Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency (EEAA)
Egyptian Pollution Abatement Project (EPAP)

Self Monitoring Manual

Secondary Metallurgical Industry

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Secondary Metallurgical Industries
Self-Monitoring Manual
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1. INTRODUCTION

The Egyptian Pollution Abatement Project (EPAP) sponsored by FINIDA has assigned Finish and Egyptian consultants for the task of developing Sector specific inspection and monitoring guidelines. This task is based on a previous collaboration between FININDA and EPAP that resulted in the development of four Inspection Guidelines:

- Fundamentals and Background Manual that provides basic information about air pollution, wastewater characteristics, solid waste, hazardous materials and wastes and work environment.
- Guidelines for Inspectorate management that discusses the strategy, objectives and tasks of the inspectorate management.
- Guidelines for Team Leaders that identifies the team leader responsibilities and tasks.
- Guidelines for Inspectors that presents a methodology for performing all types of inspection. Tasks during the various phases of planning, performing field inspection, report preparation and follow-up are discussed. Several checklists are included.

The four guidelines were later summarized into one manual named General Inspection Manual, which was developed and will be referred to as (GIM EPAP 2002). This manual covers aspects common to all industrial sectors.

On the other hand, EPAP realized the need to introduce the concept of self-monitoring, as it provides useful information to the plant's management on the production efficiency as well as the environmental status. Self-monitoring should cover, as a minimum, the monitoring of the releases to the environment including emissions to air, wastewater, solid waste and hazardous waste. A comprehensive self-monitoring plan may cover process parameters that would affect the environmental impacts. Such plan would assist the management to identify sources of waste, prevent pollution at the source, reduce emissions, and achieve economic benefits.

Therefore, a Self-Monitoring Guidebook was also developed to present the industrial community, the consultants, and government officials with the general principles and both managerial and technical aspects to be followed for self-monitoring. The textile industry was chosen as a case study for implementing and testing the manual and a self-monitoring manual for this industry was developed.

1.1 Preface

The developed manuals were tested through a number of training programs that targeted RBOs and EMUs. The inspectors involved in the training used these manuals to inspect a number of industrial facilities. Feedback from the concerned parties led to the improvement of these manuals and their continuous update. There was clearly a need for sector-specific guidelines, and EPAP took the initiative to develop such manuals. Five sectors were chosen:

- Food Industry with specific reference to the five sub-sectors of Dairy products, Vegetables and Fruit processing, Grain Milling, Carbonated Beverages and Confectionery.
- Pulp and Paper Industry
- Metallurgical Industry with specific reference to the two sub-sectors of Iron and Steel and Aluminum.
- Engineering Industry with specific reference to Motor Vehicles Assembly and Fabricated Metals industries.
- Textile Industry

1.1.1. Project objectives

The project aims at the development of sector-specific guidelines for inspection and monitoring to be used by inspectors and plant personnel respectively. These manuals are meant to be simplified but without abstention of any information necessary to the targeted users. Flowcharts, tables and highlighted notes are used for easy representation of information.

With respect to the metallurgical industry, two distinct manuals were developed, one for inspection and the other for self-monitoring. Description of the industry, pollution aspects and relevant environmental laws will be similar for both manuals. Each manual will be, as much as possible a stand-alone with occasional cross-reference to the General Guidelines previously developed to avoid undue repetitions.

1.1.2 Organization of the self-monitoring manual

The self-monitoring manual for the metallurgical industry includes eleven chapters. The first chapter represents an introduction to the whole project and to the specific sub-sector of the industry. Chapters 2 to 5 deal with the metallurgical industry and its environmental impacts.

The description of the industry in Chapter two includes the inputs and outputs, a description of the different production lines with their specific inputs and outputs. In addition, it also includes a brief description of the service and auxiliary units that could be present at the industrial establishment with their potential sources of pollution and the various emissions, effluents and solid wastes generated from the different processes.

Chapter 3 describes the environmental and health impacts of the various pollutants whereas Chapter 4 gives a summary of the articles in the Egyptian environmental laws relevant to the metallurgical industry. Chapter 5 gives examples of pollution abatement techniques and measures applicable to the metallurgical industry.

The information and steps needed to establish of a self-monitoring system are detailed in chapter 6-11 inclusive. A reasonably detailed introduction to the definition, objectives, benefits of self-monitoring are presented in Chapter 6, in addition to the link between self-monitoring and each of environmental management system and cleaner production. Chapter 7 deals with the aspects of planning of self-monitoring. Monitoring of raw materials is discussed in Chapter 8, while operation control aspects are discussed in Chapter 9. Environmental monitoring is described in Chapter 10. Chapter 11 is dealing with data collection, data processing and data usage. It is worth mentioning that there will be a frequent need of referring to other sources of information in order to plan, implement, and operate an effective and sustainable self-monitoring system. Therefore, references pertinent to subject matter will be mentioned. In addition, need may arise, in some instances where plant personnel are advised to call for external consultation in order to establish a proper, effective, and sustainable self-monitoring system.

2. PROCESSES DESCRIPTION

Secondary metallurgical processes are the production processes that starts with the output of the ore reduction process, scrap …etc as the input to the industry and its products is semi-finished products, finished products. It includes the melting, giving the aimed shape to the final output, through forming, poring liquid metal and alloys to the mold cavity and forging.

2.1 Raw materials, Chemicals, and Other Inputs

Table (1) represents the material inputs to each operation in secondary metallurgical industries.

Table (1) Material Inputs In Secondary Metallurgical Processes

Process	Material inputs
furnaces	
Induction and electric arc furnace Preheating furnace Cupola and crucible furnace	Steel scrap, liquid steel, direct reduced iron, or /and pellets briquettes, metal scrap and big iron, coke or carbonizes, ferro-alloys, limestone, gas fuel, bentonite and binding materials.
Continuous casting	
Tundish treatment process	Gas fuels, liquid fuels, Refining additions and water. Liquid steel
Rolling, drawing, extrusion and forging	
Rolling Drawing Extrusion Forging	Pillets or slabs, bars, blooms, lubricating oils, greases,
Conventional casting	
Molding Casting	Green sand, dry sand, clay, core sand, raw material, scrap, gaseous and solid fluxes (CO_2, He, N_2, Ar, cl, AlCl, ZnCl, AlF)

2.2 Production Processes

2.2.1 Furnaces

a. Electric Arc Furnace

Electric arc furnaces are the prime means of recycling steel scrap into liquid steel. They are, also increasingly being used to produce liquid steel from iron sources such as direct reduced iron (DRI) pellets or briquettes and blast furnace liquid molten steel or pig iron.

The EAF steel is batch produced. Each batch is called a "pouring". The furnaces generally range in capacity from 1 tons to over 250 tons. Smaller furnaces (5-ton capacity and up) are used to produce batches of special steels. Alloying is done in the ladle during tapping, in ladle metallurgy stations, or in ladle furnaces. A ladle furnace is a small EAF that allows the temperature of the molten steel in the ladle to be raised to the casting temperature.

The charge includes steel scrap, molten steel and the iron produced from direct reduction. They are in ratio equal 1130 kg of scrap or iron from direct reduction/ 1 ton of product. For chemical control and purification purposes, several materials are used including:

- Coke coal and carbonizers
- Iron casts
- Lime stones (10 kgm of casting elements & 100 kgm of flux for each 1 ton of product)
- Energy
  - Electric
  - Gaseous fuel, which may be used as a source of heat to reduce the electricity consumption
  - Mazout
- Water

As shown in the block diagram of Figure 1, the steel making process begins with the first addition of scrap. The furnace roof swings open and the overhead crane operator opens the clamshell bottom of the scrap bucket and let the scrap drop into the furnace. The roof closes & power is applied. Figure (2) shows an elevation and a plan for the EAF.

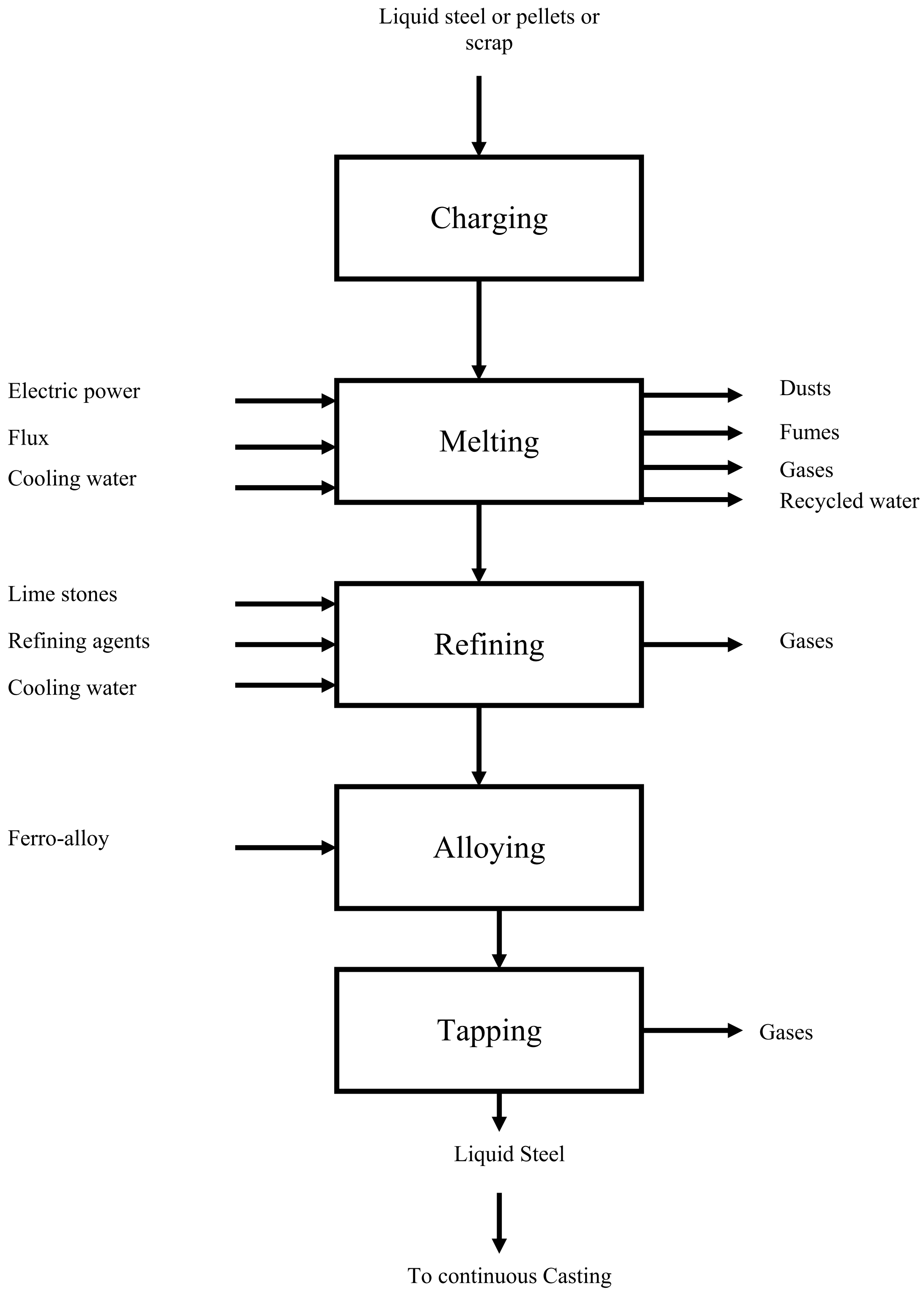
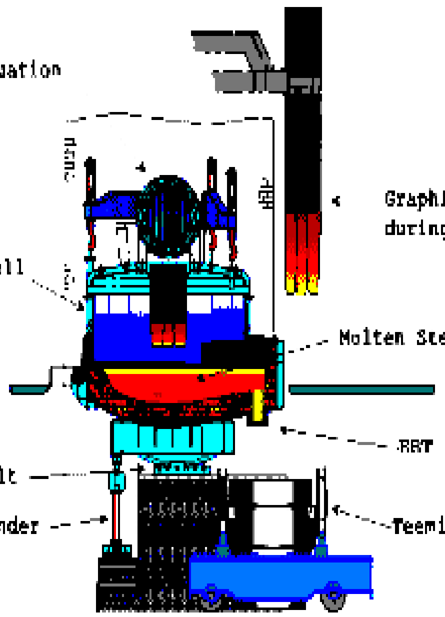


Figure (1) Steel Making in Electric Arc Furnace



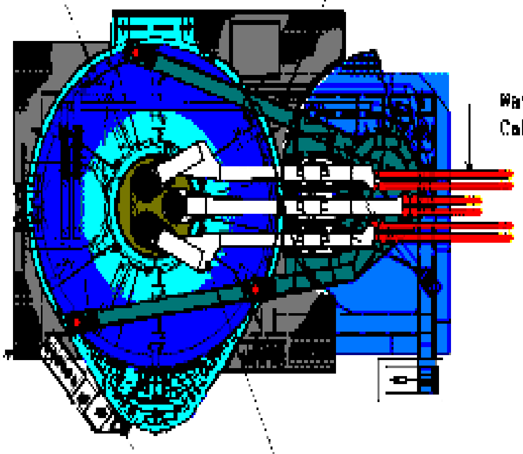


Figure (2) Electric Arc Furnace

Most furnaces nowadays use oxy-fuel burners. At least three oxy-fuel burners arc (their number differs from one type to another) turned on during the first 5 to 10 minutes of the heat (this period is relative to the furnace type, charge composition and the desired product composition) in order to accelerate melting and add heat to the cold spots of the furnaces. Oxygen lances are used to make the scrap collapse into the melt and to burn combustibles in the furnace, thereby accelerating the scrap heating and melting process. Carbon and/or lime are often added with the scrap charge. The coke or coal provides the proper reducing environment for the process. The limestone removes impurities from the steel through the formation of slag.

Alloy additions, if needed, can be provided either directly to the furnace or into the ladle. Many melt shops homogenize the melt for temperature and chemistry by injecting inert gas into the ladle. Gas is bubbled through the ladle by either a lance or a porous bottom plug.

b. Preheating Furnaces

Before forming a furnace is used to preheat different metals for hot forming, preheating furnaces are used to preheat metals to a suitable temperature before hot forming the metal inputs are generally slaps, blooms, bars, rounds and billets, this furnaces have several sources of heating energy electric, mazout, or gas. For steel forming slabs or blooms are heated to temperature 1100-1250^{o}C then formed.

Gaseous emissions from these furnaces include CO, CO_2, SO_2, NO_x and suspended particulates. Emissions depend on the fuel type and the combustion properties.

c. Cupola Furnace

The cupola is a vertical, cylindrical shaft furnace that may use pig iron, scrap iron, scrap steel, and coke as the charge components. The mechanism by which melting is accomplished in the cupola is heat release through the combustion of coke and the reaction between oxygen in the air and carbon in fuel that is in direct contact with the metallic portion of the charge and the fluxes. Figure (3) illustrates a block flow process diagram of cupola furnace.

One of the advantageous features of such a furnace is that counter-flow preheating of the charge material is an inherent part of the melting process. The upward flowing hot gases come into close contact with the descending burden, allowing direct and efficient heat exchange to take place. The running or charge coke is also preheated which aids in the combustion process as it reaches the combustion zone to replenish consumed fuel.

Greater understanding of these features accounts in part, for the continued popularity of the cupola as a melting unit. However, recent design improvements such as coke-less, plasma-fired types that alter emission characteristics are now encountered.

d. Crucible Furnace

Figure (4) shows a process flow diagram of crucible melting. Most commercial melting of nonferrous metals is done in oil-and gas-fired furnaces. These are of two basic types: stationary and tilting furnaces. In stationary furnaces the crucible is lifted in and out for pouring, while tilted crucible furnace requires a crucible with a suitable lip for pouring metals when the furnace is tilted.

Most nonferrous metals and alloys oxidize, absorb gasses and other substances, and form dross readily when heated. Various practices are followed for each kind of metal to preserve purity and obtain good castings.

In case of using crucible furnaces, for melting metals, the electric arc energy is then used to melt the steel with agitation by using nitrogen or argon. The chemicals composition is adjusted by adding certain cast additives.

