a lead alloying operation. The charge to the blast furnace will include scrap lead, scrap cast iron as a small percentage of the total charge, as well as limestone and coke. A significant percentage of slag produced in the blast furnace operation, ranging from 10-80%, is recycled directly to the charge for the next blast furnace run.

Pot-type furnaces are used for remelting, alloying and refining processes. These furnaces are usually gas fired and range in size from as low as 1-ton capacity to as high as 50 tons. Some of the more common alloying elements are antimony, tin, arsenic, copper and nickel. The finished product (billets) can be further processed, e.g. in extrusion presses, or for the manufacture of solder or boat keels.

4.3.1 Process Description, Cont'd:

The production of lead oxide represents a special phase of the lead alloying industry, and requires the use of the Barton process. Battery lead oxide with a 20% concentration of finely divided free lead is produced by the Barton process, in which the molten lead flows by gravity from a melting pot into a kettle equipped with paddles. Air is drawn through the kettles by fans which are located on the air outlet side of a baghouse. The lead oxide thus formed is carried by the air to the baghouse from which it is collected and delivered by screw conveyor to storage.

If 100% PbO is required as a finished product, a calcining furnace is operated in series with the Barton pot. Using pure lead metal as raw material, no fluxes or emission control equipment will be required.

Tin is being produced by the more modern extraction processes from ore concentrates in such purity that treatment in a reverberatory furnace will yield a metal containing at least 99.8% tin. Electrolytic refining of this metal will yield a tin content of 99.98%. It appears that tin is not recovered on a commercial scale from metal scrap.

In the secondary zinc-melting processes a number of different furnace types are used which include crucible, pot, kettle, reverberatory and electric induction furnaces, for alloying casting and galvanizing operations. Sweat furnaces are used for reclaiming zinc from higher melting point metals.

Secondary refining of zinc is normally performed in retort furnaces, which are also used for the production of zinc oxide by vaporizing and burning zinc in air.

The plants visited during this study programme generally used refinery grade zinc or the pure metal as raw material. When scrap is used as a raw material, it may be necessary to process it initially in a reverberatory furnace, before the processed scrap can be charged to the retort furnace, depending on the purity of the scrap.

4.3.2 Waste Characteristics:

The quantities of solid wastes and sludges generated in the various phases of lead and lead alloying operations will depend directly on the nature of each of these stages. As may be expected, the largest source of waste products is the blast furnace operation for the initial reclamation of lead from scrap materials. To generate 1000 lb of finished product, the total charge to the furnace may amount to in the order of 1900 lb. Depending on the quality of the scrap a subtantial portion of the total amount will include moisture and combustibles, which will be discharged to the atmosphere.

Any dust collected in the dust collection system will be recycled to the furnace and may amount to 50 lb/1000 lb of product. Slag production may be in the range of 100-150 lb/1000 lb of product, of which substanstial portions (in the range of 80%) are recycled to the blast furnace, the actual percentage dependent on its quality. The leftover portion must be disposed of on a landfill site and will contain significant proportions of iron oxide, silicon oxide and calcium oxide with trace quantities of lead and other heavy metals, depending on the composition of the scrap charged to the furnace.

In the manufacture of lead oxide and lead alloys, using blast furnace product as raw material or pure lead from other sources, no process wastes will be generated for disposal, as any skimmings from the furnaces and dust collected from the baghouse are all recycled to the blast furnace. If an industry has no blast furnace on the premises, these materials will be sold to an outside contractor. The quantity of skimmings collected from the furnace is usually in the range of 1-3% of the weight of metal charged to the furnace.

In the processing of zinc, the generation of waste materials will be directly related to the quality of raw materials used. When zinc alloys are produced from pure metals, the production of dross will be in the range of only 5 lb/1000 lb of zinc alloy. This is normally sold to a recycler. Similarly when zinc is produced for diecasting, again using pure metal or high zinc dross as raw material, the quantity of skimmings will be rather small and in the range of 4 lb/1000 lb of product. This is normally sold to a recycler and no other wastes are generated in the process. With these two types of processes it has proven unnecessary to install dust collection facilities, since the furnaces can be operated at low enough temperatures, to prevent vaporization of significant quantities of zinc.

In the zinc diecasting process significantly higher quantities of dross are produced, in the range of 22 lb/1000 lb of castings, even when refinery grade zinc alloy is used as raw material. This may be the result of the specific operating conditions, which necessitate a substantial rate of recycle of poured metal to the furnace, after trimming the castings. The dross has a high zinc content and is sold, no other wastes are produced, because again no dust collection system is necessary.

The materials flow diagram presented in Figure No. 13 illustrates the effects of using scrap as raw material on waste characteristics. Depending on the grade of scrap used, prepurification may be required in a reverberatory furnace complete with fluxing, and the necessary fume scrubber installed over the charging well. The liquid sludge removed from the scrubber is not recycled and is therefore disposed of on a landfill site and contains about 65% on a dry weight basis zinc hydroxide. Skimmings removed from the furnace may amount to 15% of the charge and can be sold for zinc recovery. The production of zinc dust in a retort furnace will result in about 80 lb skimmings per 1000 lb finished product, which can also be sold for zinc recovery. The exhaust gases released from the zinc condenser must pass through a baghouse, to remove any particulates in the form of an impure zinc oxide. This amounts to approximately 16 lb/1000 lb zinc dust produced and is also sold for recovery. The general refuse shown in Figure No. 13 will include spent lining from the furnaces and also floor sweepings, as well as wood, boxes, old skids and general office wastes.