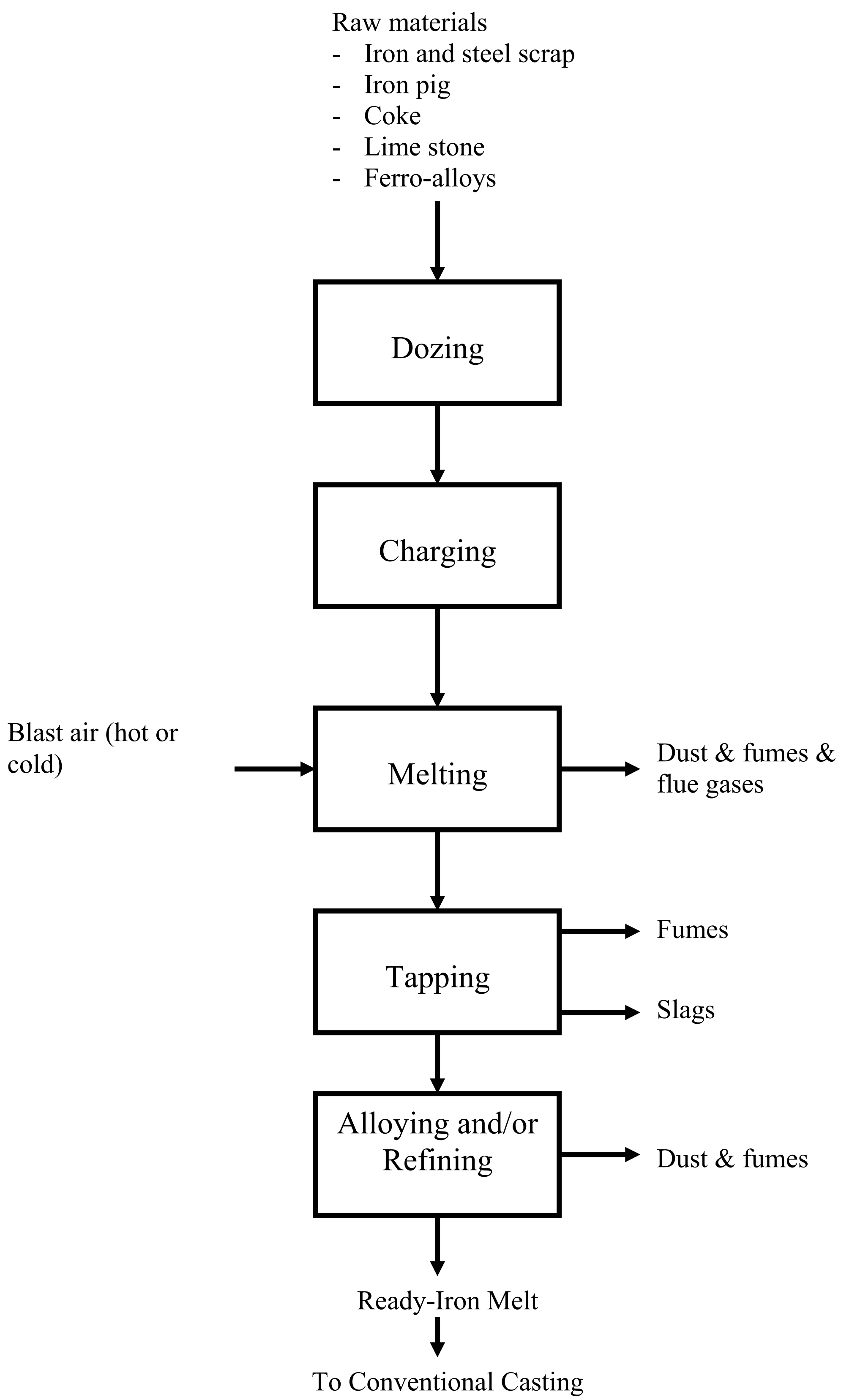


Figure (3) Block Flow Diagram for Cupola Furnace

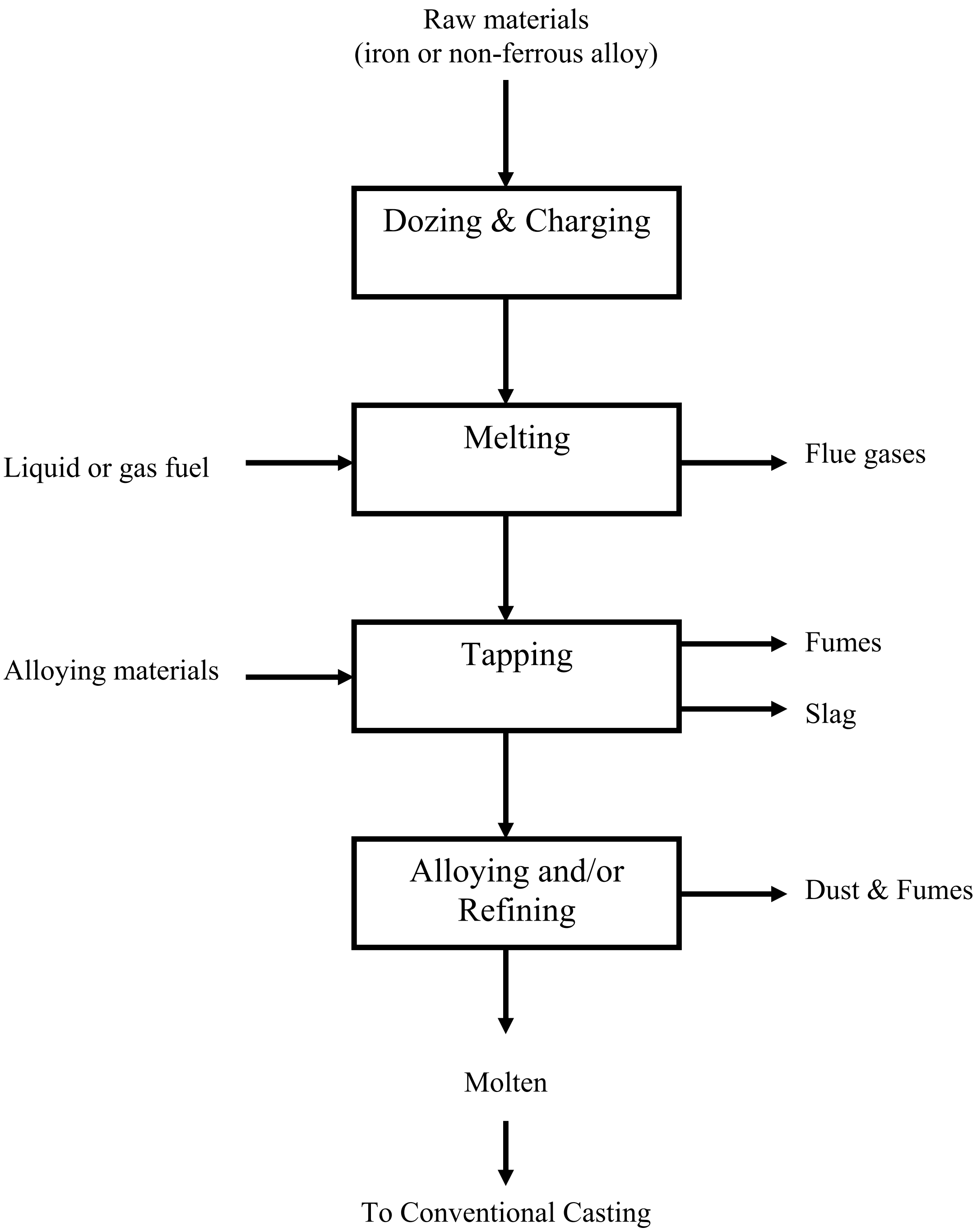


Figure (4) Block Flow Diagram for Crucible Melting

2.2.2 Continuous Casting

Continuous casting aims to produce molten steel with proper viscosity. The molten is treated in the furnace or in the ladle to be ready for pouring in the casting equipment. Liquid of gaseous fuel is used to ignite the "tundish" and for preheating, water is also used for cooling the mold and the molten metal.

Casters are steel plant equipment, which are used to process liquid steel into continuous lengths of solid steel of various cross sections. The most common sections are less than 20 cm square (billets). Larger squares are blooms and rectangles averaging 120cm in width (slabs). Special sections are rounds and so-called (near net shapes), such as beam blanks and slabs or sheets, are as thin as 2cm.

Figure (5) shows a block diagram of continuous casting of steel. Molten steel is tapped from the furnace into a refractory-lined ladle. The molten steel stream emerges from the slide gate in the ladle bottom and fills tube-like distribution vessel (tundish). The number of drain holes in the tundish corresponds to the number of strands to be cast simultaneously. The molten steel streams emerging from the tundish bottom fill oscillating water-cooled copper molds in which the molten steel solidifies as it passes through the mold and emerges from its bottom. The olds provide immediate cooling of the outer skin of the steel. As the steel emerges from the mold, the center is still molten. After complete solidification, the continuous strip is cut into convenient lengths using torch machines or shears.

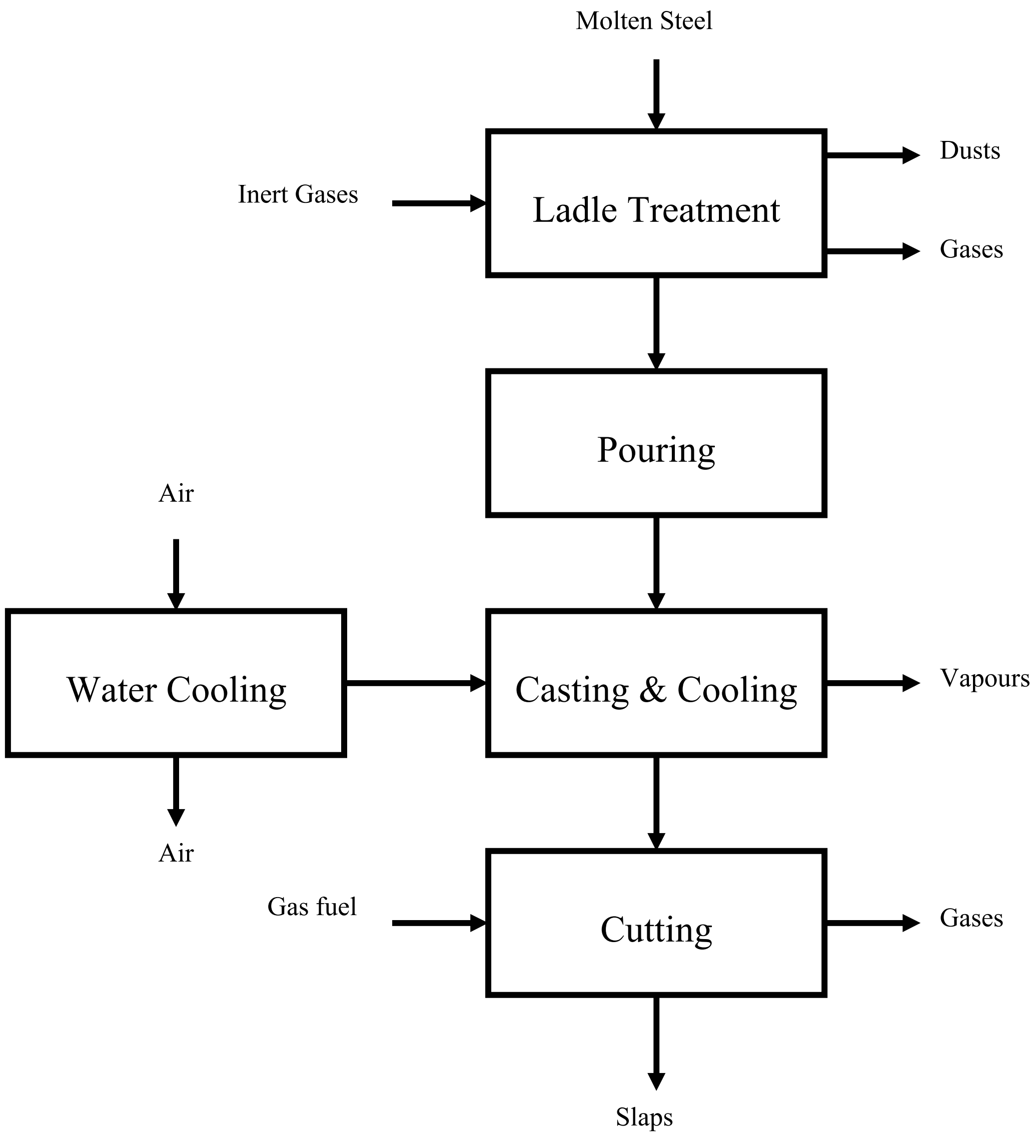


Figure (5) Block Flow Diagram for Continuous Casting of Steel

2.2.3 Conventional Casting

a. Molding

After melting, molten metal is tapped from the furnace and poured into a ladle or directly into molds. If poured into ladle, the molten iron may be treated with a variety of alloying agents predetermined by the desired metallurgical properties. It then is ladled into molds, where it solidifies and is allowed to cool further before separation of the casting from the mold (shakeout).

Molds are forms used to shape the exterior of castings and green sand mold, the most common type, uses moist and mixed with 3-20% clay and 2-5% water, depending on the process. Additives to prevent casting defects include organic material such as sea coal (a pulverized high volatility low-sulfur bituminous coal), wood or corn flour, oat hulls, or similar organic matter Cores are molded sand shapes used to form the internal voids in castings. They are made by mixing sand with various binders, shaping it into a core, and curing the core with a variety of processes.

In larger more mechanized foundries, the molds are conveyed automatically through a cooling tunnel before they are placed on a vibrating grid to shake the mold and core sand loose from the casting. in some foundries, molds are placed in an open floor space and molten iron is poured into the molds and allowed to cool. Molding and core sand are separated from the casting(s) either manually or mechanically. Figure (6) illustrates flow diagram for the molding process.

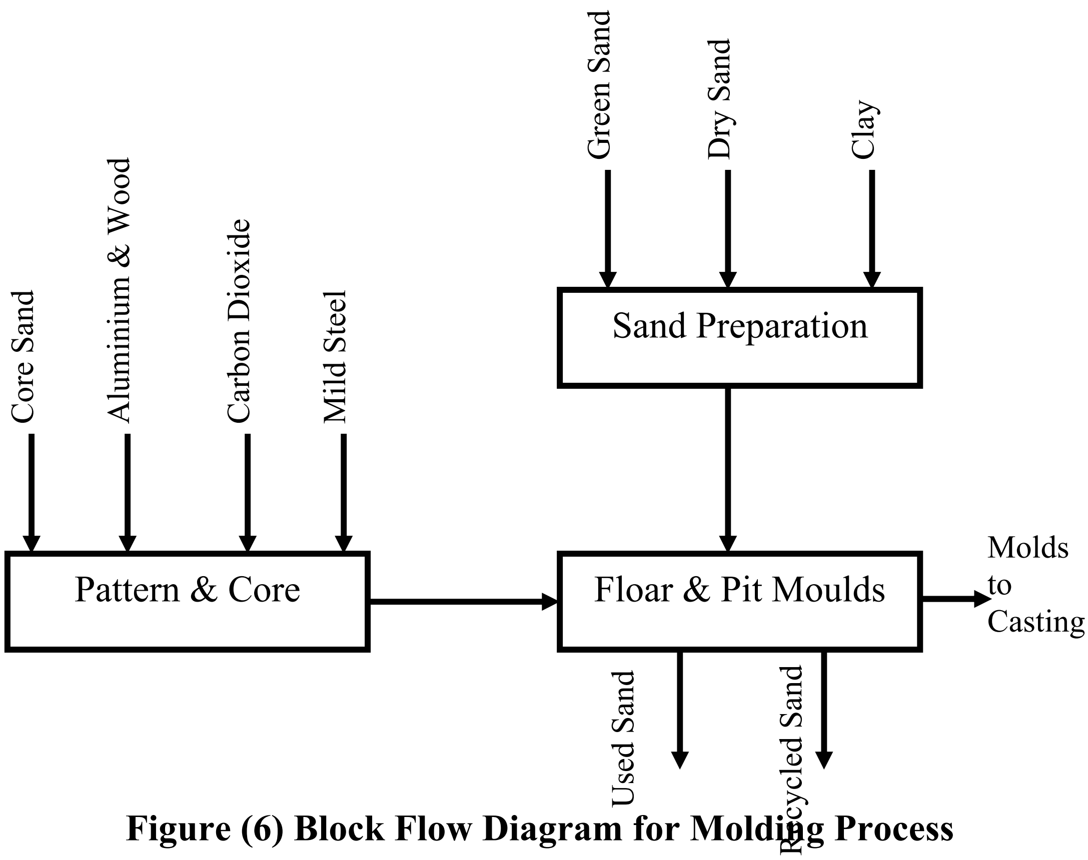


Figure (6) Block Flow Diagram for Molding Process

Used sand from casting shakeout is usually returned to the sand preparation area and cleaned, screened, and processed to make new molds. Because of process losses and potential contamination, additional makeup sand may be required.

When castings have cooled, any unwanted appendages, such as spurs, gates, and risers, are removed by an oxygen torch, abrasive saw, friction cutting tool, or hand hammer, The castings then may be subjected to abrasive blast to be cleaned and/or tumbling to remove any remaining scales.

b. Ferrous Casting

The production of ferrous castings (low-carbon, mild-alloy, high-alloy steel, or cast iron), the technology of mold and core preparation, in a general way, is similar to that used to produce castings from metals other than steel as described earlier.

Today, in Egyptian ferrous foundry production, melting is primarily accomplished with two types of electric furnaces-direct arc and induction. Arc furnace has the same construction as described before, but foundry arc furnaces are usually small in size and works relatively at higher temperature and with non-processed scrap.

The major processing operations of the typical ferrous foundry are raw-materials handling, metal melting, mold and core production, and casting and finishing (see Figure 7).

The raw-materials handling operations include the receiving, unloading, storage, and conveying of all raw materials for the foundry. Some of the raw materials used by ferrous foundries are pig iron, iron and steel scrap, foundry returns metal turnings, ferroalloys, carbon additives, fluxes (Lime- Stone, soda ash, fluorspar), sand, sand additives. And binders these raw materials are received in ships railcars trucks, or containers and are transferred by trucks, loaders, and conveyors to both open piles and enclosed storage areas. The materials are then transferred by similar means from storage to the subsequent processing areas.

When the total charge is melted, the bath surface is skimmed free of slag and the heat is tapped into the pouring ladle. At this time, adding alloys or de-oxidizers, depending on the type of alloy being melted and the melting procedure that has been established may treat the molten metal. When the castings have solidified and the molds are partially cooled, the castings are placed on a vibrating grid and the sand of the mold and- core is broken away from the casting. The sand is recycled to the sand-preparation center and then to the molding center, where a repeat of the total mold/core procedure for pouring is again carried out.

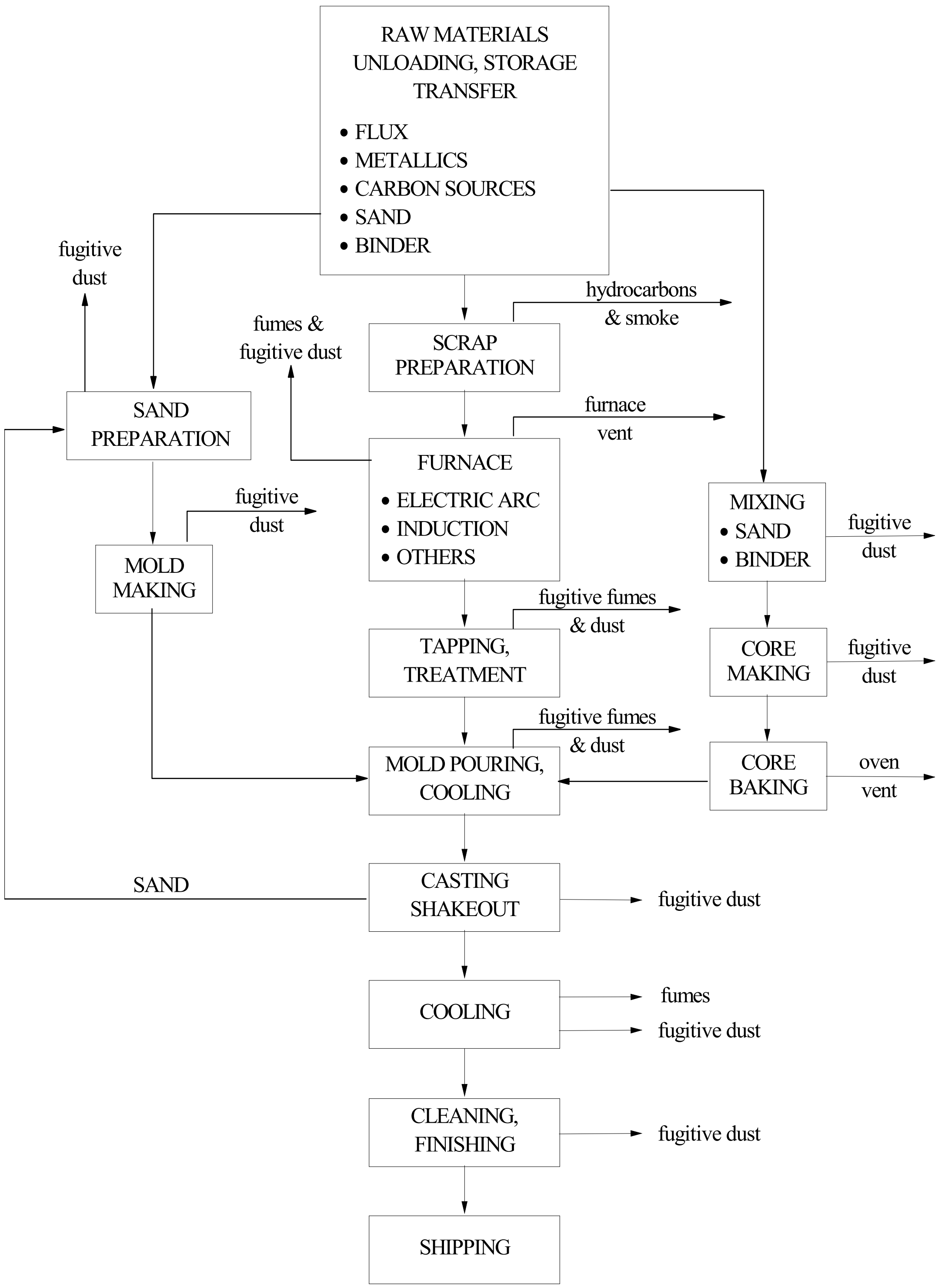


Figure (7) Block Flow Diagram for Steel Foundries and Sources of Emissions

c. *Non-Ferrous Casting*

The same as ferrous casting, some additional processes should be considered. Special care should be given to dross formation of Al &Cu oxides, which accumulates on the surface of molten metal.

Aluminum alloys will absorb or dissolve considerable quantities of Hydrogen gases in the molten state, Copper alloys dissolve a substantial amounts of oxygen & hydrogen. Flushing &fluxing are used to provide more effective separation of molten metal, dross and to remove dissolved hydrogen entrapped dross

2.2.4 Rolling, Drawing, Extrusion and Forging

Formation processes depend mainly on mechanical operations, which are applied to the casts to form the desired shapes. The major forming processes are rolling, drawing, extrusion and forging. The used raw materials include:

- Produced sections (bars, slabs, blooms and billets) from continuous casting. No pollution accompanying handling of these materials.
- Natural gas, solar or mazout is used in reheating the casts to a temperature 1050- 1100^{o} C in order to make them flexible during formation.

a. *Rolling*

As shown in the block diagram of Figure (8), shaping by rolling consists of passing the metal to be rolled between rolls that revolve at the same speed, but in opposite direction.

The ingot process makes semi-finished forms (slabs, blooms, and billets). The newer continuous casting process makes semi-finished forms (slabs, bars, rounds, blooms, and billets). In the ingot method, the finishing stages of steel making begin when ingots are lowered into furnaces called soaking pits that reheat them to an even temperature for rolling. The ingot is rolled in a primary mill into semi-finished slabs or into rectangular shapes called blooms. In the newer continuous casting process, steel is poured directly into tundish, which feeds a curved mold where the steel is solidified directly into semi-finished products. The end product can be slabs, blooms, or billets, depending on the final proportions.

During hot rolling, steel heated to about 1050- 1100 ^{o}C is placed onto the end of the rolling line. As an example, a slabs metallurgical analysis, size, weight, and intended end-use are fed into the mill's computer. Sensing devices continuously record the slab's thickness, width, and temperature, and the squeezing force of the rolls as the slab moves through the roughing and finishing. Steel rolled on the hot strip mill can be sold in this form or further processed into cold-rolled, galvanized, or aluminized steel.

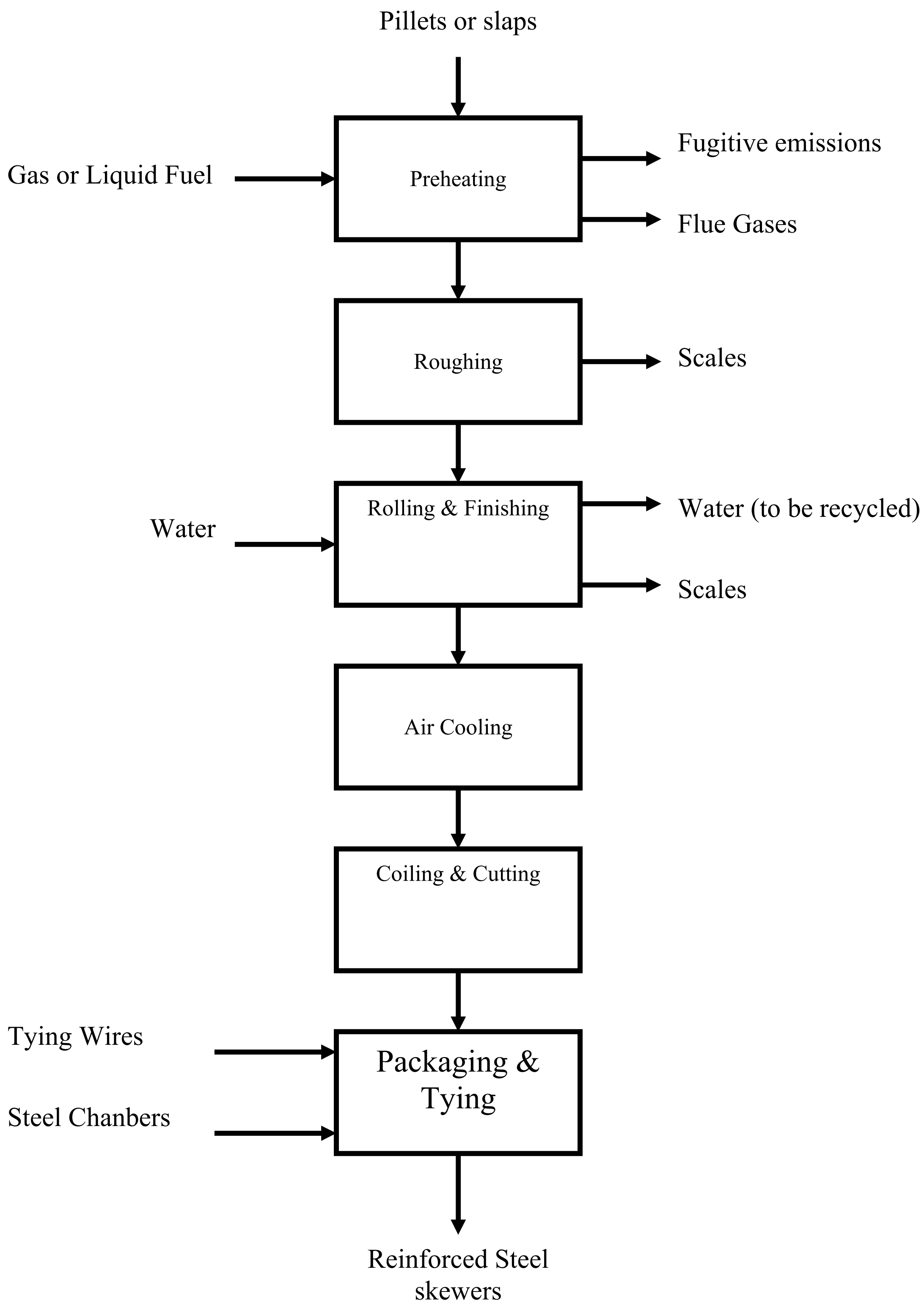


Figure (8) Flow Diagram for Hot Rolling Process

b. Extrusion and Drawing

Figure (9) shows a block diagram of both drawing and extrusion of metals. Round, rectangular, square, hexagonal and other shapes of bars up to about 4in across or in diameter, wire of all sizes, and cold drawing commonly finishes tubes. Wire cannot be hot rolled economically smaller than 0.2in. in diameter and is reduced to smaller sizes by cold-drawing. When metal is extruded, it is compressed above its elastic limit in a chamber and is forced to flow through and take on the shape of an opening. An everyday analogy is the dispensing of paste from a collapsible tube. Metal is extruded in a number of basic ways. The metal is normally compressed by a ram and may be pushed forward or backward. The product may be solid or hollow. The process may be done hot or cold.

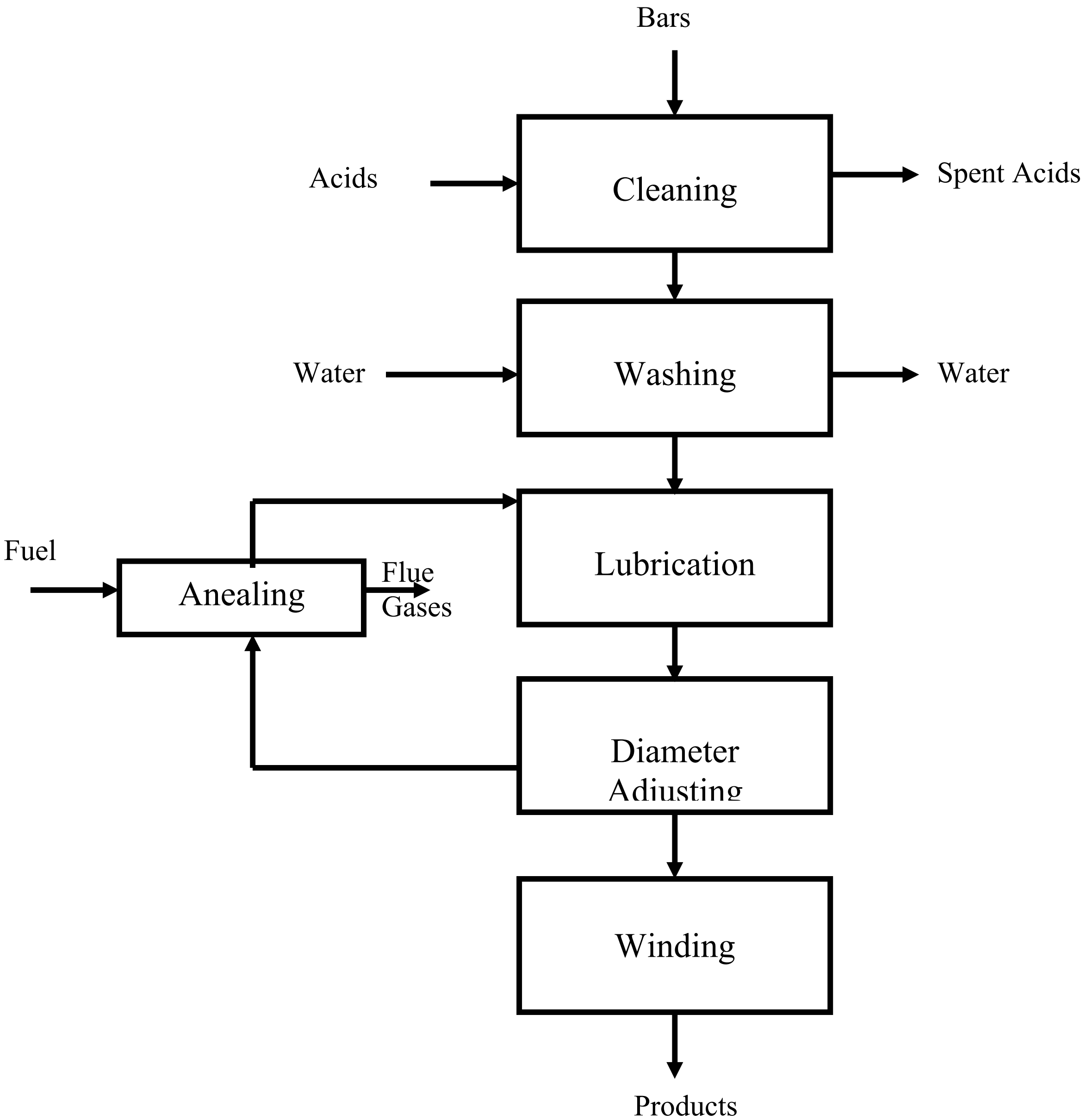


Figure (9) Block Flow Diagram for Drawing and Extrusion

c. *Forging*

Figure (10) shows a block diagram of a forging process. Forging is the forming of metal, mostly hot, by individual and intermittent applications of pressure instead of applying continuous pressure as in rolling. The products generally are discontinuous also, treated and turned out as discrete pieces rather than as a flowing mass.

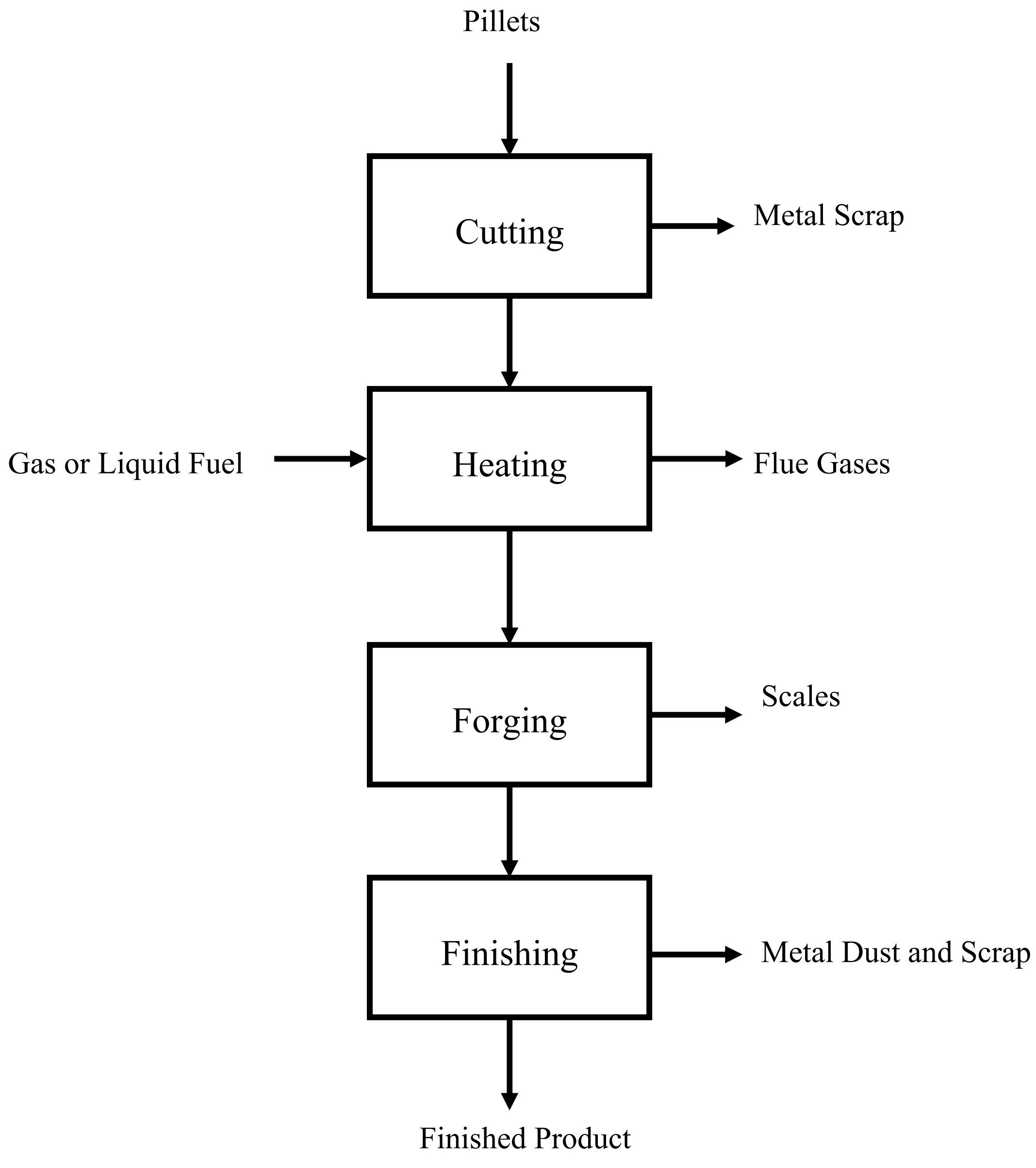


Figure (10) Block Flow Diagram for Forging Process

The forging process may work metal by compressing its cross section and making it longer, by squeezing it lengthwise and increasing its cross section or by squeezing it within and making it conform to the shape of the cavity.

Forging may be done in open or close dies. Open die forging are nominally struck between two flat surfaces, but in practice the dies are sometimes V shaped, half round, or half oval. Closed die forging are formed in die cavities. All forging takes skill, but more is required with open than with closed dies. Faster output and smaller tolerance are obtained with a closed die. Open dies are of course, much less costly than closed dies and more economical for a few parts. Either open or closed die forging may be done on most hammers and presses.

2.3 Service Units, Description and Possible Pollutant Sources

2.3.1 Boilers

Medium and large facilities, of secondary metallurgical industries may include electricity generating stations. This electricity is used in emergency or when additional electricity is needed. Boilers are necessary, for electricity generating stations, to produce steam. Fuel is burned in boilers to convert water to high pressure steam, which is used to drive the turbine to generate electricity. The gaseous emissions, due to boilers burning fuel oil (Mazout) or diesel oil (solar), contain primarily particulates (including heavy metals if they are present in significant concentrations in the fuel), sulfur and nitrogen oxides (SOx and NOx) and volatile organic compounds (VOCs). The concentration of these pollutants in the exhaust gases depends on firing configuration (nozzle design, chimney height), operating practices and fuel composition.

Wastewater is generated due to the blowdown purged from boilers to keep the concentration of dissolved salts at a level that prevents salt precipitation and consequently scale formation. The blowdown will be high in (TDS)

Also large quantities of water are used for cooling the turbines, which pollutes the discharged wastewater. The amount of wastewater generated depends on whether cooling is performed in open or closed cycle and on the recycling of steam condensate. Contamination may arise from lubricating and fuel oil. The steam condensate from the production processes, may return to the boiler (closed circuit) or discharged as wastewater causing pollution source to effluents.

The heat stress may be high, in work place, in case of absence of thermal insulation for steam pipelines.

2.3.2 Water Treatment Units

There are different treatment processes, depending on the water source and the application in the industry.

i) ***Water softening for medium hardness water :*** calcium and magnesium ions are removed from hard water by cation exchange for sodium ions. When the exchange resin has removed the ions to the limits of its capacity, it is regenerated to the sodium form with a salt solution (sodium chloride) in the pH range of 6-8. This is performed by taking the softener out of service, backwashing with the salt solution, rinsing to eliminate excess salt, and then returning it to service. The treated water has a hardness level of less than 1 ppm expressed as calcium carbonate.

ii) ***Water softening for very high bicarbonate hardness:*** Water from wells and canals is pre-treated before softening. Water is treated first by the lime process, then by cation exchange. The lime process reduces dissolved solids by precipitating calcium carbonate and magnesium hydroxide from the water. It can reduce calcium hardness to 35 ppm if proper opportunity is given for precipitation. A coagulant such as aluminum sulfate (alum) or ferric sulfate is added to aid magnesium hydroxide precipitation. Calcium hypochlorite is added in some cases. Currently the use of organic polyelectrolytes is replacing many of the traditional inorganic coagulant aid. Sludge precipitates and is discharged to disposal sites whereas the overflowing water is fed to a sand filter followed by an activated carbon filter that removes any substances causing odor and taste. A micro filter can then be used to remove remaining traces. A successful method to accelerate precipitation is contacting previously precipitated sludge with the raw water and chemicals. The sludge particles act as seeds for further precipitation. The result is a more rapid and more complete reaction with larger and more easily settled particles.

iii) ***Reverse Osmosis:*** Demineralization can also be performed by reverse osmosis. In this process water is forced through a semi-permeable membrane by applying pressure.

2.3.3 Cooling Towers

Moderate quantities of cooling water are used for cooling furnaces and the formation equipment in this industry. Cooling towers provide the means for recycling water and thus minimizing its consumption. The cooling effect is performed through partial evaporation. This causes an increase in the concentration of dissolved salts, which is controlled by purifying some water (blowdown). The blowdown will be high in TDS and will represent a source of pollution to the wastewater to which it is discharged.

2.3.4 Laboratories

Laboratories, in secondary metallurgical industries, are responsible for:

- Testing chemicals, water, wastewater, …etc. to check compliance with required standards.
- Quality control of product to check agreement with standard specifications.
- Check the physical and mechanical properties of products.

Chemicals, including hazardous materials, are used in laboratories. Storage and handling should be checked by the inspectors.

2.3.5 Workshops and Garage

Workshops are very important in the secondary metallurgical industries, where they are divided into mechanical and electrical workshops. They are responsible for repairing and maintenance of the foundry' equipment. Environmental violation could be due to:

- Noise
- Wastewater contaminated with lube oil

Pollution in the garage will depend upon the services offered. The presence of a gasoline or diesel station implies fuel storage in underground or over the ground tanks that require leak and spill control plans.
Replacing lube oil implies discharge of spent oil to the sewer system or selling it to recycling stations.

2.3.6 Storage Facilities

The specifications for the storage facilities depend on the nature and properties of the stored material

- Environmental laws stipulate that special system should be applied for handling and storing hazardous chemicals.
- Fuel is kept in under/or above ground tanks. Storage requires proper preventive plans for spills and leaks.

Table (2) shows the service units related to the metallurgical industries and their pollution sources.

Table (2) Service Units and their Related Pollution Sources

Inputs	Service Units	Pollution
Water Lime + chemicals Fuel	Treatment Softening Units Boilers Steam	Sludge Back wash Boiler Blow Down (TDS) Flue Gases
Hot Water	Cooling Towers	Cooling Tower Blowdown (TDS)
Chemicals	Laboratory	Wastewater Hazardous Materials (handling)
Lube Oil Floor and equipment rinse water Cleaning Chemicals	Electrical & Mechanical Workshops	Oily Rinse Water Solid Wastes
Fuel Oil Rinse Water	Garage	Oily rinse water Solid wastes
Raw materials Fuel Chemicals Products	Storage	Spills Raw material Hazardous material

2.4 Emissions, Effluents and Solid Wastes

2.4.1 Air Emissions

a. Electric Arc Furnace

The EAF emissions are generally generated from three sources: charging, melting, and tapping. Fume contained in the rising plume has to be exhausted from the melt shop. The evacuation system should be able instantaneously to extract these emissions as the arriving scrap bucket and cranes disperse them. The volume flow rate and emission level in the mushroom cloud is also increased if the steel maker places additives such as coal and lime into the scrap bucket. Table 3 summarizes the most important emissions in EAF.

Table (3) Air Emissions from Electric Arc Furnace

Emissions	kg/ton iron produced
CO	0.5 - 19
NOx	0.02 - 0.3
VOC	0.03 - 0.15
Pb	0.005 - 0.05
PM	6.3

An immense amount of heat, gases and fume are generated during melting. Carbon monoxide (CO) can be generated in the production of steel in an EAF. Carbon containing compounds in the additives, scrap contamination, and particularly the foamy slag practice are the source of these emissions. (2.5 kg CO, 50 g SO2, 0.25 kg NO2, 100 g particulate) per ton cast product.

As the furnace contents are heated to approximately 1600^{o}C, any metals that volatilize below this temperature will be carried away by the furnace off-gases. When coke, coal, or limestone is injected into the furnace, fine particulate of these commodities may be drawn into the off-gas system. (5 g oil, 4 g suspended solids, 145 kg EAF slag) per ton produced.

In EAF steel making, a fair amount of heavy solid particulate injected into the off-gas. A furnace using the foamy slag practice can expect to collect 26 pounds of dust per ton of molten steel, but one could expect to collect more with unfavorable oxygen injection practices or too small a fourth hole.

Furnace spout and furnace bottom tapping produce similar emissions. The emissions are mostly iron oxide and slag particulate. However, almost all EAF steel making processes add alloying elements of the ladle while tapping. This procedure can significantly increase tapping fume evolution. Therefore, the emissions, also, contain particulate consisting of oxides of these additives.

b. Heating Furnace

They are used to reheat the different metals to prepare it for the hot formation processes. These furnaces are utilized to heat the metal to a proper temperature (1100- 1250) ^{O}C, before hot formation. Inputs to heating furnaces are slabs, blooms, bars, billets and rounds.

The major emissions generating from heating furnaces are CO, CO2, SO2, NOx and particulate matter. These emissions depend on the type of the used fuel and the combustion conditions.

c. *Cupola and Crucible Furnace*

The quantity and composition of particulate emissions vary among cupolas, and even at intervals in the same cupola. Causes include changes in iron-to-coke ratios, air volumes per ton melted, stack velocity, and the quality of the scrap melted.