PRODUCTION OF ZINC DUST FROM SCRAP

MATERIALS FLOW DIAGRAM

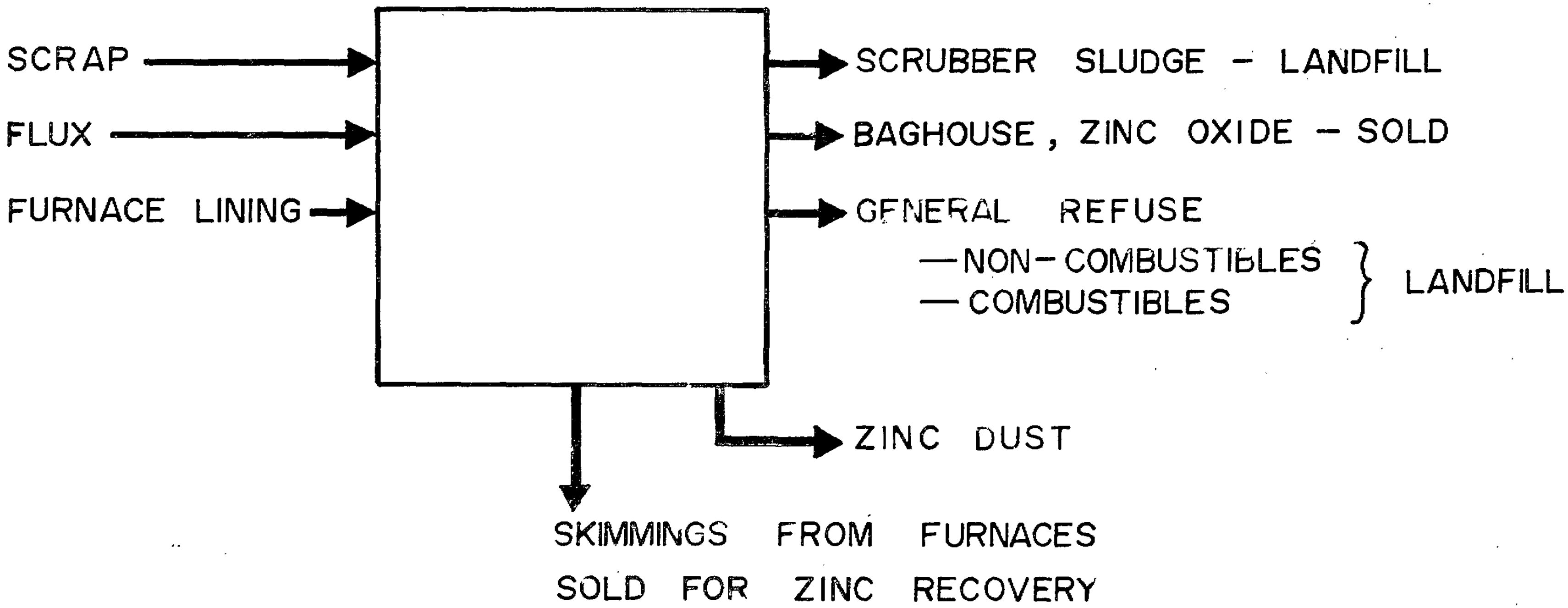


FIGURE Nº 13

4.3.3 Effects of Process Changes and Environmental Control Measures:

As a result of the recent public concern about lead as a health hazard, increased control of lead emissions would increase the quantities of lead particulates being removed from the exhaust gases. Presently the materials collected from baghouses are already recycled for metal recovery or sold to an outside contractor. Thus increased efficiency of the existing dust collection systems would simply increase the quantity of lead particulates for recycle. If however the refined emission control systems would incorporate wet scrubbers, a process would have to be provided for concentrating and dewatering the sludge prior to recycling it for lead recovery. The possibility exists that such a liquid process would leave a waste sludge stream for ultimate off-site disposal.

4.3.4 Disposal Methods:

The foregoing discussion has shown that only a few waste materials will require disposal at a landfill site: a) slag from the lead blast furnace, b) scrubber sludge from the zinc reclamation furnace and c) general refuse All other solid wastes are recovered, either for sale outside for metal recovery, or in-plant to a recovery process, i.e. blast furnace for lead or ball mill for zinc. Any waste products from the ball mill can be sold outside.

As outlined under the previous sections on disposal methods for aluminum and copper alloying, any disposal on land must fully satisfy the waste management criteria for prevention of contamination of ground water or surface water through leaching and/or runoff. The general refuse would likely be satisfactory for disposal at a municipal landfill site.

5. GROUP "C", METAL FINISHING/COATING:

Recently, Environment Canada completed a survey of the Canadian Metal Finishing Industry, which included approximately 300 plants in Ontario. It was agreed that it would not be necessary for the purposes of the current study programme to reproduce a complete listing of the Ontario Industries in this broad category, since all these companies are already on file with Environment Canada, resulting from the earlier survey.

For the current study programme site visits were made to nine industries in this category: American Motors (Canada) Ltd., Brampton; Baycoat Ltd., Hamilton; Hahn Brass Ltd., New Hamburg; Houdaille Oshawa Ltd., Oshawa; Northern Electric Co. Ltd., London; Rockwell International of Canada Ltd., Chatham; The Steel Co. of Canada Ltd., Canada Works, Hamilton; Inglis Ltd., Toronto; and International Harvester Co. of Canada Ltd., at Hamilton. Hudson Bay Diecastings Ltd., Brampton, which was visited for Group "B", really belongs in this category.