Where oily scrap is charged, the raw emissions potentially not only will be greater in quantity, but also can be much more visible. The American Foundry men Society compiled a survey of cupola emissions and found that an average emission from an uncontrolled cupola was approximately 5.8 to 7.6 kg of particulate per ton melted. Eighty-five percent of the emissions may be greater than 10 microns in size.

Dust composition and amounts vary from cupola to have a significant impact on dust composition and quantity. The dust could include some or all of the following Materials

- Iron oxide
- Magnesium oxide
- Manganese oxide
- Zinc oxide
- Silicon dioxide
- Calcium oxide
- Lead
- Cadmium

In addition, other gases and organic compounds may be emitted as part of the melting process. These include carbon monoxide, sulfur oxides, lead, and organic emissions. Both sulfur and organic emissions may be affected by the amount of oil or grease on the scrap.

The quantity of sulfur oxides also is large enough to be a definite consideration in the corrosion of air pollution control equipment. There are a number of instances of rapid deterioration of dust collectors on cupolas where corrosion protection was not considered.

Where fluorspar is used as an additive, the fluorine driven off can cause a corrosion problem with dust collection equipment. Fluorine also has the potential to dissolve glass bags. The carbonic acid formed when carbon dioxide reacts with water vapor may cause corrosion problems as well.

Cupola repair needs a charge of lining, which is considered a solid waste. Besides, during tapping, a 10-20% molten slag is obtained, which is treated by quenching. Table (4) gives emissions factors resulting from cupola furnace.

Table (4) Emission Factors of Cupola Furnace

Emissions	Factors, kg/ t
CO	7
SO_2	0.6* sulfur content in the coke
Pb	o.o5-o.o6
PM	6.9

d. Continuous Casting

Ladle emissions are negligible. The molten steel is sometimes given a cover of inert material such as rice hulls to provide thermal insulation. In addition, many modern casting facilities employ refractory-lined lids. The molten steel stream from the ladle bottom generates almost no emissions, particularly when a ceramic submersion tube surrounds it. Some emissions are seen to emerge from the molds. The emissions are caused by mold powders and mold lubricating oils. These emissions are mostly a white-blue haze generated by evaporated oil condense or mold powder combustion products. The emissions are greater if the molten steel stream is nitrogen shrouded because nitrogen prevents the burn-off of combustibles. The caster cut-off torches may also generate minor emissions because a traveling torch with an oxidizing flame cuts the red-hot steel section that emerges from the casting machine. Other emissions are generated during the maintenance of tundishes and casting ladles. These are mostly dust and iron oxide fumes from dumping and oxygen lancing sculls.

e. Rolling, Extrusion, Drawing and Forging

During the state-of-the-art of forming, the metal is introduced onto the line and passes through the major processing steps.

Uncontrolled emission estimates, calculated controlled emissions, the types of air pollution control utilized, and the techniques expected control efficiencies are summarized in Table (5). In both hot and cold forming, one can expect nitrogen oxides (NOx) emissions resulting from combustion in reheat furnaces, in annealing furnaces, or from boilers. The primary means of controlling NOx emissions is through combustion modification or selective catalytic reduction. Nitrogen oxides formed from combustion of air constituents are referred to as thermal NOx. In both hot and cold forming, one can expect nitrogen oxides (NOx) emissions resulting from combustion in reheat furnaces, in annealing furnaces, or from boilers. The primary means of controlling NOx emissions is through combustion modification ore selective catalytic reduction. Nitrogen oxides formed from combustion of air constituents are referred to as thermal NOx. The general technique to control thermal NOx is to suppress the natural gas combustion temperature to below 1400C. Above this temperature, NOx formation is exponential, while below this temperature, it is linear at a very limited rate.

Table (5) Continuous Cold Mill with BACT Controls

Purpose	Emission type	Expected uncontrolled emissions, mg/nm^3	Control technology	Calculated controlled emissions mg/m^3	Percent control
Flattens steel	Particulate matter	1000	Fabric filter	10	99
Connects coil	Particulate matter	300	Fabric filter	3.6	99
Remove oxidation	Particulate matter	1000	Fabric filter	10	99
Cleans surfaces	HCl vapor	3250	Counter current packed tower scrapper with missed eliminator	6.5	99
Reduces thickness of strip	Roll coolant spray (water & oil)	100	Baffle plate collision mist eliminator	20	80
Removes oil from strip	Alkali mist	100	Horizontal air washer	5	95
Removes light oxide	HCl vapor	140	Gas washing tower	1.7	99
Tempers/ restores/flattens	Negligible	-	Non	-	-
Applies protective oil coat	Oil aerosols	13	mist eliminator	1.3	90

Table (6) summarizes the main sources and the type of air pollutant produced from the secondary metallurgical processes.

Table (6) Main Metallurgical Industry Air Pollutants

Air pollutant	Main Characteristic	Principal Sources
Carbon monoxide (CO)	Colorless, odorless gas with strong affinity to hemoglobin in blood	Incomplete combustion of fuels and other carbonaceous materials
Hydrocarbons (HC)	Organic compounds in gaseous or particulate form (such as methane, ethylene, acetylene); component in forming photochemical reaction	Incomplete combustion of fuels and other carbon containing substances
Lead (Pb)	Heavy, soft, malleable , gray metallic chemical element ; often occurs as lead oxide aerosol or dust	Occupational exposure in nonferrous metal smelting , metal fabrication, battery making and from automobiles, if tetraethyl lead is still used as an anti-knock compound
Nitrogen oxides (NOX)	Mixture of gases ranging from colorless to reddish-brown	Stationary combustion (power plants) , mobile sources and atmospheric reactions
Particulate matter	Any solid or liquid particles dispersed in the atmosphere, such as dust , ash , soot metals,	Stationary combustion of solid fuels; industrial process such

Air pollutant	Main Characteristic	Principal Sources
	and various chemicals; often classified by diameter size-particles >(50 microns), (50 microns), fine particulate (<3 microns)	as cement and steel manufacturing
Sulfur dioxide (SO_2)	Colorless gas with pungent odor; oxidizes to from sulfur trioxide (SO_3) and sulfuric acid with water	Combustion of sulfur containing fossil fuels, smelting of sulfur-bearing metal ores, certain industrial establishments
Temperature	____	Heating, preheating and melting furnaces ladle preheating , Molten metal
Moisture	____	Rolling water cooling circuits, foundries furnaces Cooled by water chills, continuous casting and slag cooling
Noise	____	All rotating and movable machine parts, gas flow

2.4.2 Effluents

The major source of effluents in the EAF is the water used in cooling, the rolling processes is also using a substantial amounts of oils and lubricating fluids. The conventional casting process may use some liquid chemicals for the cleaning process of the casting, but it comprises minor amounts of effluents.

Table (7) gives water pollutants from metallurgical processes.

Table (7) Main Metallurgical Industry Wastewater Pollutants

Indicator	Main Characteristics	Principal Sources
Dissolved oxygen level	Dissolved oxygen is necessary in stream life to survive. Soluble organic matters deplete the oxygen by the activity of aerobic reaction. The quantity of soluble organic matters in a waste is measured either by biochemical oxygen demand, chemical oxygen demand, total organic compounds, or total oxygen demand. These measurements calculate the quantity of oxygen that a given waste will take from a stream.	Different metallurgical industries
Total dissolved solids (TDS)	TDS is a measure of the total inorganic salts and other inorganic substances that are dissolved in water.	Occurs in wide variety of industrial wastes, but in particular, high quantities in the manufacture of . Iron steel and aluminum production washing of raw materials.
Suspended solids	Includes soil and other solid particles.	Caused by industrial processes such as the manufacture of iron and aluminum production and foundries
Nutrients (phosphorous and nitrogen)	Essential for aquatic life in small amounts.	Produced slag granulation , washing of some raw materials
Color and turbidity	Produced by compounds such as lignin and tannin	Result from processes in cooling , raw materials washing
Oil and grease	Oils and greases are generally biodegradable .	Generated by many metallurgical industrial processes including those form aluminum, iron and steel.
pH value	Measures acidity and alkalinity of a stream	Wastewater from virtually all metal industrial processes causes some change in the PH level.
Temperature	Increases temperature caused by discharge of industrial cooling water into streams.	Result from several metallurgical processes that use water for cooling such as smelting and refining furnaces, ladle preheating and heat treadmill furnaces.

2.4.3 Solid Wastes

Solid waste from EAF is mainly the slag and the scales. In continuous casting the pilots of the pillets, scale of the continuous rolled pillets. In conventional casting, including molding the burned sand deserves a special attention, through the molding process there is a possibility of attaining burned hydrocarbon compounds (used in binding, cementing of thee mould, degassing practice and some additions for gas adsorption during poring).

3. ENVIRONMENTAL AND HEALTH IMPACT

3.1 Impacts of Air Pollutants on Health and Environment

Table (8) shows the major effects of air pollutants on the human health.

Table (8) Impact of Air Pollutants on Health

Air pollutant	Principal Health Effects
Carbon monoxide (CO)	Absorbed by lungs; impairs physical and mental capacitors; affects fetal development; aggravates
Hydrocarbons (HC)	Acute exposure cases eye, nose, and throat irritation; chronic exposure is suspected to cause cancer
Lead (pb)	Enters primarily through respiratory tract and wall of digestive system; accumulate in body organs causing serious physical and mental impairment
Nitrogen oxides (NO_X)	Major role as component in creating photochemical smog evidence linking respiratory problems and cardiovascular illnesses
Particulate matter	Toxic effects or aggravation of the effects of gaseous pollutants; aggravation of respiratory or cardio respiratory symptoms
Sulfur dioxide (SO_2)	Classed as mild respiratory irritant; major cause of acid rain
Temperature	Physiological load tire feeling , heat stress
Moisture	Unfavorable working condition, heat stress
Noise	Hearing loss, decreased unfavorable working condition

Pollution emitted from metallurgical industry is measured in terms of volume and the hazards it presents. Air pollutants in the atmosphere cause concern primarily because of their potential adverse affects on human health. The adverse human heath effects attributable to air pollution from metallurgical industry include acute conditions such respiratory illness and long term effects such as cancers and birth defects: Other potential adverse impacts of air pollution include damage to animal life, vegetation and buildings, and the degradation of visibility.

3.2 Impacts of Effluents on Health and Environment

Water pollution threatens individuals who come in direct contact with surface such as the river Nile and lakes, as well as those who depend on surface and ground water for drinking water. Water pollutants can enter the food chain through crop irrigation and the contamination of aquatic life. Impacts of pollutants of wastewater of metallurgical industry can range from a loss of aesthetics to a reduction in biological health, which is reflected in a variety of ways: From the loss of species diversity in the ecosystem to direct human health hazards.

Metallurgical industry discharges of concern are, heavy metals, metals, total and suspended solids. They have seriously degraded the quality of important water bodies such as the Nile river. Modern industrial facilities use a range of physical, chemical, and biological treatment technologies to bring the water quality of discharges to acceptable levels. Table (9) gives the impacts of effluent' pollutants on health and environment.

Table (9) Impact of Effluent' pollutants on Health and Environment

Indicator	Impacts on Health and Environment
Dissolved oxygen level	As the level of dissolved oxygen falls below five parts per million, adverse effects are observed on aquatic life. Many fish and marine species cannot survive significant reductions in dissolved oxygen
Total dissolved solids (TDS)	Accelerates corrosion in water system and pipes. Depresses crop yields when used for irrigation, and at high levels adversely affects fish and other aquatic life; may make water unfit for drinking.
Suspended solids	Turns waterways brown; adversely affects aquatic life; creates sludge blankets that can produce noxious gases; interferes with operation of water purification plants.
Nutrients (phosphorous and nitrogen)	At high levels nutrients stimulate growth of algae and seaweed, tend to accelerate eutrophication, and increase oxygen depletion.
Color and turbidity	Major aesthetic problem
Oil and grease	Unsightly and possibly flammable
pH value	Changes in the pH value may upset the ecological balance of the aquatic environment; excessive acidity may create air pollution problems from hydrogen.
Temperature	Decreases ability of water to assimilate waste; increase bacterial activity; may upset ecological balance of aquatic environment.

3.3 Impact of Solid Wastes on Health and Environment

Heavy metals, cyanide, inorganic matters, acids or bases, are the main wastes produced from metallurgical industries that can poses substantial hazards to human health or the environment when improperly managed. Because some of these hazardous wastes may undergo violent chemical reaction with water or other materials generates toxic gases, vapors or fumes; or if it is a cyanide or sulfide bearing waste that can generate toxic gases vapors, or fumes.

Table (10) provides some toxic chemicals with their health impacts. Table (11) lists some toxic chemicals possibly produced from hazardous wastes.

Table (10) Effects of Some Toxic Chemical on Health

Chemical	Effects on Human Health
Arsenic	Vomiting, poisoning, liver etc damage
Cadmium	Suspected cause in human kidney pathologies: tumors, renal dysfunction, hypertension, and arterio-sclerosis. Itaiitai disease (weakened bones)
Carbon tetrachloride	liver damage, heart disorder and failure
Chloroform	Kidney and liver damage
Copper	Gastrointestinal irritant liver damage
Cyanide	Acutely toxic
Lead	Convulsions, anemia, Kidney and brain damage
Mercury	Irritability, depression, kidney and liver damage Minamata disease
Nickel	Gastrointestinal and central nervous system
Iron and its oxides	Causes lungs fibrosis due to inhalation of dusts resulting from raw materials preparation
Carbon Tetra Chloride	Causes sickness, vomit, colic, diarrhea, and frustration for central nerves system, which causes dizziness. These effects lead to unconsciousness

Table (11) Some Toxic Chemicals Produced from Hazardous Wastes

Chemical	Effects on Environment
Low oxygen level	Toxic to aquatic organisms, causes reproductive defects in and fish, bioacumulates in aquatic organisms
Arsenic	Birds and toxic legume crops
Benzene	Toxic to some fish and aquatic invertebrates
Bis-(2- ethyl-hexyl) phthalate	Eggshell thinning in birds, toxic to fish
	Toxic to fish and bio-accumulation in aquatic organisms
Carbon tetrachloride	Ozone- depleting effects
Chloroform	Ozone- depleting effects
Copper	Toxic to fish
Cyanide	Kills fish, retards growth and development of fish
Lead	Toxic to domestic plants and animals, biomagnifies in food chain
Mercury	Reproductive failure in fish, inhibits growth of and kills fish, methylmercury biomagnifies
Nickel	Impairs reproduction of aquatic species
Silver	Toxic to aquatic organisms

4. EGYPTIAN LAWS AND REGULATIONS

There are a number of laws and regulations that address the different environmental violations. The following are the laws applicable to the metallurgical industry.

4.1 Concerning Air Emissions

Article 40 of Law 4/1994, article 42 of the executive regulations and annex 6 deals with gaseous emissions from combustion of fuel. The statutes relevant to the fuel combustion are:

- The use of mazout and other heavy oil products, as well crude oil shall be prohibited in dwelling zones.
- The sulfur percentage in fuel used in urban zones and near the dwelling zones shall not exceed 1.5%.
- The design of the burner and fire-house shall allow for complete mixing of fuel with the required amount of air, and for the uniform temperature distribution that ensure complete combustion and minimize gas emissions caused by incomplete combustion..
- Gases containing sulfur dioxide shall be emitted through chimneys rising sufficiently high in order that these gases become lighter before reaching the ground surface, or using fuel that contains high proportions of sulfur in power generating stations, as well as in industry and other regions lying away from inhabited urban areas, providing that atmospheric factors and adequate distances to prevent these gases from reaching the dwelling and agricultural zones and regions, as well as the water courses shall be observed.
- Chimneys from which a total emission of wastes reaches 7000 – 15000 kg/hr, shall have heights ranging between 18 – 36 meters.
- Chimneys from which a total emission of gaseous wastes reaches more than 15000 kg/hour, shall have heights exceeding at least two and a half times the height of surrounding buildings, including the building served by the chimney.

The permissible limits of emissions from sources of fuel combustion are given in tables (12 and 13) (Ministerial decree no. 495, 2001).

Table (12) Maximum Limits of Emissions from Sources of Fuel Combustion in Boilers

Pollution	Maximum limit mg/m^3 of Exhaust
Sulfur Dioxide.	3400
Carbon Monoxide.	250
Smoke.	50

Table (13) Maximum Limits of Emission from Fuel Burning Sources

Pollutant	Maximum Permissible Limit, mg/ m^3
SMOKE	250
DISPERED ASHES	250 (sources existing in urban regions, or close to residential areas)
	500 (sources for from habitation)
	500 (burning of wastes)
SULPHUR DIOXIDE	Existing 4000 New 2500
ALDEHYDES	Burning of waste 20
CARBON MONOXIDE	Existing 4000 New 2500

4.2 Concerning Effluents

Limits for pollutants in wastewater vary depending on the type of receiving water body. The parameters that should be monitored and/or inspected are BOD, COD, pH, temperature, residual chlorine, TSS, TDS, Oil and Grease. Table (14) presents the permissible limits for discharges to the different recipients (sea, Nile, canals, agricultural drains, public sewer) according to the different relevant laws. Spent lube oil has a negative impact on water and soil and therefore its disposal should be monitored/inspected. A record should be kept for this purpose.

Table (14) Egyptian Environmental Legal Requirements for Industrial Wastewater

Parameter (mg/1 unless otherwise noted)	Law 4/94: Discharge Coastal Environment	Law 93/62 Discharge to Sewer System (as modified by Decree 44/2000)	Law 48/82: Discharge into :			
			Underground Reservoir & Nile Branches/Canals	Nile (Main Stream)	Drains	
					Municipal	Industrial
BOD (5day,20 deg.)	60	<600	20	30	60	60
COD	100	<1100	30	40	80	100
pH	6-9	6-9.5	6-9	6-9	6-9	6-9
Oil & Grease	15	<100	5	5	10	10
Temperature (deg.)	10C>avg. temp of receiving body	<43	35	35	35	35
Total Suspended Solids	60	<800	30	30	50	60
Settable Solids	—	8 cm^3/ l (10 min) 15 cm^3/ l (30 min)	—	20	—	—
Cadmium	0.05	0.2	0.01	0.01	Total concentration for theses metals should be: 1 for all flow streams	
Chromium	1	—	—	—		
Chromium Hexavalent	—	0.5	1	1		
Copper	1.5	1.5	1	1		
Iron	1.5	—	1	1		
Lead	0.5	1	0.05	0.05		
Nickel	0.1	1	0.1	0.1	—	—
Zinc	5	—	1	1	—	—
Total heavy metals	—	<5	<1	1	1	1
Aluminum	3	—	—	—	—	—

4.3 Concerning Solid Waste

A number of laws address solid waste management. The following laws apply to scrap and sludge from the WWTP:

- Law 38/1967, which addresses public cleanliness, regulates the collection and disposal of solid wastes from houses, public places, commercial and industrial establishments.
- Ministry of Housing, Utilities and Urban Communities (MHUUC) decree No. 134 of 1968, which provides guidelines from domestic and industrial sources, including specifications for collection, transportation, composting, incineration and land disposal.
- Law 31/1976, which amended law 38/1967
- Law 43/1979, the Law of Local administration, which provided that city councils are responsible for "physical and social infrastructure", effectively delegating responsibility for infrastructure functions.
- Law 4/1994 regulates incineration of solid waste

4.4 Concerning Work Environment

Violations of work environment could be encountered:

- Wherever burning fuel is performed: gas emissions, regulated by article 43 of Law 4/1994, article 45 of the executive regulations and annex 8. The limits for the relevant pollutants are presented in table (15).
- Wherever heating is performed: temperature and humidity are regulated by article 44 of Law 4/1994, article 46 of the executive regulations and annex 9. Table (16) shows the maximum limits for heat stress.
- Near heavy machinery: noise is regulated by article 42 of Law 4/1994, article 44 of the executive regulations and table 1, annex 7. These limits are given in the tables (17, 18 and 19).
- Ventilation is regulated by article 45 of Law 4/1994 and article 47 of the executive regulations.
- Work environment conditions are addressed in Law 137/1981 for Labor, Minister of Housing Decree 380/1983, and Minister of Industry Decree 380/1982.

Table (15) Threshold Limits for Some Pollutants in Work Place

Material	Threshold			
	Time average		Exposure limits for short periods	
	ppm	mg/m^3	ppm	mg/m^3
Acetone	750	1780	1000	2375
Aluminum metal and its oxides	10		20	
Welding smoke and fumes	5			
Carbon Dioxide	5000	9000	15000	27000
Carbon Monoxide	50	55	400	440
Ethylene Glycol Vapor	50	125	50	125
Ethyl Methyl Ketone	200	590	300	885
Trichloro Ethylene	50	270	150	805
Fine Saw Dust		5		10
Carbon Tertiary Chloride	100	435	150	655
Xylene			5	

Table (16) Maximum Permissible Limits for Heat Stress (law 4/1994)

Type of Work	Low Air Velocity	High Air Velocity
Light work	30^o C	32.2 ^{o} C
Moderate work	27.8 ^{o} C	30.5 ^{o} C
Severe work	26.1 ^{o} C	28.9 ^{o} C

Table (17) Maximum Permissible Noise Levels (law 4/1994)

No	Type of place and activity	Maximum permissible noise decibel (A)
1	Work place with up to 8 hour and aiming to limit noise hazards on sense of hearing	90 dB
2	Work place where acoustic signals and good audibility are required	80 dB
3	Work rooms for the follow up, measurement and adjustment of high performance operations	65 dB
4	Work rooms for computers, typewriters or similar equipment	70 d.B
5	Work rooms for activities requiring routine mental concentration	60 dB

Table (18) Noise Intensity Level Related to the Exposure Period

Noise intensity level decibel (A)	95	100	105	110	115
Period of exposure (hour)	4	2	1	½	¼

Table (19) Noise Intensity Level In Intermittent Knocking Places

Noise Intensity db	Max Allowable Knocks During Daily Work Period
135	300
130	1000
125	3000
120	10,000
115	30,000

3.1 Concerning Hazardous Material and Wastes

Law 4/1994 introduced the control of hazardous materials and wastes. The metallurgical industry does not generate any hazardous wastes. Hazardous chemicals such as hydrochloric and nitric acids are used for washing vessels. The hazardous chemicals used in the lab and the fuel for the boilers, fall under the provisions of Law 4/1994. Articles 29 and 33 of the law makes it mandatory for those who produce or handle dangerous materials in gaseous, liquid or solid form, to take precautions to ensure that no environmental damage shall occur. Articles 25, 31 and 32 of the executive regulations (decree 338/1995) specify the necessary precautions for handling hazardous materials. Storing of fuel for the boilers is covered by the Law 4 as hazardous material There is no explicit articles in Law 4/1994 or in decree 338/1995 (executive regulations), regarding holding a register for the hazardous materials; article 33 is concerned with hazardous wastes. However, keeping the register for the hazardous materials is implicit in article 25 of the executive regulations regarding the application for a license.

3.2 Concerning the Environmental Register

Article 22 of Law 4/1994 states that the owner of the establishment shall keep a register showing the impact of the establishment activity on the environment. Article 17 and Annex 3 of the executive regulations specify the type of data recorded in the register.

The emergency response plan and the hazardous materials register will also be part of the environmental register as stated in law 4/ 1994.

4. POLLUTION ABATEMENT PROCEDURES

5.1 Air pollution abatement measures

a. Electric Arc Furnace (EAF) Steel Melting

Most EAF have fabric filters (baghouses) for fume cleaning and collection. Both positive- and negative-pressure fabric filters are used. Cleaning methods of all types-reverse air, shaker, and pulse jet-are employed. The reverse air filter is the most commonly used type of filter.

Pulsejet bag-houses are sometimes used for EAF fume cleaning. Most EAF fume systems carry furnace sparks to the baghouse where they tend to cause bag spark damage. Well-designed baghouse hopper inlets have the ability to drop these sparks out in the hopper before they have a chance to travel onto the bag surface. Collected dust should be removed from the baghouse hoppers as soon as possible in order to prevent dust re-entrapment and bridging of dust in baghouse hoppers. As an alternative to the baghouse (dry) emission control system, scrubbers are also in use today. These systems use water sprays to trap the particulate mailer the water is collected and re-circulated to the scrubber. Sludge is collected in a clarifier. This sludge must be dewatered prior to further handling.

Contact of the molten steel with air should be minimized. Maintaining a slag layer, shrouding and using ladle covers are examples of this type of control and reduce the formation of particulate emissions. The degree of inert gas stirring may increase the fumes generated. High gas rates lead to vigorous agitation of the steel heat, exposing molten steel to the air.

Certain wire or powder additions, such as calcium silicate, greatly increase fume emissions owing to their high vapor pressures and high reactivity. When injected into the ladle, vigorous reactions result in the release of a white fume. The LM furnace may share a common bag house with an EAF or other secondary emission sources in the foundry.

b. Forming Processes

During the state-of-the-art of forming processes, metals are introduced onto the line and passes through the major processing steps. In both hot and cold forming, one can expect nitrogen oxides (NOx) emissions resulting from combustion in reheat furnaces, in annealing furnaces, or from boilers. The primary means of controlling NOx emissions is through combustion modification or selective catalytic reduction. The general technique to control thermal NOx is to suppress the natural gas combustion temperature to below 1400C. Above this temperature, NOx formation is exponential, while below this temperature, it is linear at a very limited rate.

c. Casting

a-1 Iron Foundries

There are two primary collection methods for foundry particulate-wet and dry. Wet scrubbers include low- and high-energy types. Dry collection includes baghouses mechanical collectors, and electrostatic precipitators. In addition, the control of organic compounds may require incineration or afterburners. Air toxics merit special consideration, requiring careful selection of the collection method.

- Wet Collectors

All wet collectors have a fractional efficiency characteristic-that is, their cleaning efficiency varies directly with the size of the particle being collected. In general, collectors operating at a very low-pressure loss will remove only medium to coarse particles. High-efficiency collection of fine particles requires increased energy input, which will be reflected in higher collector pressure loss. In addition, gas scrubbers may be used to control odors, toxic and sulfur dioxide emissions. In this case, acids, bases, or oxidizing agents may have to be added to the scrubbing liquid.

- Dry Collectors

The most frequently encountered equipment for the removal of solid particulate matter from an air stream or gas stream is the fabric dust collector or bag-house. Filter media are available for hot corrosive atmospheres, such as furnace emissions. Operating inlet temperatures up to260C are not uncommon.

Teflon-coated woven-glass-fiber bags have been used on a large majority of cupola installations because of their high temperature resistance. Afterburners may be used in some processes to control emissions, particularly when oily scrap or hydrocarbons in any form are charged into the furnaces or scraps preheat systems. If afterburners are not used, carbon monoxide and oil vapors may be emitted through the discharge stack of the air pollution equipment.

In general, in the selection of collection devices for all processes, moisture, temperature, and the presence of corrosive materials must be considered.

a-2 Steel Foundries

Controls for emissions during the melting and refining operations focus on venting the furnace gasses and fumes directly to an emission collection duct and control system. Controls for fugitive furnace emissions involve the use of either building roof hoods or special exhaust hoods near the furnace doors to collect emissions and route them to emission-control central gathering points. Emission control systems commonly used to control particulate emissions from the electric arc and induction furnaces are normally bag filters, electrostatic precipitators, or venturi scrubbers. Many of the present-day electric arc furnaces incorporate the canopy hood with other systems

5.2 Liquid wastes abatement measures

a. Electric Arc Furnace Steel Melting

Some parts of the electric arc furnace must be water-cooled (electrodes champs, cover rings, bottom side of the furnace…). No contamination of this water is expected. That water may be completely cooled and recycled. Also the water used in cooling compressors is recycled. If wet scrubbers are used, water is sprayed to trap the particulate; then water is collected and re-circulated to the scrubber. Sludge must be de-watered prior to further handling.

b. Rolling

Usually cooling water is completely recycled with an addition of about 20% per day as a loss. The mills collect waste oil, which must be stored in two ways to be sold to licensed suppliers. Mill scales (1-3% of the production) can be reused in sintering plants.

c. Iron and Steel Casting Production

Water is used in iron and steel foundries as an addition of 3-5% of molding mixtures; this water goes in vapor. Also water is completely recycled by making use of it for cooling the furnaces and compressors. Some foundries use water in washing. This water must be treated before discharging.

d. Metal Drawing and Extrusions

Water is used for cooling the dies. Because contamination is expected, water is completely recycled.

e. Oils

Different types of oils are used as lubricants, which amounts of its wastes depend upon working contamination conditions and machine design. In metallurgical plants oils (rejects) ranges from 60-80%; these amounts must be collected, stored in a proper and safe way to be sold.

5.3 Solid wastes abatement measures

a. Electric arc Steel Making

From 10-20 kg of slag is produced from smelting carbon steel in a medium size electric arc furnace. The amount of slag also depends upon the refining and alloying process. Usually slags mixed with broken and waste refractors are collected to be dumped.

b. Rolling

Scales are the main solid wastes of steel rolling. These scales are collected from the rolling pass or from the cooling water to be reused as a part of charging material of sintering or to be added to the steel melt as a de-oxidizer and refiner.

c. Iron and Steel Castings

Waste refractories, burned sands, and slag are the main solid wastes of iron foundries, which must collected and dumped in a proper way. Defected castings, rejects and heeding systems are completely recycled in the shop. They are used as charging metals in the melting unit.

5.4 Examples of cleaner production

To avoid possible facility closings, the iron steel industry has been actively investigating cleaner alternatives. One promising technology, the direct steel-making project that was jointly funded by the American Iron and Steel Institute (AISI) and the U.S. Department of Energy (DOE), concluded on March 31, 1994. This technology reduces, melts, and refines iron in a single reactor. Another option, DOE cost-sharing program for the smelting of steel plant waste oxides began on April 1, 1994. Based on the success of recent trials, and the further knowledge that was gained from this follow-on program, the technology is now well understood and fully developed. A feasibility study for a demonstration plan may now be available.

6. ENVIRONMENTAL SELF-MONITORING

Self-Monitoring (SM) is a process that primarily relates to measurements of process inputs, releases and environmental pollution levels, as well as process conditions (operation controls) that are directly related to the monitored emissions. Self – monitoring is necessary for the plant to improve its economic performance by identifying the sources of wastes in raw materials, water, and energy that represent the main sources of pollution. Thus, the plant would be able to implement pollution prevention techniques that could reduce production costs and minimize compliance costs, which should lead to improved economic and environmental performance of the plant.

In addition, self-monitoring may include reporting of the results to the pertinent authorities. Monitoring can be carried out by the industrial establishment, or on its behalf, and paid for by the industrial establishment. The information obtained from the sampling component of the monitoring system must be recorded and the results reported to the appropriate internal and external decision-makers.

6.1 Benefits of SM

In general, the benefits of self-monitoring results to the operators include:

- Raising their awareness about the process performance and efficiency
- Having them ready for inspection by authorities.
- Providing inspectors with more reliable data to verify the single unrepresentative samples and/or measurements
- Raising their awareness about impact of pollutants
- Implementing corrective actions if non-compliance occurs.
- Deciding on raw materials, additives, fuels, and investment strategies.
- Identifying trends in plant performance and setting alarms.
- Improving process efficiency.

These benefits are generated through implementing an integrated environmental self-monitoring plan that comprises:

- Emission monitoring, which covers releases to air, wastewater, and solid and hazardous waste as well as regulated working conditions
- Monitoring of process parameters (operation controls) that are directly related to the releases; such as temperature, pressure, and humidity. In addition, process conditions such as shutdowns, maintenance operations, and spills need to be also monitored, linked to emissions, and reported.

6.2 Scope and Objectives of SM

As previously indicated, environmental self-monitoring comprises the monitoring of environmental releases (emissions) as well as the monitoring of process parameters (operation controls) that affect the environmental impact of the facility. The objectives of each type are separately detailed as follows:

a) Emissions self-monitoring

The basic objective of self-monitoring is to monitor compliance with environmental regulations. As the inventory for hazardous materials and wastes is mandatory with procedures for handling and storage as regulated by law 4/1994, self-monitoring should assist in covering this area. The objectives of emission monitoring may go beyond monitoring compliance; i.e. to assist improving environmental performance. In other words, monitoring of emissions at the process level is necessary to minimize emissions at the source through pollution abatement and prevention measures. While Egyptian regulations consider only concentration of the pollutants, self-monitoring may include pollution loads as well as the environmental impact on the receiving media. These data are required to assess the improvement of the environmental performance.

b) Process self-monitoring (operation control)

In most industrial facilities monitoring of process operations already exists. Some process operation controls should be monitored for improved environmental benefits. The main objectives of process self-monitoring (operation control) is:

- Optimization of process operation by controlling the operating conditions
- Minimization of losses
- Planned maintenance and repair as opposed to emergency maintenance and shutdown
- Minimization of cost through conservation of energy and water

6.3 SM and Environmental Management Systems (EMS)

Aside from the regulatory aspects, SM has shown to be a necessary tool for the plant to manage its releases, control its environmental impacts and improve its environmental performance. Such achievements represent the main objectives of the Environmental Management Systems (EMS), which in turn constitute a requirement for internal monitoring, checking and implementing the corrective actions. In addition, EMS encourages the industrial plants to adopt Cleaner Production, (CP), and Pollution Prevention, (P2), measures as the main tools for continual improvement. This can be achieved only by implementing a comprehensive and effective SM plan.

The following sections highlight the concept of EMS, link to SM and link between SM and cleaner production.

6.3.1 Environmental Management Systems (EMS)

An Environmental Management System (EMS) is a framework that helps a company achieve its environmental goals through consistent control of its operations. The EMS itself does not dictate a level of environmental performance of the company; each company tailors its EMS to its specific business goals. Compliance with environmental laws and regulations has become a major goal that has to be attained with minimum cost. This is the minimum level for environmental performance to be achieved through the EMS. In general, an EMS comprises five phases leading to continual improvement; commitment and policy, planning, implementation, evaluation and review. These phases will be herein explained within the context of the standard system "ISO 14000", which is internationally recognized. With regard to Egypt, this system is being gradually implemented by the Egyptian Industry. The different stages of the EMS form a cycle (Figure 11) that allows feedback of information and continuous improvement. This system includes the following elements:

1. ***Environmental policy.*** Top management commits to an environmental policy that comprises, as a minimum, compliance with laws and regulations, pollution prevention and continual improvement. The policy is the foundation of the EMS
2. ***Planning***: The company first identifies environmental aspects of its activities. Environmental aspects are those items such as air pollutants or hazardous wastes that can have negative impacts on people and/or the environment. Once the pertinent laws and regulations are identified, the company sets objectives and targets. An objective is an overall environmental goal (e.g. minimize use of chemical x). A target is a detailed, quantified requirement that arises from the objective (e.g. reduce use of chemical ***x*** by 25% by September 2003). The final part of the planning stage is developing an action plan for meeting the targets, including schedule, resources, and the clearly defined steps to meet the targets.
3. ***Implementation.*** This phase comprises the establishment of the structure, assignments and responsibilities of the designated personnel. An important component is personnel training and awareness for all employees. Other steps in the implementation stage include documentation, document control, implementing operation procedure, and setting up internal and external communication lines. In addition, an emergency and preparedness plan has to be developed.
4. ***Checking and Corrective Action***. The company monitors its operations and activities to ensure that targets are being met. If not, the company takes corrective action and keeps records for the emissions and environmental performance. Internal audit is a key element to improve the system.
5. ***Management Review.*** Top management regularly reviews the results of the evaluation to see if the EMS is efficient and effective. Management determines whether the original environmental policy is consistent with company values. The plan is then revised to optimize the effectiveness of the EMS. The review stage creates a feedback of information necessary for continuous improvement.

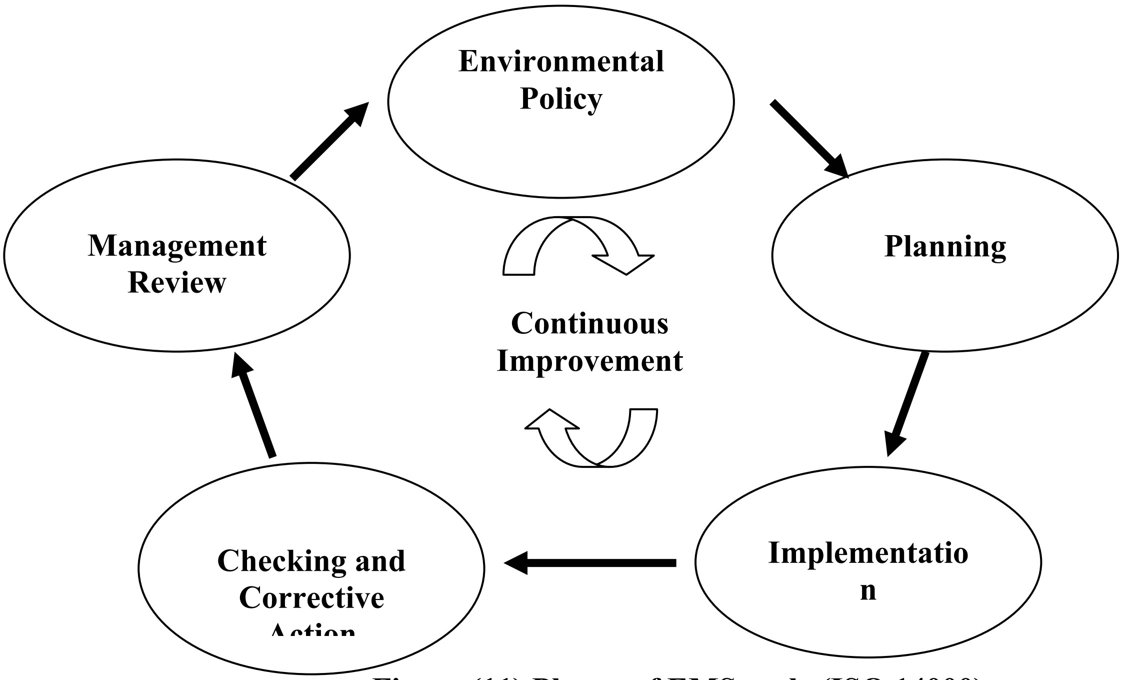


Figure (11) Phases of EMS cycle (ISO 14000)

6.3.2 Link between self-monitoring and (EMS)

As previously explained, an EMS e.g. ISO 14000, comprises 5 stages: environmental policy, planning, implementation, checking and corrective actions. By analogy, the self-monitoring system (SMS) can be looked at using the same concept. Taking into consideration the definition, concept and principles of self-monitoring, as stated in the "Guide Book on Self Monitoring", the elements of SMS can be rearranged as follows:

***Commitment*:** In general, an effective self-monitoring requires that the management of the plant be committed to environmental compliance, as a minimum. However, this commitment will be an integrated part of the environmental policy in the EMS, if exists.

Planning: The planning of the SM is mainly based on objective (s) that have been set. For a basic SMS, the objective would be monitoring of regulated parameters to assist in achieving regulatory compliance; e.g. end-of-pipe emissions and discharges. In an advanced SMS, the objectives may include monitoring of operation controls as well as emissions and wastes at the source, to help in implementing pollution prevention and cleaner production measures. In all cases, the objectives of self-monitoring should be in line with the objectives of EMS, if exists. In such case, the self-monitoring plan can be part of the EMS plan and includes:

- Description of the regulatory limits for compliance
- Brief description of the actual situation (existing monitoring activities, devices, equipment, resources,..).
- Objectives and targets with time frame for implementation.
- Identification of parameters monitored, location of monitoring points and preparation of a self-monitoring schedule.
- Description of methods and procedures used for sampling, analyses, measurements, calculations, recording and data manipulation.

- Description of tasks
- Training program

***Implementation*:** The implementation of SM means that the tools and mechanisms for collecting the relevant data are functioning. On the other hand, the implementation phase in EMS means that the environmental performance of the plant is improving. The implementation of SM results in large amount of data that need representation, interpretation and reporting in order to be useful as tools for decision making for corrective actions. The decision making requires knowledge about the status of:

- Emissions as compared to limits set by law.
- Toxic and hazardous releases: concentration, handling procedures and transfers.
- Maintenance and repair.
- Percentage losses of raw materials, products and utilities.
- Process operating parameters.

***Evaluation*:** Evaluation of the self-monitoring plan through regular auditing will allow its continuous improvement. Evaluation should include all aspects of the plan (training, meeting targets, reliability of data, efficiency of devices,…etc). On the other hand, the evaluation of the EMS involves checking and taking corrective actions of all system components, including the monitoring activities.

***Review*:** On the basis of the evaluation of the monitoring plan, a review can be made of the monitoring objectives and targets. In case of EMS, the management review covers all the involved procedures, including monitoring activities.

It is clear from the above explanation that self-monitoring is an integral part of any EMS. More specifically, self-monitoring is the tool for the evaluation function of an EMS. Figure (12) illustrates relationship and interaction among the main elements of EMS and SMS.