A similar division into subcategories was made as described under Section 4 for Group "B", to simplify the discussion and analysis of the waste characteristics. The following process groupings were selected as a basis for the indicated division: a) mechanical processes; b) physical; c) chemical and d) electrolytic. Even more than for Group "B", this division into the above subcategories cuts across most companies in Group "C".

A greater problem turned out to be the general lack of information from the company records, to permit a meaningful correlation of quantities of waste generated and unit production from each area of the company, segregated according to the above division into subcategories.

This experience illustrates the limitation of the current study programme, as it was based solely on the available information supplied by the various industries from their own operating records. A detailed in-plant study would be required to make an accurate assessment of the waste quantities and characteristics originating in the various production areas from each company, on the basis of which a projection can be made for the respective subcategories of this group of industries.

5. GROUP "C", METAL FINISHING/COATING, Cont'd:

A major problem,encountered in attempting to prepare a general projection of waste characteristics for this group of industries, is the wide variation of types of products made in the various subcategories, and consequently in the required manufacturing processes. Since most of the processes used in these industries are "wet", the degree of treatment (or absence of such) of the resulting waste waters will have a significant effect on the volumes and characteristics of wastes requiring land disposal. The location of the industry combined with negotiated surcharge agreements with the municipality vs full compliance with the municipal sanitary sewer by-laws will also have a major bearing on the quantities of waste requiring land disposal.

5.1 Process Description:

A rather comprehensive summary description of the various metal finishing operations is given in Environment Canada report EPS3/WP/75/2, review of the Canadian metal finishing industry. For this reason the following discussion in this section will be in point form only, to prevent unnecessary duplication of the material presented in that report.

The mechanical finishing processes include sand blasting, tumbling, vibratory finishing, polishing, and buffing. One or several of these may be in use in a given shop at one or more stages in the production sequence. Generally some abrasive compound or mixture of compounds will be used along with air or water as a carrier. The experience gained during the study programme showed polishing and buffing as dry operations, in each case equipped with a dust collection facility.

The most widely used physical process of metal finishing is galvanizing or hot-dip zinc coating. The metal must be pretreated with alkaline cleaners or with acid pickling and cleaning.

5.1 Process Description, Cont'd:

A number of processes are included in the following category of chemical processes for metal finishing: Chemical cleaning, vapour degreasing, soak cleaning, and pickling. Various chemical processes are also used to strip faulty coatings off work pieces, to permit salvage. Phosphating imparts a stable non-metallic surface to the work piece, primarily to improve the corrosion resistance, e.g. under paint, or to provide a base for waxes and oils. Chromating is also used to produce a corrosion resistant coating which at the same time is a good base for painting. Other chemical finishing operations include electrolytic plating, bright dipping and metal coating.

Electro-cleaning and anodizing are included in the electrolytic processes. The process of electro-cleaning is one of the final stages prior to electroplating. Depending on the specific sequence of operations in the plating shop, electro-cleaning may be used at one or several stages. Anodizing is used primarily for aluminum, while zinc anodizing is done on a limited basis.

The primary electrolytic process is electroplating, which is used in a large number of shops, and in a wide variety of sequences. One of the more common plating sequences is copper-nickel-chromium. However, the specific sequence used in a plating operation will depend on the raw material to be used and the range of products to be manufactured in the plant complex. Generally the plating operation forms part of an overall manufacturing complex, instead of being an independent shop.

As indicated previously, the characterization of industrial wastes requiring land disposal from the metal finishing industry is complicated by the variety of processes occurring within the whole operation, including mechanical, physical or chemical and electrolytic processes. Because of the sequential nature of such a finishing operation, it is simply impossible to arrange a typical shop into separate blocks, corresponding to the various types of processes, which would facilitate any such waste characterization programme.

5.2 Waste Characteristics:

The major objective of this study was to correlate the quantities of industrial waste for land disposal with a unit production rate. A problem in this connection in the metal finishing industry is the absence of a universally accepted unit of production. Some companies expressed their production in terms of square footage of plated metal, while others record production on a weight basis, as pounds or tons per unit time. Still another method simply records the total number of pieces plated. The particular method of expression seems to depend on the configuration of plated parts.

Possibly a more suitable baseline for developing uniform production data may be unit mass of metal plated out (deposited), e.g. anode nickel or copper, or chromic acid. The total quantity of wastes generated could then be correlated to this new unit mass.

It would then be necessary to develop a similar modified basis of production rate for the other finishing operations, since all such processes involve the surface of the metal parts to be treated. In some shops it may be possible to work on the assumption that all production passing through the plating line has also passed through all the various other metal finishing processes in the same shop. However it is realized that such an ideal situation will generally not occur, because of the normal variability of the production sequences, caused by variations of product types and quality requirements.

The characteristics of wastes (e.g. sludges or spent chemical solutions) will depend on the degree of recycle of chemical solutions and of rinse waters achieved in the operation, and will also be influenced by the requirements for treatment of the process wastewaters. Discharge to the storm sewer makes treatment mandatory, while wastewater discharge to the municipal sanitary sewer will involve the local municipal by-law. As a direct result of tighter by-law enforcement and of more stringent effluent quality criteria, the quantity of wastes for land disposal from the metal finishing industry will increase.