6.3.3 SM Link to Pollution Prevention and cleaner production

Growing understanding that escaping raw materials, chemicals and products constitute major pollution sources, industry has opted to implement pollution prevention measures at the source. These measures include in-plant and in-process modifications as well as resource conservation (minimization of water and energy consumption). The implementation of these measures will decrease the end-of-pipe treatment cost. However, plant management will have to undertake a cost-benefit analysis to determine which measures are economically viable.
Self-monitoring is the tool that helps undertake these analyses by providing the necessary data and information about process inputs and outputs as well as the framework for performing the required tasks.

The introduction of emission monitoring for the purpose of improved environmental performance through the application of cleaner technology widens the objectives of the plant EMS beyond compliance with relevant laws and should be met with economic incentives from the part of the competent authorities.

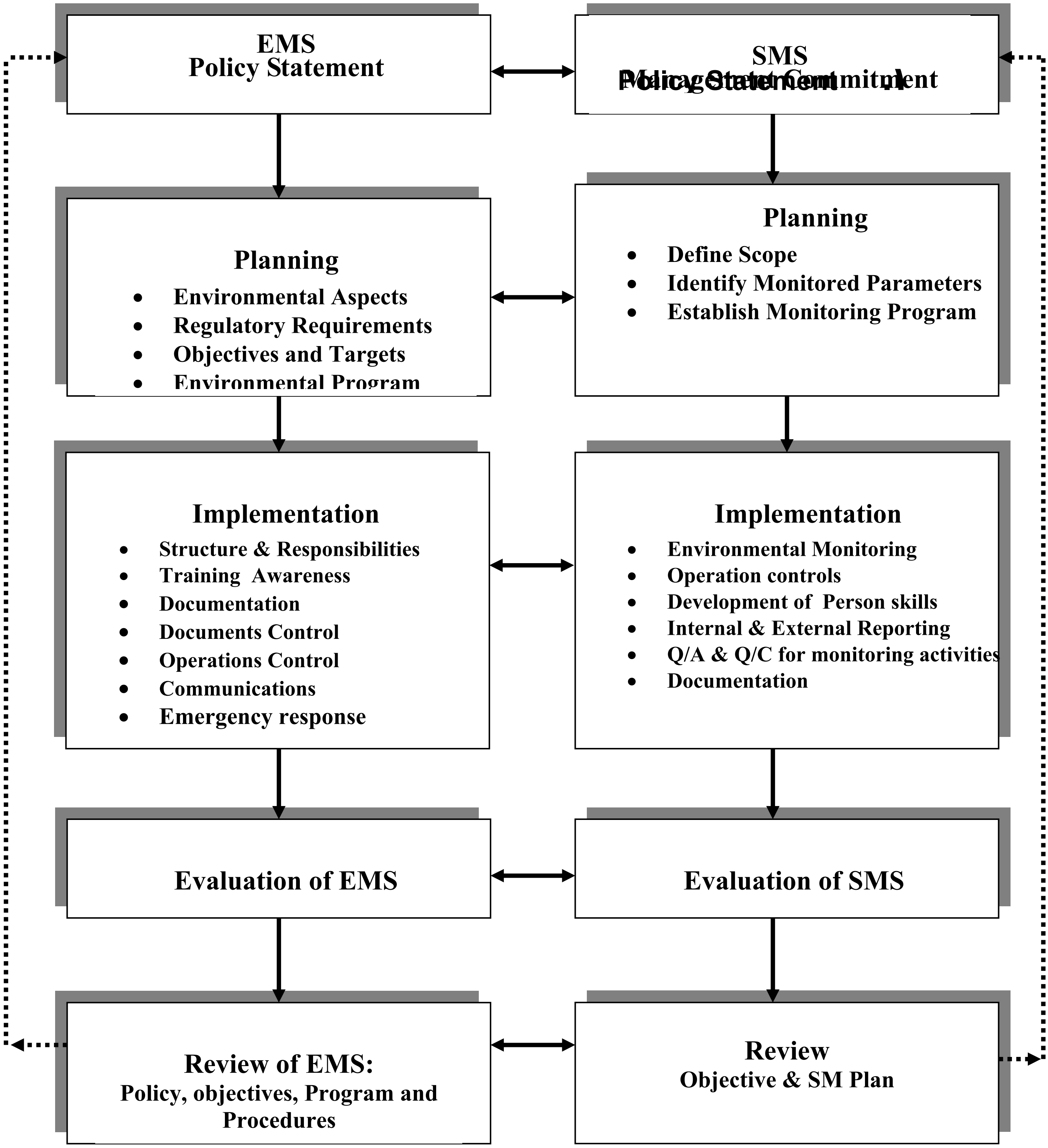


Figure (12) Relationship between EMS and SMS

6.4 Regulatory Aspects

In developed industrial countries, e.g. in Europe, the competent authorities must approve the monitoring program, specify the standards and quality requirements for self-monitoring that are to be achieved by the operator, and ensure those possibilities for cheating and fraud are minimized. The competent authorities will receive self-monitoring reports periodically from the operator. These should provide summary information, following data reduction, in a format facilitating easy comparison with permit limits. Additionally, the competent authorities would inspect the operator's self-monitoring records, including log sheets covering sampling, analyses, instrumental monitoring, and data-reduction calculations.

6.4.1 SM and Environmental Register

According to Law 4/1994, industrial facilities (operators) are required to keep a record of their inputs, outputs and releases in the environmental register as stated by which implicitly requires some sort of self-monitoring. The Egyptian Environmental Affairs Agency (EEAA) is mandated to check the validity of the data in the Environmental Register. The responsibilities of the operator and the competent authority are not affected by who carries out the monitoring. It is the responsibility of the operator to comply with laws and regulations. On the other hand, the competent authorities (inspectors) are responsible for assessing and ensuring the operator's compliance.

When combined with Self-monitoring, the Environmental Register can offer benefits to the ***competent authorities*** through:

- Utilizing the operator's knowledge and experience of his process in planning and carrying out a monitoring program that can lead to improved control over releases to the environment.

- Self-monitoring will normally provide more information than may be obtained by periodic inspection by the competent authorities.

- Providing a mechanism for educating the operator about the requirements for complying with relevant laws, regulations and permits and for increasing of management responsibility for compliance and the impact of process releases on the environment.

6.4.2 SM and Inspection

Self-monitoring does not constitute self-regulation. SM provides additional information on which the competent authorities can judge whether an operator is complying with relevant legislation and conditions of permits. It does not change the duty of the competent authority to assess compliance by means of inspection and by performing its own monitoring or choose to rely on the operator's monitoring data or a combination of both. The competent authority continues to be responsible for enforcement.

As mentioned above, SM provides a wealth of information that can be utilized by the competent authority in reviewing standards and developing applicable environmental policies. However, the competent authority will have to check the reliability of the SM data. Thus, inspectors may be required to check the SMS plan, QA/QC procedures, data handling and documentation. In this context, it is expected that inspectors may perform the following tasks:

- Check the SM program
- Check and verify the specified measurement standards
- Check the reliability of the data (by carrying out independent monitoring).
- Inspect SM arrangements such as:
    - The positioning and serviceability of fixed instrumentation.
    - Records confirming the maintenance and calibration of instrumentation and sampling equipment.
    - Manual sampling and analytical procedures.

This expected interaction would help both partners, i.e. the operator and the competent authority, in achieving their objectives in terms of reliability of emission data and environmental performance.

7. PLANNING OF SM

Planning for SM starts by setting the objectives. It should be clear that a number of process control parameters needs to be monitored, along with environmental monitoring. For the purpose of this manual environmental self-monitoring will be considered in addition to monitoring of process parameters that are related to emissions (operation controls).

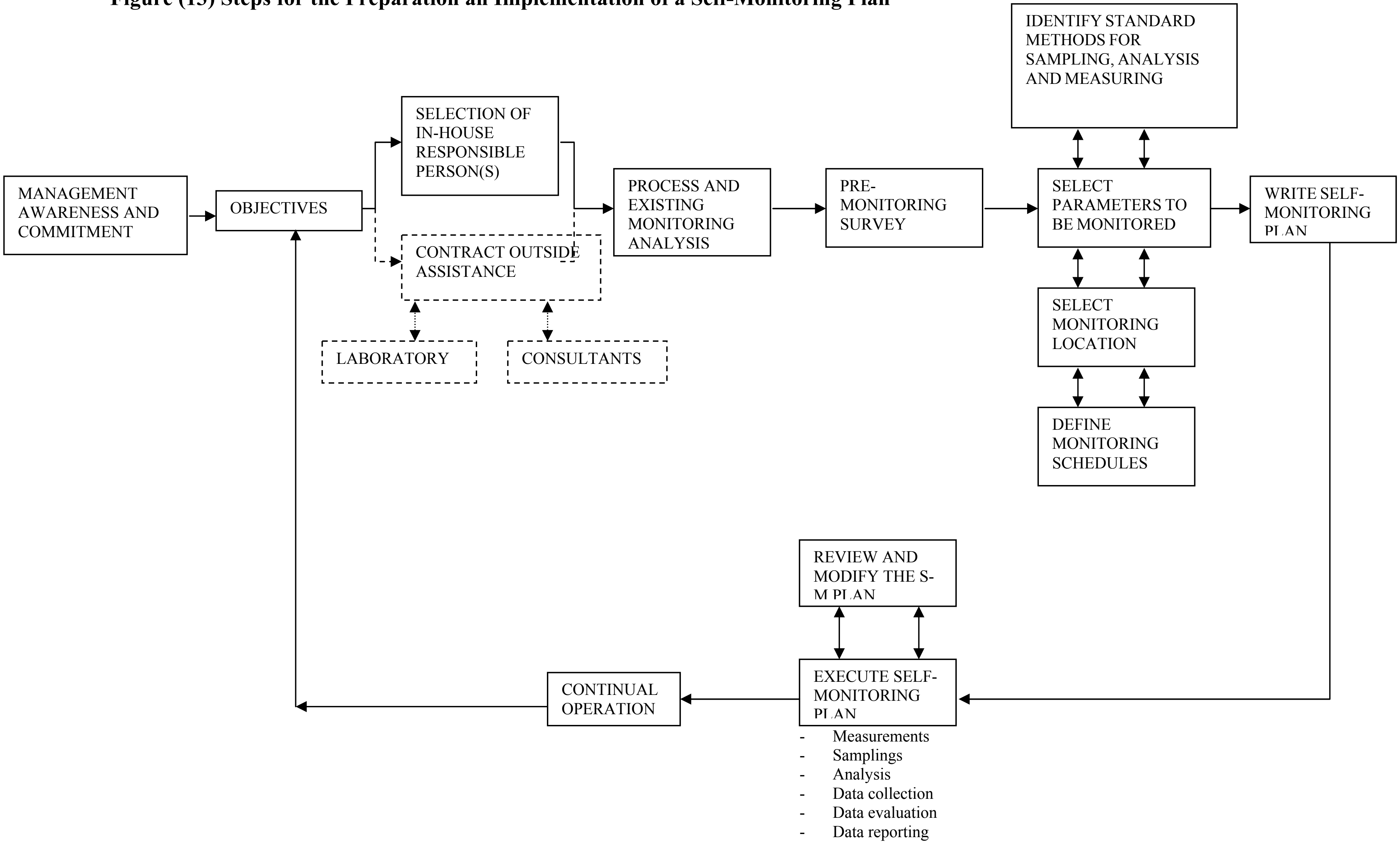
Compliance monitoring requires measurements, analysis and data on end-of-pipe releases, whereas operation controls target the production units that offer pollution prevention opportunities. The environmental manager with the help of various sector managers should carry out the planning activities.
With reference to ”Guidebook for Industrial Self-Monitoring”, the main elements of the Self-Monitoring Plan, that describes the SMS, include:

- Objectives and results required from the self-monitoring system
- Organization and share of responsibilities and tasks
- Planning activities and design of an implementation schedule
- Definition of the parameters and relevant monitored indicators to reach the objectives
- Design of an appropriate measurement and sampling program
- Data processing and reporting procedures
- System for follow-up of decisions, actions and monitoring development
- Quality assurance and control

With reference to the Guidebook for Industrial Self-Monitoring the objective of the SMS can be limited to provide the data required for the Environmental Register which is mandated by the Environmental Law, e.g. total inputs, outputs and emissions on the plant level. This objective ”compliance with regulations” requires the ”Basic Self-Monitoring System” which comprises the minimum requirements. In these cases where self-monitoring is not mandatory, operator can build a ”basic” self-monitoring system that focuses on the regulated emissions, as a minimum. Then, the system can be gradually upgraded, ”continual improvement” through internal auditing of all system components. Other objectives, e.g. waste minimization, pollution prevention and improved environmental performance require upgraded SMS that includes monitoring of inputs, outputs and releases on the level of operations and detailed processes. In all cases, the established SMS should be gradually improved and upgraded, considering the plant financial and economic constrains.

The following sections are detailing the stepwise activities that are needed to develop a viable, realistic, and applicable plan for a self-monitoring system. Figure (13) presents the various steps for the preparation and implementation of a self-monitoring plan.

Figure (13) Steps for the Preparation an Implementation of a Self-Monitoring Plan



7.1 Assessment of existing monitoring capacity

Assessment of existing monitoring capacity includes the following aspects:

- Management system: presence of an EMS, existing system for data collection and reporting.
- Human resources: available personnel, level of training; motivation.
- Technical resources: monitoring equipment and laboratory, status of equipment
- Financial resources: available budget for self-monitoring activities.

Table (20) presents an example of a checklist for existing self-monitoring activities.

Table 20. Example for assessing the status of existing monitoring activity.

Monitored activity	Location	Parameter	Associated tasks	Person in charge	Frequency
Wastewater	Final discharge	Flow rate	Recording flow on flow meter Inspect meter Calibrate Data analysis, representation	Operator X Supplier Operator Y Lab staff	Daily
		BOD, COD..	Grab sample Sample preservation Analysis Review results and reporting	Lab technician Lab staff Lab staff Chief of Lab	Once a week

7.2 Identification of key parameters

The identification of key monitoring parameters requires an understanding of the manufacturing processes and the operation of the various units. The brief description provided in section 2 and the relevant tables can help identify some of these parameters. However, a pre-monitoring audit is necessary to determine sampling and measurement locations and schedules needed to design the self-monitoring plan. Priority should be given to parameters that determine compliance with environmental laws. A table describing the monitoring activities can be prepared for process and compliance monitoring.

The exact positions of the monitoring points within the production line have to be determined on a case by case basis by production experts, according to the following criteria (SM Guidebook, EPAP 1999):

- Representativeness of the monitoring point.
- Criticality of the monitoring point
- Accessibility of the monitoring points

The choice of the parameters is determined by the type of production, the legal requirements, the nature of the pollutant and its load, and the importance of the parameter for decision making. For each of the proposed parameters the trends and variations should be monitored in addition to the value of the parameter at a given time.

7.3 General data required

When assessing the performance of the operation and its impacts on the environment, some basic information is needed to put the monitoring data into the context of interpretation. Such information is about:

- Identification: Name, address, plant location, name of owner, manager and head of environmental department.
- Inputs name, type and amount: Raw materials, chemicals, fuels, water, steam, electricity.
- Technology: Description of process, applied technology, operating conditions (temperature, pressure), maximum capacity, operating capacity during monitoring.
- Outputs name, type and rate: Products, by-products
- Abatement techniques: Air pollution prevention, wastewater treatment, solid waste management, noise abatement
- Emissions and their sources: receiving media, pollutant type, concentration and load, pollutant impact.
- Existing EMS system, analyses and measurement results, relevant environmental laws and allowable pollutant levels.
- Assessment of legislative and regulatory requirements.

7.4 Data collection, manipulation and reporting

Data collection and analysis should be carefully planned according to the following principles:

- Base the analysis on trends over a long period to take into consideration the shock loads that characterize the metallurgical industry.
- Determine the causes and degree of variability of a parameter. A dramatic change of a low-variability parameter may be interpreted as a sign of anomaly of the process. This will require an investigation to find the potential source of the problem and take the right corrective action.
- Study the correlation between different parameters. The cause of variation for a highly variable parameter may be correlated to another parameter.

A considerable amount of data may be generated by the operator carrying out self-monitoring especially when continuous monitoring instrumentation are used. Data reduction is necessary to calculate time-averaged means, percentile values and the like. When compliance data are recorded in the environmental register the relevant calculations for data reduction should be specified.

Measured values are used to form half-hourly mean values for each successive half-hour to generate frequency distribution. For each calendar day a daily mean value, related to the daily operating time, is calculated from the half-hourly mean values and kept on file. Measurement results should be kept in the environmental register for at least 10 years (Article 22 of law 4/1994 and 17 of its executive regulations). An annual report is prepared on the outcome of the measurements including information on:

- Measurement planning
- The outcome of each individual measure
- Measurement methods used

- Operating conditions that are important for the assessment of individual data and measurement results.

7.5 Criteria for selecting monitoring method.

The choice of monitoring method used to determine the value of the parameter depends on the specific features of the process, the emission sources, the physical state and properties of the sample and the nature of emissions from the operation. The latter can be classified as:

Normal emissions	Occur during normal operation and normal process and abatement technique conditions .
Diffused and fugitive emissions	These are emissions from a certain process but from scattered points such as emissions from ventilation ducts, barrels, and scattered small stores. The diffuse emissions are calculated/estimated by monitoring the source periodically and assessing the long-term emission from the measurement results or by mass balance calculations.
Exceptional emissions	Exceptional emissions refer to varying input or process conditions, start-ups, shutdowns, by-pass of a process for malfunctioning and accidental causes. The emissions can differ from those of normal operation in their volume and/or concentration. These emissions can be multiple compared to normal emissions. It can be impossible to measure the concentration or volume of the exceptional emissions as the measuring device is calibrated according to the normal operating conditions. Estimation techniques should then be performed.

There are four basic methods that may be used to develop estimates:

- Direct or indirect measurement
- Mass balance
- Emission factors
- Engineering calculations

7.5.1. Direct or indirect measurement

a) Direct measurements: Using monitoring data or direct measurements is usually the best method for developing chemical release and/or other waste-management activity quality estimates. Data may have also been collected for the facility through an occupational health and safety assessment. If only a small number of direct measurement data is available or if the monitoring data are not based on a representative sample, another estimation method should be used to give a more accurate result.

> ***Note : Treatment Efficiencies***
> Supplier data on treatment efficiencies often represent ideal operating conditions, should be adjusted to account for downtime and process upsets during the year that would result in lower efficiencies. Efficiencies reported by supplier are often general and may not apply to specific chemicals. For example, an incinerator or flare may be 99.99% efficient in destroying organic chemicals, but will have a 0% efficiency in destroying metals.

For successful measurements the following considerations should be satisfied:

- The frequency of measurement and sampling must cover temporal variations of the process and specifically the period during which harm occurs.
- Continuous monitoring is suitable for large emission sources, such as stacks and wastewater canals except in cases where high temperature or corrosive substances are involved. At smaller sites the cost of continuous monitoring is weighed against the value of the monitoring results and the possibility of obtaining representative results from periodic measurements.
- Utilization rate (percentage of continuous monitoring time to total operation time) should be known when performing continuous monitoring.
- The process conditions must be specified when monitoring takes place (e.g. start-up, shutdown, production rate, operating production lines, and failure of abatement equipment).

b) Indirect measurements: These are performed through surrogate parameters. Surrogate parameters are variables that can be closely related to conventional direct measurements of pollutant releases or impacts and which may therefore be monitored and used instead of direct values for some practical purposes. Surrogates are commonly used in operation control as they give an early warning of possible abnormal conditions or emissions. Surrogates may provide a relative measurement rather than an absolute value and may only be valid for a restricted range of process conditions. On the other hand, surrogates can provide more continuous information than direct measurements. It is also often cost-effective as it allows more discharge positions to be monitored for the same resources. The advantages and disadvantages of surrogate parameters are summarized in Table (21).

A surrogate can be used for compliance monitoring purposes if all the following conditions are met:

- It is closely and consistently related to a required direct value (e.g. fuel sulfur vs. directly measured SO_2, relationship between opacity and particulate concentration, condenser temperature and VOC emissions).
- It is regularly calibrated against the direct value.
- It is cheaper or easier to monitor than the direct value, or gives more frequent information
- Its value can be related to specific limits
- The process conditions where it is measured matches the conditions where direct measurements are required.
- Any extra uncertainty due to use of surrogate is not significant for regulatory decisions or process management.

Table (21) Advantages and disadvantages of surrogate parameters

Advantages	Disadvantages
- Cost savings - More continuous information e.g. continuous opacity vs. periodic dust sampling - Allow more positions form discharge monitoring - Sometimes more accurate e.g. fuel sulfur vs. SO_2 - Give early warning of possible abnormal emissions e.g. combustion temperature warns for increase in dioxin	- Need cost for calibration against direct values. - May provide relative measurement rather than an absolute value - May not valid only for a restricted range of process

Advantages	Disadvantages
emissions. - Causes disruption to process operation. - May combine information from several direct measurements e.g. temperature indicates energy efficiency, emissions and process control.	conditions. - May not command as much public confidence as direct values. - Sometimes less accurate.