5.2 Waste Characteristics, Cont'd:

The data presented in the following section will illustrate the relative scarcity of information for this industrial waste characterization study, which could be obtained from the industry's operating records. It will become clear that this information does not provide a proper basis for a generalized projection of waste characteristics related to unit production.

5.2.1 Mechanical Processes:

The metal finishing industries visited during this study programme had a range of mechanical processes in use, including polishing and buffing, tumbling and vibratory finishing. However, data on waste characteristics could only be obtained from plant records for several of the polishing and buffing operations. In each case the facility included cyclone and baghouse dust collection systems, to control particulate emission. The quantity of material removed from the dust collection facilities ranged from approximately 5-40 lb/1000 lb of finished product. In terms of total quantity these amounts were approximately equal to the respective total amounts of buffing and polishing compounds used in the various operations. This would seem reasonable, as the amount of metal actually removed from the work piece would be relatively small compared to the mass of abrasive compounds used. The actual usage of buffing and polishing compounds will depend on the specific nature of the polishing and buffing operation and the quality of the work piece.

The solid wastes resulting from these operations were generally disposed of as part of the general plant refuse by haulage to a sanitary landfill site.

5.2.1 Mechanical Processes, Cont'd:

Where liquid wastes resulted from the mechanical finishing operations, such as tumbling or vibratory finishing, they were part of the total wastewater flow from the shop, and consequently no separate data could be obtained for the development of waste characteristics from these operations.

5.2.2 Physical Processes:

One of the plants visited during this study programme has a hot-dip zinc galvanizing line in operation. Available data showed no quantities of solid wastes being generated in this process. The production of any solid wastes (mainly dross) will be minimal, by ensuring that the coating pot is well covered to prevent the formation of zinc oxide.

5.2.3 Chemical Processes:

Most of the plants visited during this survey have one or more chemical processes included in the sequence of finishing operations. These include phosphating, chromating, pickling and cleaning, and painting.

One plant with phosphating and painting operations discharges the small volumes of process wastewaters to the sanitary sewer, while the paint and chemical sludge and also the miscellaneous oils and spent solvents are hauled to an off-site incinerator.

When the general plant processes include pickling, the process wastewater must be treated, prior to its being discharged to a sanitary sewer. A number of plants visited during this survey have such treatment facilities in operation. Depending on the specific processes used, treatment would be provided for pH correction, chromium reduction, and precipitation of heavy metals.

5.2.3 Chemical Processes:

When necessary, the treatment will also include cyanide destruction. Sludge dewatering is normally provided by vacuum filtration and in isolated cases by pressure filtration.

Available data indicate a rate of sludge production in the range of 7 lb/1,000 lb of finished product, with a dry solids content in the range of 25 to 50 per cent. These dewatered sludges are normally disposed of by landfill. The range of heavy metals present in the sludge will include all the metals processed in the finishing operation. Therefore care must be taken to ensure that leaching of hazardous metals such as copper, chromium and zinc into the ground water or surface water is prevented.

One plant is currently in the process of installing the required treatment facilities to comply with the municipal by-law criteria, by providing pH control and precipitation of heavy metals. The settled sludge will be further dewatered by centrifuge, which is expected to produce a 20 percent solids cake for land disposal. It is expected that in the range of 15 to 20 lb of this dewatered sludge per 1,000 lb finished product will be generated for land disposal. This compares with a current rate of sludge production of 0.2 lb/1,000 lb finished product, while the process waste waters are discharged directly to the sanitary sewer.

Another plant neutralizes its acid rinse waters with sodium hydroxide before discharge to the sanitary sewer, while the spent pickle liquor is used by a neighbouring industry for pH control of their alkaline waste waters. This illustrates the possibility under certain circumstances of solving two waste water treatment problems jointly, with lower total cost, than the two separately.

5.2.3 Chemical Process, Cont'd:

One company segregates its waste solvents and oils, for reclamation by an outside contractor. The possibility of on-site reclamation facilities is being considered.

5.2.4 Electrolytic Processes:

As observed during this study, treatment of process wastewater was provided at those plants where electroplating was a major constituent of the finishing operations. The treatment facility included destruction of cyanides, reduction of chromium, control of pH and chemical precipitation of the heavy metals. The treated effluent was usually discharged to the local sanitary sewer. Sludge dewatering was achieved by vacuum filtration, with the filter cake being trucked to land disposal, as part of the general plant refuse.

Only one plant had data on the quantities of filter cake correlated with the unit production. This indicated a range of 7 lb sludge/1000 lb finished product. However, no information was available on the percent moisture in the filter cake or its chemical composition.

Another source of solid wastes is the spent filter media from the continuous filtration of plating solutions. Available information indicates an approximate rate of usage of 20 lb filter media/1000 lb finished product, which removes approximately 8 lb contaminants/1000 lb product from the plating solutions. The spent filter media with contaminants is normally disposed of on a landfill site along with the general plant refuse.

Batch dumps of acid or alkali are in some cases stored and then bled to the waste treatment facility, or are allowed to flow to the treatment plant as a slug.

5.2.4 Electrolytic Processes, Cont'd:

Spent plating solutions may be sent out for reconditioning, or trucked to deep-well disposal. One plant indicated a range of 2-3 lb spent plating solution per 1000 lb finished product requiring deep-well disposal.

The principle of in-plant recycle was illustrated in one instance, where spent acid from the plating line was used as pickling acid within the same plant. The spent pickle liquor was transported to a neighbouring company, for their use in pH correction of alkaline wastewaters.

6. FUTURE TRENDS:

Increased public concern for maintenance of adequate environmental quality standards will impose greater restrictions on the current land disposal practices of industrial wastes. This will include tighter control on the operation of landfill sites and disposal wells. Of major concern is the positive prevention of leaching of hazardous metals from disposal sites.

To keep future increases of disposal costs to a minimum, the iron and steel industries must develop alternate uses for some of their present waste products, as these industries are presently the major producers of solid wastes for land disposal.

The practice of recycling and reclamation of valuable metals from waste materials should continue. For this reason it is recommended that the management of disposal sites is changed to a stockpiling operation, to permit retrieval of valuable metals at a future date from a single source of albeit low grade raw material. However at that time economical technology may have been developed to permit efficient recovery of metals from these sources.

Implementation of higher standards for air and water quality control, relative to present criteria, may require the addition of secondary treatment processes. In certain instances such additional treatment may leave a residue of sufficiently different quality that it cannot be included in present in-plant recycling schemes, and as a result will complicate waste disposal requirements. In such a situation a careful evaluation must be made of the benefits of such increased treatment vs the problems caused by the disposal of the resulting residue.

In the metal finishing industry improved environmental controls will involve reduction of water pollutants and industrial wastes for land disposal. This can be achieved by a combination of water recycle and reuse, chemical recovery and sufficient wastewater treatment. Such a programme will involve substantial capital investment as well as daily operating costs.

6. FUTURE TRENDS, Cont'd:

However, the direct benefits will include reduced water consumption, lower consumption of chemicals and lower cost of disposal of any remaining wastes.

For many of the smaller shops such a programme of environmental controls will be economically unjustifiable. Present experience indicates that for the smaller shops the alternative to adequate waste treatment and environmental control is closing down the plant. Continuation of this trend would leave only the larger companies in operation and would perhaps see the growth of some of the smaller ones which receive work on a jobbing basis from other companies.

The technology is available for achieving satisfactory environmental controls, however, many companies do not have the necessary funds or the competent personnel for ensuring the satisfactory and reliable operation of any control systems.

As a first step toward improved control of industrial waste disposal, it is recommended on the basis of this study programme, that the appropriate regulatory agencies require a simple programme of record keeping on the quantities of waste materials, the frequency of hauling and the location of the disposal site. These records should include on a regular basis an analysis of the composition of the waste material disposed of.

L.S. LOVE AND ASSOCIATES LTD.

APPENDIX I:

ONTARIO FERROUS FOUNDRIES

Auto Specialties Mfg. Co. Canada Ltd.,
614, Tecumseh Road East,
Windsor

Benn Iron Foundry Limited,
P.O. Box 130,
Wallaceburg

Canada Iron Foundries Limited,
1010, Talbot Street,
St. Thomas

Crawford Machine and Foundry Ltd.,
100 Wilson Street,
Woodstock

Domestic Foundry Ltd.,
1595, Crawford Avenue,
Windsor

Eureka Foundry Division,
Kelsey-Hayes Canada Ltd.,
Woodstock

Ford Motor Co. of Canada Ltd.,
2780, Riverside Drive, East
Windsor

Homes Foundry Ltd.,
200, Exmouth Street,
Sarnia

Kent Foundry Limited,
Leeson Drive,
Chatham

Marshall Foundry
940, Assumption Street,
Winsdor

Standard Induction Castings Ltd.,
3827, Peter Street,
Windsor

Wells Foundry Limited,
1250, Florence Street,
London

George White and Sons Co. Ltd.,
P.O. Box 129,
London

Ex-Cell-O Corp. Ltd.
London

ONTARIO FERROUS FOUNDRIES

Anthes Eastern Limited,
P.O. Box 1009,
St. Catharines

Babcock & Wilcox Canada Ltd.,
Coronation Boulevard,
Galt

Bibby Foundry Limited
Beverly Street,
Galt

Brown Boggs Foundry & Machine Co. Ltd.
Sherman Avenue North,
Hamilton

Canada Iron Foundries Limited,
P.O. Box 633,
Hamilton

Canada Valve Limited,
36, Water Street South,
Kitchener

Canadian Blower & Forge Co. Ltd.,
Woodside Avenue,
Kitchener

Crowe Foundry Limited,
P.O. Box 460,
Hespeler

Cunningham Foundry & Machine Co. Ltd.,
Berryman Avenue,
St. Catharines

Dominion Foundries and Steel Ltd.,
P.O. Box 460,
Hamilton

J.R. Fergusson Co. Ltd.,
1, Hope Street,
Dundas

Foster Wheeler Ltd.,
P.O. Box 1007,
St. Catharines

Galt Malleable Iron Ltd.,
P.O. Box 396,
Galt

ONTARIO FERROUS FOUNDRIES

Hartley Foundry Division,
McLean-Bessemer Ind. Ltd.,
Brantford

William Hastings Foundry,
219, Freerick,
Stratford

The Indiana Steel Products Company of Canada Ltd.,
Kitchener

International Harvester Co. of Canada Ltd.,
208, Hillyard Street,
Hamilton

International Malleable Iron Co. Ltd.,
208, Hillyard Street,
Hamilton

Kondu Manufacturing Company Ltd.,
P.O. Box 247,
Preston

Lake Foundry and Machine Co.,
Div. of R.T.A. Industries Ltd.,
Queen Elizabeth Way,
Grimsby