7.5.2. Mass balance

A mass balance involves determining the amount of chemical entering and leaving an operation. The mass balance is written as follows:

Input + Generation = Output + Consumption

- **Input** refers to the materials (chemicals) entering an operation. For example, oil and greases when added to the rolling process as a lubricant, it would be an input in the rolling operation.
- **Generation** identifies those chemicals that are created during an operation. For example, when high lead fuels are used in preheating furnaces, additional lead dioxide may be produced (generated).
- **Output** means any stream by which the chemical leaves the operation. Output may include on-site releases and other waste management activities to the environment, storage, or disposal; or the amount of chemical that leaves with the final products. In a mold preparation, for example, sand in the mold may leave the operation as part of the product (the mold and burned sand form) and as defects of the surface of the castings which goes to disposal in the casting cleaning process.
- **Consumption** refers to the amount of chemical that is converted to another substance during the operation (i.e., reacted). For example, phosphoric acid would be consumed by neutralization during wastewater treatment.

The mass balance technique may be used for manufactured, processed, or otherwise used substances. It is typically most useful for chemical that do not become part of the final product, such as catalysts, solvents, acids, and bases. For large inputs and outputs, a mass balance may not be the best estimation method, because slight uncertainties in mass calculations can yield significant errors in the release and other waste management estimates.

Material balance calculations are also used to examine the effects of emission reduction on the material balances of the plant. A material balance calculation gives an impression of the magnitude of the emission of a specific substance but can not show neither accurate emission amounts, nor their division between emissions into the air, water discharges or solid wastes. Material balance calculations are often based on evaluated process flows and concentrations. Calculating a reliable average emission level for a factory means long term monitoring of the processes and statistical examination.

7.5.3. Emission factors

An emission factor is a representative value that attempts to relate the quantity of an emission released with an associated activity. These factors are usually expressed as the weight of emission released divided by a unit weight, volume, distance, or duration of the activity (e.g. kg of emission released per kg of product). Emission factors have been developed for many different industries and activities. Emission factors depend on the technology used, raw materials and pollution control devices. Emission factors can be obtained from industrial database e.g. DSS (available at EEAA).

> ***Note***
> *Sources of information on emission factors should be carefully evaluated and the conditions for using the factors reviewed to determine if it is applicable to the situation at the facility.*

7.5.4. Engineering calculations.

Engineering calculations are assumptions and/or judgements used to estimate quantities of listed chemicals released or managed. The quantities are estimated by using physical and chemical properties and relationships (e.g. Raoult's law, Ideal gas law) or by modifying an emission factor to reflect the chemical properties of the toxic chemical in question. Engineering calculations rely on the process parameters; thorough knowledge of the operation is required to complete these calculations.

Engineering calculations can also include computer models. Several computer models are available for estimating emissions from landfills, wastewater treatment, water treatment and other processes.

8. MONITORING OF RAW MATERIALS, UTILITIES AND PRODUCT

Inputs and outputs data is needed for estimating the nature and amount of the releases when assessing the reliability of the monitoring results. The input data includes the quantity and quality of raw materials, chemicals, fuel and water used.

8.1 Raw materials and chemicals

A peculiarity of the metallurgical industries is that the raw materials used are enormously variable, in chemical composition, in quantity, in form and type ..etc. as covered in chapter 2. However, the identification of a specific raw material that is used in the industrial plant is primary to the self-monitoring system. In the few following paragraphs the steel will be considered the basic raw material, these does not mean that the applicability of the guidelines is confined to steel plants. Alternatively, the raw material used in a specific nonferrous industry could be the raw material to be monitored.

The amount of steel scrap received per charge and cost/kg are important monitoring parameters. The quality of scrap is assessed by chemical methods. Some factories use scrap yards for storage of the scrap, the steel may be subject to rust that will change the chemical composition.

Data of the inputs and outputs is needed in estimation of the nature and amount of the releases when assessing the reliability of the monitoring results. The input data includes the quantity and quality of raw materials, chemicals, fuel and water used. On the other hand, output data may comprise the quantity and type of products, by-products and saleable waste. Both the input and output data can be used as reference measures when reporting and assessing the emissions.

Quality and quantity of raw material used in the production are key parameters to monitor. When a plant uses several raw materials, self-monitoring may concern some or all of them. Selected raw material to monitor can be, for example:

- The most expensive ones,
- The ones whose quality is the most critical for the quality of the final product, the operation of the process or the quality of discharges and emissions or waste.
- The most polluting ones that should be replaced by less polluting ones
- The most important ones with regards to the quantity used

All information concerning the characteristics of the raw material used and particularly all material safety data sheets should be obtained from the suppliers. The following are some key parameters that can be included in the self-monitoring plan for electric arc furnace, Table (22).

Table (22) Monitoring of raw materials for EAF

Parameters	Monitoring Method	Indication
Amount of raw material(scrap, refining additions) necessary to produce 1 ton of steel.	Weighing, measuring, book keeping and recording.	Rationality in the use of raw materials
Cost of the raw material(s) necessary to produce 1 ton of steel.	Book keeping and accounting reports.	Assess economical burden due to non rational use of raw material and possible avoidable extra costs.
Proportion of the cost of raw material(s) in the cost of the product & its variation.	Book keeping and accounting reports.	Assess economical burden due to non rational use of raw material
Quality of the raw material(s). Its contents of steel scrap, non-metallic inclusions and sulphur, phosphorus content.	Statistical Sampling, chemical analysis, chemical content control during processing.	Avoiding possible production problems due to bad quality. Identifying raw materials harmful for the environment.
Quantity of rejected raw material per unit of product.	Weighing, measuring, book keeping and recording	Losses, process efficiency, storing or handling problems.

8.2 Utilities

Monitoring of energy consumption takes into account the different forms of energy. It is important to note that heat and electricity cannot be summed up, as they are not commensurate. The energy efficiencies of heat and electricity should therefore be dealt with separately, see table 23.

Table (23) Monitoring of Utilities

Parameters	Monitoring Method	Indication
Energy consumption per ton produced • Electricity • Fuel	Consumption measurements and book keeping Fuel flow accumulator	Energy use efficiency
Repartition between the different types of energy used	Recording and book keeping	Energy use efficiency
Water consumption per ton of product produced per ton of production & and its variability	Flow measurements, book keeping and recording	Water use efficiency, most of the discharge related parameters are calculated
Quality of the utilities	According to the specific criteria	Impact on the smooth running and efficiency of processes
Cooling water : Chemical quality		
Electric power : Voltage level		

9. OPERATION CONTROL

Processes should be operated at the optimum operating conditions to ensure the highest yield and productivity as well as product quality. Operation control deals with the control and monitoring of key parameters that affect environmental performance. These key parameters are monitored to minimize losses and therefore pollution. Planned maintenance is also important to minimize pollution and improve environmental performance.

9.1 Monitoring process parameters

The Process parameters play a major role in affecting the types and amount of pollutant that is produced from the production process.
The EAF charging have an impact on the pollutants types produced, it should be examined for the amount of polymers present and the heavy metals.
The inlet airflow in the cupola furnace has a slight effect on the amount of air pollutants produced.
The capacity of the rolling mills and accordingly, the size of lubrication units are effective in determining the amount of oils and greases present in the effluents.
However, the slag amount in all the melting processes (ferrous metals and alloys) are almost dependent on the capacity and the usage efficiency.

9.2 Planned maintenance

Maintenance can be classified broadly into planned and emergency maintenance. Various types of planned activities (preventive, predictive) are undertaken with the basic objective of avoiding the need for emergency (breakdown) maintenance and the corresponding loss of plant profitability. The cost of an unscheduled breakdown resulting in loss of production can be substantial, and the cost of repairs may also be considerably higher than the cost of routine, planned maintenance of the equipment.
A preventive maintenance program must include the following basic elements:

- Inventory of equipment with detailed design and operating parameters. The operating parameters are monitored as indicators for predictive maintenance.
- A record of failure rate and causes
- Evaluation of condition of equipment using the following criteria:
  - Maintenance cost per unit of product
  - Downtime due to maintenance
  - Percent of planned maintenance hours as compared with emergency maintenance
- Determination of corrective actions.

It is clear from the above paragraph that maintenance is a pollution prevention measure as it increases the efficiency of the unit, minimizes water consumption by preventing leaks, helps conserve energy through proper maintenance of electric and mechanical equipment as well as insulation of steam pipes. Table (24) includes examples of the parameters that can be monitored. The following are examples of typical maintenance procedures for some service units operated in chemical plants:

Compressors and refrigeration systems

Routine checking should include:

- Testing for leaks
- Checking refrigerant charge
- Checking oil level and lubrication

Furnaces, preheating and cupola

There are many items to be checked, such as checking operating procedures, detection of flame failure, flame color, leaks in liquid fuel tubes and feeding system detection of unburned combustibles. With respect to energy conservation, the maintenance of steady state combustion, . The following parameters should be monitored:

- Temperature of molten metal, gas and water
- Pressure
- Fuel to air ratio

Scrubbers and hoods

The primary consideration in the maintenance of scrubbers and hoods is to maintain efficient operation

- Check the baghouses and ceramic filters for any blocking.
- Check air supply for air baghouses
- Check the flue gas temperature.

Table (24) Monitoring and preventive maintenance

Parameters	Monitoring method	Indication
Total number of shut downs and production interruptions	Recording	Overall assessment of the process reliability and avoided environmental loads
Number of equipment failures resulting in production shut down per type of process and type of equipment	Recording	Critical equipment
Process performance monitoring	Methods depending on the performance criteria	Process performance/ efficiency of equipment
Process equipment condition monitoring	Numerous methods, inspection, testing	Prevention of failures

10. ENVIRONMENTAL MONITORING

Environmental monitoring covers emissions to air, effluent and solid and hazardous waste. Section 4 presents the various law and regulations that apply to emissions, effluents and wastes from the metallurgical industry. Expected pollutants and hazardous releases from the industry are specified in section 2.4. For each production line related pollution aspects are identified in section 2.2. The pollution aspects of service units are presented in section 2.3. The output from the measurements and analysis of the parameters are recorded in the environmental register of the facility. Table (25) presents the compliance monitoring activities for the different aspects of pollution as per environmental laws.

Monitoring of pollutants and releases requires careful consideration of the techniques being used because of the expected effect on the interpretation and hence, the reliability of the collected data. The common techniques used in environmental monitoring will be explained in next section.

10.1 Emission to air

Emissions in the metallurgical industries are mainly due to the gases from fuel combustion in preheating furnaces, and electric arc furnaces. Emissions, especially from point sources depend on the efficiency of the control technology being used. Hoods are usually employed for emission control. The following are the most important parameters in emissions self-monitoring in metallurgical industries.(esp. furnaces).

Flue gases from Electric Arc Furnace : SO_2, CO_2, CO, NO_x
Flue gases from the rolling furnace : Soot

Air emissions can be measured either on periodical or continuous basis.

Periodical measurements: Periodical measurements give the state of emissions over the chosen sampling time. Quantities needed in every emission calculation, such as volume flow, oxygen content and humidity of the fume, are determined by periodical measurements. Periodical measurement results are also used as a support for converting the continuous concentration measurement results into annual emissions.

Periodical measurements are carried out as manual single measurements or as short period continuous measurements by the plant itself or by an exterior measurer. Periodical emission measurements are carried out annually for the following emission components: NO_x,SO_2, CO,CO_2, Cl and particles. In all cases, it should be noted that regular maintenance, control and calibration are needed to obtain an acceptable measurement accuracy level.

Continuous measurements**:** The continuous measurements describe the temporal variation of the concentrations of the emission components during the operation. General requirements for continuous monitoring systems are that the sampling locations should be representative and that the monitoring equipment should be suitable for the concentrations to be monitored in the prevailing circumstances. The emission control data system should preferably be part of the process control system

Sulfur dioxide, TRS, particles, carbon oxide are generally measured continuously.

Emission calculation**:** Differences between the different calculation methods can cause mistakes when comparing the environmental loads of different plants. Material balance calculations are used to complete emission measurements in order to get an impression of the reliability of the measurement results as well as to create a general view of the total emission level of each component. The amount of diffuse emissions that can not be recorded by emission measurements can be substantial.

10.2 Effluents (wastewater)

The regulations set the limits for the concentrations of specific pollutants of in wastewater when discharged to a recipient body. For monitoring purposes, the discharge values for specific substances or parameters are mostly expressed as total amounts per unit time. In some cases these values are given as specific amounts per ton of product or as purification efficiencies. Limit values are set for a large number of parameters such as COD/BOD_5, TSS, phosphorus and nitrogen.

Monitored control parameters**:** Typical wastewater control parameters include the following:

- Wastewater flow (Q), m^3/d
- Total suspended solids (TSS), mg/l
- Temperature, ˚C
- Chemical oxygen demand (CODCr)
- Biological oxygen demand (BOD_5)
- Total nitrogen (N), mg/l
- pH
- Conductivity, mS/m

Flow measurement**:** Measuring of the total wastewater flow is required for the operation of the wastewater treatment plant. There have been no provisions on the procedures or the accuracy of a flow measurement, but installation of automatic composite samplers (preferable flow dependent) can be used. Wastewater flow is usually measured with venture measurement equipment, but also magnetic and ultrasonic methods are used. Measurement equipment is maintained several times a year and the measurement system is calibrated regularly.

Regular maintenance, control and calibration are needed to obtain an acceptable measurement accuracy level. The structure of the measurement system, a possible mounting fault or a false choice for measurement area can cause errors. Other sources of error or factors disturbing the measurement are dirt deposition and temperature variations. Evaluation of the total error is extremely difficult, as it must include all these factors.

Sampling: Well realized sampling is essential for determining of wastewater discharges. There are general instructions for wastewater sampling. However, industry-specific problems such as variation of the wastewater quality or flow rate have to be solved on case-by-case basis. Samples are either single grab samples, composite samples, or composite samples in proportion to the flow. A single grab sample reveals the composition of the wastewater at the sampling time. With several single samples it is possible to follow the wastewater load peaks, quality variation and the variation range of the significant parameters. A composite sample reveals the average composition over a chosen period. A 24-hour composite sample is normally taken in proportion to the flow so that the sampler is controlled by flow meter.

Sampling period and sample size should be considered on case-by-case basis depending on the analyses used and on the issues affecting the reliability of sampling and analyses. Samples for wastewater analysis are mostly taken over 24 hours, 5-7 days a week. In some cases samples are frozen and combined to cover a longer period. Samples for COD and suspended solid determination are taken daily or continuously and analyzed daily. Samples for BOD and nutrient determination are usually taken weekly. pH and conductivity are usually measured continuously.

Analyses: A specific analysis program may be needed for each plant. The program usually covers a wide range of measurements and analyses, as predetermined in the self-monitoring plan. The measurements and analyses should be carried out according to the standards recommended by the authorities.

It is important to mention that in year 2000, EEAA/Central Laboratories developed a document detailing all the standard sampling and analysis techniques for wastewater.

Calculations: Wastewater discharges are calculated and reported as specified in the monitoring plan. Discharges are often calculated as below:

Discharge per day	The arithmetic mean value of the daily samples taken during one month divided by the number of sampling days
Discharge per month	Daily discharge multiplied by calendar days
Discharge per year	Sum of the values of monthly discharges

The efficiency of biological wastewater treatment is also controlled by calculating the reduction of organic matter (BOD, COD) between untreated wastewater before primary sedimentation and treated wastewater after secondary clarification. A typical wastewater discharge monitoring report includes e.g. monthly mean values and variations for discharges at the monitoring points before and after the treatment, applicable limit values and also some production information.

10.3 Monitoring of solid waste

The properties of solid wastes that are generated, especially when they are utilized or taken to a landfill, have to be investigated. The general principles in landfill operation are that the composition, leachability, long term behavior and the properties of the waste. The approval for using a landfill for a specific waste is based on the origin and the properties of the waste. The evaluation of the waste is based on the following:

- The composition of the waste
- The organic content and degradation properties of the waste,
- The content and leachability of harmful compounds, and
- The ecotoxicological effects of the waste and the landfill waters

Table 25a. Compliance monitoring for air pollution and Work Environment

Major pollution sources	**Impact**	**Parameter monitored**	**Method used**	**Source type**		**Operating Conditions**		**Person responsible**	**Frequency**
				Point	Diffuse	Normal	Exceptional		
Furnaces									
EAF Preheating furnaces Cupola furnace Crucible furnace	Air Work Environment	CO, NOx, VOCs PM Heavy metals Noise	Gas analyzer PM collector Noise meter						Depends on needs
Continuous casting									
Ladle treatment Casting	Work Environment	Dust Fumes	Gas analyzer Thermometer						Depends on needs
Conventional casting									
Molding Ferrous casting Non ferrous casting	Work Environment	Dust Fumes Heat	Gas analyzer Thermometer						Depends on needs
Rolling, Drawing, Extrusion and Forging									
Rolling Drawing Extrusion Forging	Work Environment	Fumes Heat							
Boiler									
Energy and Steam Generation	Air Work Environment	SOx, NOx, HC, CO, PM Temperature	Gas analyzer Thermometer						Depends on needs

Table (25b) Compliance Monitoring for Wastewater and Solid Waste

Major Pollution Sources	Impact	Parameter monitored	Method used	Source type Point Diffuse	Operating Conditions Normal Exceptional	Frequency	Remarks
Furnaces							
EAF Preheating furnaces Cupola furnace Crucible furnace	Receiving water body	Cooling water: Organic substances (COD, BOD), TSS, oils.	Analysis			Depends on needs	If discharged directly, water pollutants need to be monitored.
	Landfill	- Dust - Slag	Balance			Depends on needs	If discharged directly, water pollutants need to be monitored.
Continuous casting							
Ladle treatment Casting	Receiving water body	Cooling water: Organic substances (COD, BOD), TSS, oils.	Analysis			Depends on needs	If discharged directly, water pollutants need to be monitored.
	Landfill	- Dust	Balance			Depends on needs	If discharged directly, water pollutants need to be monitored.
Conventional casting							
Molding Ferrous casting Non ferrous casting	Receiving water body	Cooling water: Organic substances (COD, BOD), TSS, oils.	Analysis			Depends on needs	If discharged directly, water pollutants need to be monitored.
	Landfill	- Dust	Balance				
Rolling, Drawing, Extrusion and Forging							
Rolling, Drawing Extrusion Forging	Receiving water body	- Cooling water: Organic substances (COD, BOD), TSS, oils. - Spent chemicals	Analysis			Depends on needs	If discharged directly, water pollutants need to be monitored.
	Landfill	Scales	Balance				
Utilities							
Boilers, Cooling towers Water treatment Labs, Workshops Garages	Receiving water body	- Cooling water and wastewater: Organic substances (COD, BOD), TSS, oils. - Spent chemicals - Spent oils	Analysis			Depends on needs	If discharged directly, water pollutants need to be monitored.
	Landfill	- Scales - Dust - Solid waste	Balance				

Major Pollution Sources	**Impact**	**Parameter monitored**	**Method used**	**Source type**	**Operating Conditions**	**Frequency**	**Remarks**
				Point Diffuse	Normal Exceptional		
Wastewater treatment plant							
Wastewater	Receiving water body	**- Organic substances (COD, BOD)** - Suspended solids, heavy metals	Analysis			Depends on needs	
Solid waste	Landfill	**- Sludge, Scrap**	Mass balance			Depends on needs	

11. DATA COLLECTION, PROCESSING AND USAGE

The general objective for the self-monitoring system is to produce data that is representative, repeatable, reliable, compatible and comparable. These characteristics are dependent on the applied measures for quality control and quality assurance throughout the data production chain i.e. volume determination, sampling, sample pretreatment, treatment and analysis, data processing and reporting.

11.1 Data collection and processing

The different parts of the monitoring system of a plant include diverse factors affecting the reliability and comparability of the emission data. These factors have to be taken into consideration in sampling, sample treatment and analysis as well as in processing and reporting of the data. Requirements for the whole data production chain should be set in the monitoring program. In addition, implementation of the relevant measures for quality control and quality assurance is extremely important in obtaining maximum reliability, repeatability and comparability.

The aspects and parameters that are involved in data collection and processing are explained in the Annex A. Figure (14) shows the main aspects and parameters that affect the effectiveness of SM in terms of reliability, repeatability and comparability.