Lincoln Foundry Ltd.,
P.O. Box 98,
St. Catharines

Massey-Ferguson Industries
Brantford,

McCoy Foundry Company Limited,
258, Catharine Street North,
Hamilton

McKinnon Industries Ltd.,
St. Catharines

The Niagara Foundry Company Ltd.,
757, Buttrey Street,
Niagara Falls

Rockwell Manufacturing Co. of Canada Ltd.,
100, Crimea Srreet,
Guelph

Snowdons General Castings Co. Ltd.,
315, Gray Street,
Brantford

ONTARIO FERROUS FOUNDRIES

Stanton Pipes (Canada) Ltd.,
Hamilton

Welland Iron and Brass Ltd.,
130, Niagara Street,
Welland

Welmet Industries Ltd.,
Welland

Central Foundry
Hespeler

Galt Malleable Iron Ltd.,
Paris

Philip Gies Fdy. Ltd.,
Kitchener

ONTARIO FERROUS FOUNDRIES

Canada Iron Foundries Limited,
169, Eastern Avenue,
Toronto

Canada Iron Foundries Limited,
324, Cherry Street,
Toronto

The Canada Metal Company Limited,
721, Eastern Avenue,
Toronto

Crouse Hinds Co. of Canada Ltd.,
1160, Birchmount Street,
Scarborough

Grinnel Company of Canada Ltd.,
244, Dundas St. West,
Toronto

John T. Hepburn Ltd.,
914, Dupont Street,
Toronto

Tomlinson Industries Ltd.,
352, Front Street East,
Toronto

Toronto Foundry Limited,
1884, Davenport Road,
Toronto

ONTARIO FERROUS FOUNDRIES

Orangeville Foundry,
Orangeville

Otaco Limited,
Orillia

C.S. Castings Ltd.,
Orillia

Walkerton Foundry,
Walkerton

Barber Turbine and Foundries Ltd.,
Meaford

Black-Clawson Kennedy Ltd.,
Owen Sound

Dorr-Oliver-Long Ltd.,
Orillia

Fahralloy Canada Ltd.,
Plant #1,
Orillia

Fahralloy Canada Ltd.,
Plant #3,
Orillia

J.A. Wotherspoon Ltd.,
Oakville

ONTARIO FERROUS FOUNDRIES

REGION 5

Beach Foundry Limited,
Ottawa

Bowmanville Foundry Co. Ltd.,
Bowmanville

Cornwall Brass & Iron Foundries Ltd.,
Cornwall

Findlays Limited,
Carleton Place

Fittings Limited,
135, Bruce Street,
Oshawa

H. Imbleau and Son Ltd.,
Renfrew

International Hardware Co. of Canada (1963) Ltd.,
Belleville

Lawson, McMullen,Victoria Ltd.,
Ottawa

The Ontario Malleable Iron Co. Ltd.,
Propect Street,
Oshawa

The Ottawa Foundry Co. Ltd.,
1995, Merivale Road,
Ottawa

Stephens - Adamson Mfg. Co. of Canada Ltd.,
Belleville

Stittsville Foundry,
120, Orville Street,
Stittsville

ONTARIO FERROUS FOUNDRIES

Port Arthur Shipbuilding Co.,
Port Arthur

Woodside Machinist and Foundry Co.,
173, Manitou Street,
Port Arthur

ONTARIO FERROUS FOUNDRIES

The Algoma Steel Corporation Limited,
Sault St. Marie

The Cobalt Foundry Limited,
Cobalt

Neelon Steel Limited,
Foundry Street,
Sudbury

Soo Foundry and Machine Co. Ltd.,
Sault St. Marie

The Wabi Iron Works Ltd.,
P.O. Box 20,
New Liskeard

Wabi Iron Works Ltd.,
Sudbury

List of Metal Recovery and Non-Ferrous Alloying Industries

1) Alcan Canada Products Ltd., Kingston, Ontario.
2) Anaconda Canada Ltd., Toronto, Ontario.
3) Canada Metal Co. Ltd., Toronto, Ontario.
4) Cominco Ltd., Mississauga, Ontario.
5) Cramco Alloy Sales Ltd., Toronto, Ontario.
6) Federated Genco Ltd., Burlington, Ontario.
7) Federated Genco Ltd., Toronto, Ontario.
8) Hewitt Metals Corporation Ltd., Windsor, Ontario.
9) Hudson Bay Diecasting Ltd., Brampton, Ontario. *
10) The Ingot Metal Co. Ltd., Toronto, Ontario.
11) Metals & Alloys Ltd., Toronto, Ontario.
12) Ram Refined Alloys Ltd. Toronto, Ontario.
13) Ratcliff's (Canada) Ltd. Hamilton, Ontario.
14) Tonolli Co. of Canada Ltd. Mississauga, Ontario.
15) Toronto Refineries & Smelters Ltd. Toronto, Ontario.
16) Total Metal Recovery Services Ltd. Toronto, Ontario.
17) Usarco Limited, Hamilton, Ontario.
18) Z. Wagman & Son Limited, Toronto, Ontario.

* Note: This company should actually be classified in Group "C", rather than in Group "B", because of their various finishing operations, and because they receive pure metal as raw material and do not produce alloys.

APPENDIX II

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APPENDIX III GENERAL GLOSSARY:

Additives - Materials added to foundry sand in the preparation of the moulds and cores. These usually consist of silica flour, corn flour, glutin, bentonite clay, iron oxide, oils, pitch, wood flour, sea coal and soda ash. Other additives are called "linocures" A.B. & C., and linoils. The linocures are flashed off at the time of pouring.

Air Set Moulding - A type of moulding technique where the moulding sand is mixed with additives, which harden on exposure of the mould to the air to "set" the sand and so form a mould.

Alloy Steel - Steel containing one or more alloying metals, such as chromium, molybdenum or nickel, which have been added to impart particular physical, mechanical or chemical properties.

Bar Mill - A rolling mill equipped with grooved rolls to produce from reheated blooms or billets an elongated steel product of round, square of other cross section.

Barton Process - A special process for the production of battery lead oxide, by drawing air through the agitated molten lead and collecting the lead oxide in a baghouse.

Basic Oxygen Furnace (BOF) - A barrel-shaped furnace, into which molten pig iron and scrap are charged, and oxygen is injected downwards onto the bath to produce a heat of steel.

Beneficiation - Any process for improving the structure or grade of iron ore for use in a blast furnace, including crushing, roasting, sintering, agglomerating, concentrating, etc.

Billet Mill - A rolling mill for converting ingots or blooms that have been heated to rolling temperatures into billets to be used in the production of wire, rod, bars and seamless pipe. The billet may be square or rectangular in section, the width not exceeding twice the thickness. The cross sectional area is usually not more than 36 square inches.

Blast Furnace - A vertical shaft furnace, equipped with a hot air blast, for producing pig iron from iron ore. The furnace is usually operated on a continuous basis. Raw materials, consisting of iron ore, coke and limestone, are charged at the top, and molten pig iron and slag are tapped from the bottom at intervals.

Blooming Mill - A rolling mill for reducing reheated steel ingots to blooms, an intermediate or semifinished product destined for further processing. A bloom is not more than tiwce as wide as it is thick and has a cross section of not less than 36 square inches.

Burnt Out Sand - The layer of sand in the mould which is exposed to the molten metal of the casting, and thus becomes "burnt" or dead, and hence not suitable for reuse

Cake - Alloyed metal (copper) from the casting shop, in rectangular form and used for the rolling of sheet products.

APPENDIX III GENERAL GLOSSARY, (cont'd):

Chipping - A method of removing excess metal, seams and other surface defects from semifinished steel by means of a chisel or gouge so that such defects will not be worked into the finished product.

Coke Breeze - Undersize coke from screening and crushing operations.

Coke Ovens - Large ovens for heating coal in the absence of air to drive off volatile matter and leave coke as the solid residue. The process results in the production of metallurgical coke, domestic coke and coke breeze, as well as by-products such as tar, gas and aromatic hydrocarbons.

Cold Reduction Mill - A mill for rolling sheet and strip at approximately room temperature with the object of elongating it and reducing its thickness. Cold reduction develops higher tensile properties, greater surface hardness, better finish and closer dimensional tolerances in the product.

Concentrates - (see beneficiation) Processed iron ores in which the iron content has been increased by the removal of certain other constituents such as silica.

Conditioning - The removal of surface defects from semifinished steel by chipping, scarfing, grinding or machining to prepare it for further processing.

Continuous Casting (Concaster) - A process for casting molten steel directly into semifinished shape (e.g. billet, slab) thus eliminating the normal ingot forming and primary rolling operations.

Continuous Galvanizing - The process of coating a continuous strip of steel with zinc by running it through a bath of molten zinc.

Dross - A scum formed on the surface of molten metal, in the purification of non-ferrous metals, containing all the impurities and some of the fluxing chemicals and varying quantities of metal. Depending on its metal content, dross is recycled or treated for metal recovery.

Electric Furnace - A furnace in which the source of heat is an electric current. The electric furnace method is one of the processes for making steel - especially stainless steel, where even temperature control is essential.

Electrolytic Tinning - A process which employs an electric current to deposit a uniform coating of metallic tin upon a steel sheet.

Filler - The metal which fills the opening through which it is poured into the mould.

Flat Rolled Products - Plate, sheet and strip products of rolling mills equipped with smooth-faced rolls in contrast to grooved or cut rolls used in the manufacture of shapes.

Flushing Liquor - Condensate from the volatile products driven off in the coking process plus condensate from steam in the collecting mains.

Flux - Materials (e.g. limestone) used in iron and steelmaking furnaces to combine with impurities in the charge and produce a molten slag, which can be separated from the metallic end product.

APPENDIX III GENERAL GLOSSARY, (cont'd):

Foundry Iron - Blast furnace iron which has been cast into "pigs" or small slabs of iron, for use in the foundries.

Galvanizing - The process of coating steel with zinc by immersing it in a bath of molten zinc.

Gangue - The earthy or rocky material accompanying the ore in a mineral deposit.

Garbage - Animal and vegetable waste resulting from the handling, preparation, cooking and serving of foods; largely composed of putrescible organic matter and its natural moisture.

Heat - Tonnage of a single batch of steel produced in BOF, open hearth or electric furnace.