11.2 Using SM outputs

The implementation of the self-monitoring plan will basically result in three outputs:

- Data and information about the facility
- Preparing the environmental register as required by law.
- Reports describing results of the self-monitoring and problems faced during implementation
- Feed back and decision making

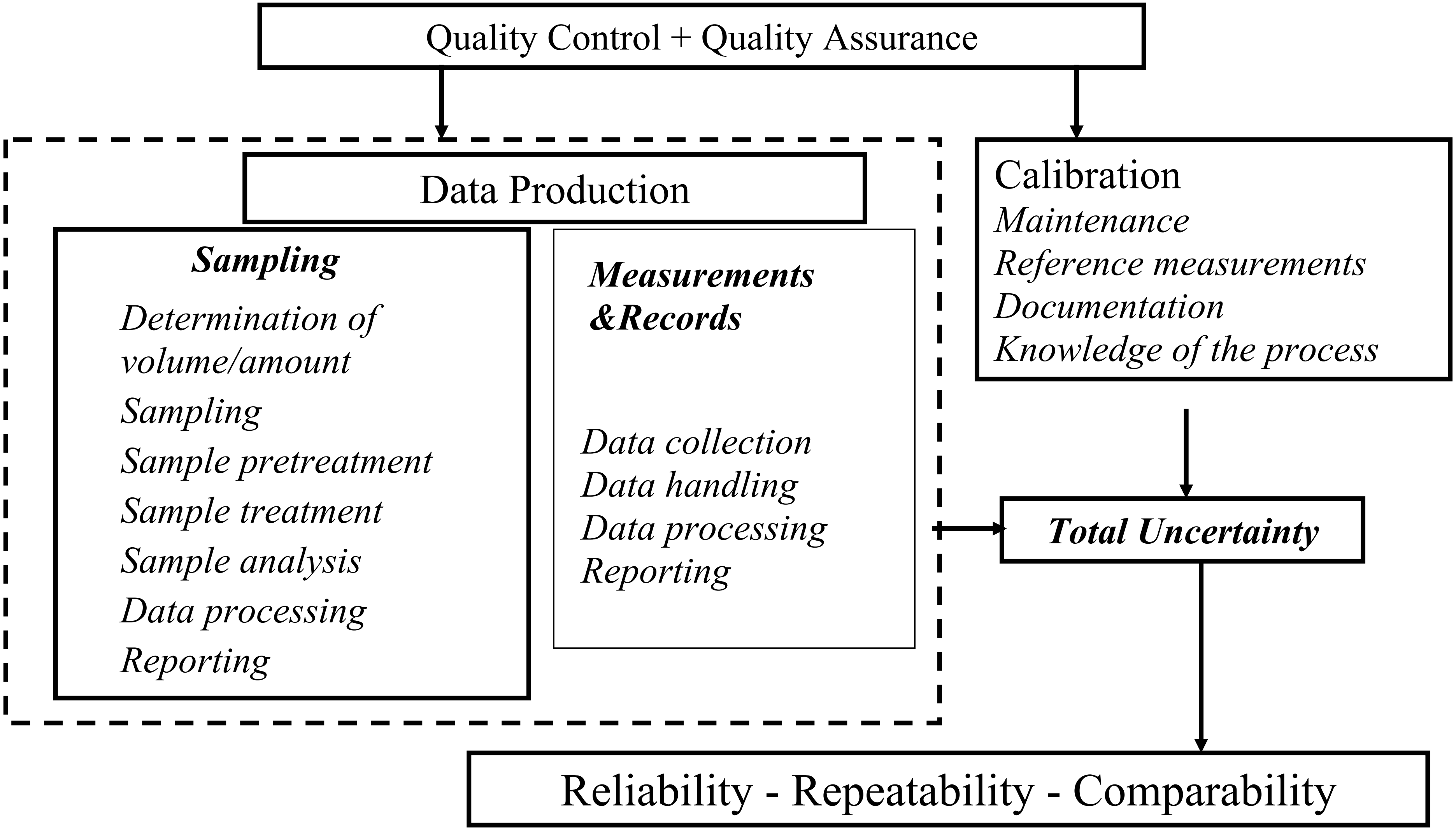
11.2.1 Techniques for summarizing and illustrating data

It is best practice to record process and environmental information in a detailed archive or database. It can then be related easily to the monitoring results and used to evaluate, compare and manage aspects of process performance such as:

- the rate of release of pollutants compared to production
- the rate of generation of waste compared to production
- the rate of consumption of energy and/or materials compared to production
- the impacts on environmental receptors compared to production or to their sensitivity
- the overall resource efficiency of the process, i.e. production compared to inputs or raw materials and energy, and outputs of pollutants and waste

There are many techniques used in the interpretation of results (e.g. statistical analysis of the measurement results, reduction of operating conditions to normal conditions when monitoring gaseous emissions).

Figure (14) Parameters Affecting SM Reliability



11.2.2. Environmental register

Only monitoring data related to compliance will be included in the environmental register. Description of the measuring and/or analytical techniques used should be reported as well as the location of sampling and measuring. EEAA/EPAP prepared a detailed description of the environmental register, based on the requirements of law 4/1994, see Annex B. The competent authorities could request the inspection of the measuring devices to check their operability and the maintenance record for these devices. The procedures for taking samples could also be checked by the inspector. The inspectors check whether the facility has provided information that is relevant and of sufficient quality. To assess compliance, a simple numerical or statistical comparison between the measurements, their uncertainty and the limit value is performed.

According to Law 4/1994, compliance self-monitoring data should be recorded and kept for a minimum of 10 years.

11.2.3. Reporting

Description of the reporting scheme, its content, recipient and purpose should be included in the self-monitoring plan. A monitoring report is a uniform presentation of data over a fixed period. An annual monitoring report that provides information of the past calendar year is always required. Shorter period reports are required for significant polluters. The conditions of the process and equipment as well as location of monitoring points should be specified. Reporting can be:

- **Internal** to inform management and raise the environmental awareness of the facility personnel. It should include problems met during the implementation of the SM plan to be used in decision making.
- **External** for the competent authority based on the environmental register, establishments are required to report on environmental violations.

11.2.4. Internal auditing and conclusions on results

The data obtained must be compared regularly with the objectives written down in the monitoring program to check that they are being met.

11.2.5. Feedback and decision making

Feedback on the assessment of compliance based on the monitoring results should include all parties involved with the monitoring activities. The participants should make the necessary improvements and corrections to the next monitoring program.

In those parts of the monitoring program where compliance is met, possible reduction in frequency of monitoring can be considered and instead move resources to parts that need more accurate monitoring, e.g. borderline or non-compliance situations.

Feedback should include all parts of the monitoring program, process, product control, maintenance, environmental management and occupational safety. Detailed requirements should be set for the improvements needed and a date fixed for their implementation.

11.2.6. Using outputs in public relations

The monitoring data is refined and distributed to the end users such as national and international reporting, research and statistical purposes, citizens, and the media.The citizens have the right to present complaints about the health or environmental impacts caused by the operation these complaints are directed to the permitting and supervising authority. Monitoring data is needed e.g. in national research and statistics, for planning and evaluation purposes, by national group organizations and the media.

Annex A

DATA COLLECTION AND PROCESSING

The general objective for the self-monitoring system is to produce data that is representative, repeatable, reliable, compatible and comparable. These characteristics is dependent on the applied measures for quality control and quality assurance throughout the data production chain i.e. volume determination, sampling, sample pretreatment, treatment and analysis, data processing and reporting. Data production chain is explained in Section 3.

1 Reliability

The realism and correctness of the measurement results should be assessed against the knowledge of the processes and inputs, e.g. by using mass balance calculations.

Good knowledge of the process: This is essential for achieving reliable emission data. Process input variations can include varying properties of the raw material, chemicals or fuel used in the processes, and the size of the input. The interdependency between the inputs, processes and outputs (products and environmental load) should be known to be able to assess the correctness of the monitoring results.

Total uncertainty: The results obtained from any measurement have a specific uncertainty. It is important that the uncertainty is estimated and taken into account when the results are used in process management or for regulatory purposes. For example, the measurement result 10 g/t ± 2 g/t indicates that the uncertainty for this specific measurement is 20 % of the measured value.

Each step of the data production chain has an uncertainty and the total uncertainty of the measurement is the sum of these partial uncertainties. Uncertainty of each step of the data production chain must be known in order to be able to give the uncertainty of the final results, i.e. the uncertainty of the whole data production chain. When assessing the measurement uncertainty it is good to keep in mind that the factors causing measurement error can also affect each other.

Calibration and maintenance have to be carried out according to the relevant instructions and the management of them must be documented.

Reference measurements are carried out to certify the reliability of the measurements in practice. Results of an independent and neutral measurement laboratory are compared with the operator or consultant monitoring results. Reference measurements should be carried out regularly.

2 Comparability

Monitoring systems at the individual plants differ according to the scale, production, capacity or economic aspects of the operation. Data on necessary auxiliary measures and good documentation of the measurement procedure improves both the comparability and reliability of the results. All reference data, i.e. auxiliary measures and reference data (inputs and outputs) should be clearly defined in the monitoring program or permit according to the nationally and internationally used standards and guidelines.

3 Data Production Chain

The different parts of the monitoring system of a plant include diverse factors affecting the reliability and comparability of the emission data. These factors have to be taken into consideration in sampling, sample treatment and analysis as well as in processing and reporting of the data. Requirements for the whole data production chain should be set in the monitoring program.

Data Production Chain: The data production chain includes the following phases:

- *Determination of volume/amount*
- *Sampling*
- *Sample pretreatment*
- *Sample treatment*
- *Sample analysis*
- *Data processing*
- *Reporting*

Determination of volume/amount**:** The accuracy of determination of the volume of the release has a substantial impact on magnitude of the total emissions. Variations in the volume measurement results can be caused either by variations in the flow of the emission or in the accuracy of the measurement. Measurement of volume flow or amount of the emission can be continuous, periodic or single.

Sampling: Continuous emission analysis includes sampling, sample pretreatment, sample treatment and analysis. Variations in the process or emission treatment affect also the quantity and quality of the sample. Both sampling conditions and the sampling point must be representative. Measurement of emission concentration can be continuous, periodic or single. The sample must be representative in relation to the measurement point, emission flow/amount, sampling period and time period.

Sample pretreatment**:** Sample pretreatment includes all treatment of the sample before it is taken to the laboratory. The need for sample pretreatment is determined by the needs to protect the substance to be determined from any changes before analysis. Usually the appropriate pretreatment method is presented in the standards.

Sample treatment: Sample treatment includes operations in the laboratory before analysis, such as dilution, concentration, pH adjustment, adding of reagents. Sample treatment is usually carried out according to standards or specific method instructions. The treatment methods used should be documented.

Sample analysis: Sample analysis includes physical, chemical or biological determination of the parameter. Figures presented in emission reporting are not always comparable, without describing the analysis methods used.

Data processing: The calculation methods for the emission data are process specific and their function is to give as true load data for the specific process as possible. The correspondences of the equations to the reality must be checked from time to time and automatically in cases of any changes having an impact on them. The following general rules for emission calculation need to be determined and used nationally to harmonize the methods:

- calculation methods for the peak of an hour, calendar day, monthly/annual means
- amount of emission data needed for calculation of the annual mean of the emission
- exceeding times, i.e. percentage of time of the exceptional emissions of the total operation time
- utilization rate for the continuous measurements, i.e. percentage of time during which the measurement system has not been available of the total operation time
- calculation formulas used for data conversion into reference conditions
- conversion factors used for data conversion between different units
- calculation methods for total emissions over a certain period

Reporting: Data reporting should include sufficient data on the parameters, pollutants and other measures that are defined in the monitoring plan. The data to be reported should be presented in the form required with all the additional information and documentation.

A ***monitoring report*** is a uniform presentation of the emission data over a fixed period. An annual monitoring report-providing information of the past calendar year is always required. In case of large industrial sites, shorter period reports are demanded (a monthly report or a report over 3, 4 or 6 months). Emission data must be presented in a form easy to compare with the given emission limits. The following data is needed for reporting:

- *The emission parameters and pollutants* are reported with all the relevant the reference parameters, auxiliary measures and uncertainties expressed as required in the monitoring program in one or more of the following forms:

- Specific emissions (ton / ton of production): used for assessing performance or efficiency
- Total emissions (t/ year) : used for assessing the environmental load
- Concentration (mg / m^3, PPM, % O_2): used for e.g. operation control
- Flow rate (m/s): used for e.g. velocity/rate for flue gas/effluent
- Residence time (s): used e.g. for assessing completeness of combustion
- Temperature (^{0}C): requirements for controlling certain exhaust pollutants.
- Heat (W): thermal stress in the recipient
- The *exceptional and diffuse emissions* are included in the total emissions of the period.

- *Operation control data should be available to the authority.*
- *Utilization rate of the measurement system is expressed e.g. as percentage of the process operation time.*
- *Documentation of the reference measurements.*

4 Quality control and quality assurance

Quality control is a system of routine technical activities to measure and control the quality of monitoring data as it is being produced. QC includes e.g. checking of equipment, methods and procedures, and that the monitoring system is regularly calibrated and maintained. The relevant instruments personnel and analytical laboratories should be certified under recognized schemes.

Quality assurance includes a system of reviewing the implementation of the quality system by personnel not directly involved in the monitoring process. QA reviews verify that the quality objectives are met and ensures that the monitoring carried out represents the best available results.

Guidelines for the below listed factors help to harmonize the practical factors at site level. The monitoring plan can determine the listed factors even in details. If the plant or the laboratory uses a sub-supplier in any step of the data production chain, the competence of the sub-supplier has to be checked, too. Quality system work involves the following processes:

Data production chain
Maintenance and calibration
Certification and Accreditation

Annex B

REGISTER OF ENVIRONMENTAL CONDITION

General Information:

- Name:
- Address:
- Contact Person:
- Position:
- Time Period covered by the current data:

General Description of the facility:

- Industrial Sector:
- Actual Production:
- Production Capacity:
- Products:
- Capital Investment:
- Annual Turnover:
- Number of Employees:
- Year of Start of Operations:
- Major Renovations:

Location:

- The location of the plant shown on a map describing also neighboring areas.
- Layout describing the location of the building, unit processes, storage areas and other parts of the plants of wastewater and air emission points to be shown on the layout.
- The maps should also show types of the surrounding and sensitive areas (Hospitals, Schools, Settlements, Parks).

Raw Materials:

- Use of raw materials & auxiliary materials (ton/year)
- Opening times for processes shall be reported as follows:
    1. Annual average operating time (days/year or hour/year)
    2. Weekly operating time and operating days per week
    3. Daily operating time and shifts per day
    4. Possible daily or seasonal variations
- Maximum amounts of each kept in storage
- Describe storage area
- Danger substance:

List of danger substance used

Name of substance	Annual consumption	Environmental properties (flammability,……)

- Describe storage areas (capacities, preventive emergency, constructions, ventilation,………..).
- The method for circulation of the danger substance by (hand, windlass,……).

Raw Water:

- Sources of raw water.
- Amounts of raw water taken per source and year.
- Use of water:
  1. For processes
  2. For lighting
  3. For other purposes

Laws and Legislation:

- State laws & regulations pertinent to the establishment. Attach copies of possible decisions and permits:
  1. Law no. 4/94 (yes or no)
  2. Law no. 93/62 (yes or no)
  3. Law no. 48/82 (yes or no)
  4. Law no. 137/81 (yes or no)
- Attach copies of the correspondence with EEAA & other environmental authorities.

Process Description:

- Attach copies from schematic diagrams for each unit processes.
- Describe the utilities (e.g. boilers).
- Using of raw water for each unit:

Name of Unit	Water consume

- Using of energy & fuels for each unit:

Name of Unit	Fuels consume

Gaseous Emissions:

- Describe the gaseous emissions (for each stack).
- Name of each unit giving rise to air pollution.
- Rate of gas emission (m^3/year):

Pollutants	Concentration of Pollutants mg/m^3	Limits of Law 4/94 for Combustion of Fuels mg/m^3	Limits of Law 4/94 for Emission of production processes mg/m^3	Loads of Pollutants ton/year

- This table for each stack.
- Measure the conc. of pollutants according to Annex no. 6 in the Executive Regulations of Law 4/94 if this emission generated from unit processes but if this emission generated from combustion of fuels so the measurement of the conc. of pollutants according to Article no. 42 in the Executive Regulations of Law 4/94.
- Describe all treatment facilities for gaseous emissions (estimate, material balance, individual measurement, continuous monitoring of process parameter, continuous monitoring of emissions).
- Treatment processes for gaseous emissions:
  1. Name of unit linked by the equipment of treatment
  2. Type of the equipment
  3. Describe the equipment
  4. Design efficiency %
  5. Actual efficiency %
- Pollution before & after treatment:

Conc. of the pollutants before treatment mg/m^3	Conc. of the pollutants after treatment mg/m^3	Loads of the pollutants before treatment ton/year	Loads of the pollutants after treatment ton/year

- This table for each treatment unit.
- Describe treatment, transport, and disposal of sludge from air pollution control

Wastewater Emissions:

- Attach copy show discharge points of industrial sewerage and domestic sewerage on the maps.

Wastewater Treatment Plant:

Describe wastewater treatment facilities with layouts and drawing. The following information shall be given:

- Processes flow diagram
- Machinery
- Design parameter
- The unit linked by the equipment of treatment.
- Type of treatment (initial, secondary, advanced).
- Capacity of the plant (m^3/hour).
- Type of equipment.
- Describe the treatment of sludge.
- Describe the way used for disposal of sludge.
- Loads of pollutants:

Pollutants	Loads of pollutants for income water	Loads of pollutants for outcome water

- The design efficiency (%) & actual efficiency.
- Monitoring of efficiency

Discharge sewerage:

Table for pollutants according to discharge points and discharge points after the treatment.

Pollutants	Conc. of Pollutants (mg/l)	Limits of Law	Loads ton/year

- The concentration of pollutants measure according to the annex no. 1 of the Executive Regulations of Law 4/94 if the wastewater discharge into the sea.

- The concentration of pollutants measure according to modify by Decree 9 for 1989 if the wastewater discharge into Municipal Sewerage.
- The concentration of pollutants measure according to the Article no. 61, 62, 66 of Law no. 48/82 if the wastewater discharge into Fresh water or Non fresh water.

Solid Waste Loads:

- Solid waste for each unit
- Name of each unit

Kind of Solid Waste	The Quantity of Solid Waste ton/year	Volume of Solid Waste m^3/year	Notes
• Paper • Plastics • Glasses • Organic Compound • Metals • Anther Materials			

- This table for each unit.

- Describe the waste disposal areas (total solid waste)

Kind of Solid Waste	The Quantity of Solid Waste ton/year	Volume of Solid Waste m3/year	Notes
• Paper • Plastics • Glasses • Organic Compound • Metals • Anther Materials			

Hazardous Wastes (Article no. 28 of Law no. 4/94):

- Hazardous waste for each unit (Name of units):

Kind of Hazardous Waste	The Quantity of Hazardous Waste ton/year	Volume of Hazardous Waste m3/year	Notes

Working Environment:

- According to Annex no. 7,8,9 of Law no. 4/94
- Name of each unit

Pollutants	Conc. of Pollutants (mg/m3)	Limits of Law no. 4/94	Loads ton/year
• Temperature • Humidity • Noise • Heat • Vibrations • Bacteria & Viruses • Odors • Other Emissions			

Self Monitoring of Emissions

Article no. 17 of Law no. 4/94:

- **Wastewater:**
- Parameters monitored (BOD, COD, TDS, TSS, Heavy metals, ……etc.)
- Sampling Location, Sampling Frequency and Time Table.

Sampling Location	Time between Samples

- Analytical Procedures:
- The person who responsible for monitoring and reporting

- **Gaseous Emission from Stacks:**
- Parameters monitored (NOx, Sox, COx, CO, ………. Etc.)
- Sampling Location, Sampling Frequency and Time Table.

Sampling Location	Time between Samples

- Analytical Procedures
- The person who responsible for monitoring and reporting

- **Working Environment:**
- Parameters monitored (dust emissions, odors, noise, ………….. etc.)
- Sampling Location, Sampling Frequency and Time Table.

Sampling Location	Time between Samples

- Analytical Procedures
- The person who responsible for monitoring and reporting

Annex C

REFERENCES

- ***"Monitoring and Control Practices of Emissions in Pulp and Paper Industry in Finland", 1998, Saarinen K., Jouttijarvi T. and Forsius K.,*** Saarinen K**.** ***Finnish Environment Institute***

- ***"Data Production Chain in Monitoring of Emissions", 1999,*** Saarinen K, ***Finnish Environment Institute.***

- ***Draft Document "Self-Monitoring Manual for Metallurgical Industry", August 2002, prepared by Dr. Mohamed Abdel Hamid El Refaii, Faculty of Engineering, Al Azhar University. RCEP3.***