Hot Strip Mill - A mill for rolling heated steel slabs through a series of rolling stands to produce sheets, usually in coiled form.

Ingot - A mass of molten steel poured into an ingot mould to solidify. It differs from a casting in that it requires rolling or forging to become a semifinished or finished product.

Iron - A metallic element, found in the earth's crust in combination with other materials, from which pig iron and steel are made.

Landfill - Any disposal site or dump for solid wastes, not necessarily operated according to the regulations for a sanitary landfill.

Limestone - (see flux) The most common flux, calcium carbonate.

Merchant Bar- A quality designation for steel bars which are suitable for structural purposes and miscellaneous common uses involving mild cold bending, mild hot forming, punching and welding.

Open Hearth Furnace - A steelmaking furnace into which pig iron (usually molten) and steel scrap are charged for melting and refining. The bath is heated by the convection of hot gases over the surface of the metal and by radiation from the roof.

Pelletizing - A process of forming pellets by tumbling fine-grained (beneficiated) iron ore concentrates in an openended drum at specific temperature and moisture levels and then hardening the pellets at high temperature in a furnace or on a moving grate.

Pickling - The process of chemically removing scale, oxide and other foreign material from steel to obtain a chemically clean surface. Sulphuric or hydrochloric acid is the cleaning agent generally employed.

APPENDIX III GENERAL GLOSSARY, (cont'd):

Pig Iron - The direct metallic product, either solid or molten, of a blast furnace smelting iron ore.

Pig Machine - A machine consisting of travelling moulds into which molten pig iron is poured, to produce small slabs of iron for foundry use.

Plate Mill - A rolling mill for producing steel plate from reheated slabs. In some steel plant arrangements a plate mill may serve also as the initial rolling stage of a hot strip mill.

Precipitator- A device utilizing an electric charge to collect dust from waste gases and thereby minimize air pollution from the operation of facilities such as blast furnaces and open hearths equipped with oxygen lances.

Refractories - Materials, used for furnace linings, which do not melt at furnace temperatures. They must also possess a relatively high degree of resistance to the destructive influences of abrasion, thermal shock, pressure, corrosion and erosion.

Refuse - General solid wastes, rather than garbage, from domestic, commercial or industrial establishments.

Riser - The metal which fills the opening through which it is poured into a mould.

Rod Mill- A type of rolling mill equipped with grooved rolls for the production of steel rods from reheated billets. The product is usually round in cross section but smaller than a bar in diameter.

Rolling Mill - Basically, a rolling mill consists of two horizontal rolls mounted one above the other, revolving at the same speed, but in opposite directions, so that the steel to be processed is drawn between them. The operation forms the steel into the desired shape and improves its mechanical characteristics. Rolling mills may comprise a series of rolling stands and may be classified by purpose (e.g. Rod Mill) or by design (e.g. four-stand).

Sanitary landfill - A method of disposing of garbage, refuse and ashes on land without nuisance, fire or public health hazards, by application of a 2-foot earth cover on the compacted waste at the end of each operating day.

Scale - An oxide of iron formed on steel during hot working or upon exposure to air or steam at elevated temperatures. The scale may be removed during processing to improve the quality of the final product.

Scarfing - (deseaming, desurfacing) A method of removing seams and other surface defects from semifinished steel by means of a gas torch (e.g. oxy-acetylene).

Shake-Out - A machine to separate the casting from the sand mould and the core.

APPENDIX III GENERAL GLOSSARY, (cont'd):

Sintering - A process of fusing, by applying heat on a moving grate, fine iron ore and iron-bearing materials, such as mill scale, with coke breeze and fluxes, so that the product (sinter) may be charged into a blast furnace without impeding the upward flow of heated gases.

Slab - A semifinished hot rolled product rolled from an ingot on a slabbing or blooming mill, and intended for further rolling into plate, sheet, strip or other flat product. It is distinguished by its section, having a minimum thickness of 1½ inches and a width at least twice its thickness.

Slab Furnace - A furnace in which cold steel slabs are brought to a uniform temperature suitable for rolling.

Slag - The molten nonmetallic layer covering hot metal in a blast furnace or open hearth and formed through the use of fluxes to remove gangue and to assist purification of the metal.

Slag (foundry) - The molten nonmetallic layer formed in a cupola or an electric furnace through the use of fluxes, to remove the impurities from the scrap charge, and to further purify the molten metal.

Soaking Pit - A furnace or pit in which steel ingots are brought to a uniform temperature suitable for rolling or forging.

Sprue - A term used to describe the metal of the filler or riser on a casting. The sprue is normally recycled to the electric furnace or cupola.

Steel - A malleable alloy of iron and carbon produced by melting and refining pig iron and/or scrap steel. Carbon (in a range from .02 to 1.7%) is an essential ingredient but other elements, such as manganese and silicon, may be included to provide specific properties.

Steel Button - Pieces of steel which are recovered from the slags from the open hearth, basic oxygen and electric furnaces, and which can be recycled to the steel making furnaces.

Teeming - The pouring of a heat of molten steel from a furnace.

Tundish- Distributes the molten steel from the ladle into the moulds of the continuous casting machine.

Universal Slabbing Mill - A rolling mill for the production of steel slabs from ingots, which incorporates, in addition to horizontal rolls, one of more sets of vertical rolls. The thickness of the slab is controlled by the horizontal rolls and the vertical rolls control the width.

Zone - Part of reheating furnace where a bank of burners is located.

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