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

Self Monitoring Manual

Fabricated Metals Industry

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Fabricated Metals Industry
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 FINIDA 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 three guidelines were later summarized into one that will be referred to as the General Inspection Manual GIM (EPAP, 2002), which was developed, in order to cover the 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 Industries 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 fabricated metals 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 manual

The self-monitoring manual for the fabricated metals 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 fabricated metals 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 in 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 fabricated metals industry. Chapter 5 gives examples of pollution abatement techniques and measures applicable to the fabricated metals 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.

1.2 Introduction to the Fabricated Metal Products Industry

The fabricated metal products industry comprises facilities that generally perform two functions:

- Forming metal shapes
- Performing metal finishing operations, including surface preparation.

Consequently the main processes associated with this industry can be divided into three types of operations (i.e., metal fabrication, metal preparation, and metal finishing). The establishments concerned are those that fabricate ferrous and nonferrous metal products and those that perform electroplating, plating, polishing, anodizing, coloring, and coating operations on metals.

1.2.1 Product Characterization

Fabricated structural metal products, metal forging and stamping, metal cans and shipping containers, cutlery, hand-tools and general hardware, screw machine products, bolts, nuts, screws, rivets and washers, heating equipment and plumbing fixtures, coating, engraving and related services and miscellaneous fabricated metal products.

The International Standard Industrial Classification –ISIC gives the code 3800 for metal products, machinery and equipment.

1.2.2 Egyptian Particularities

The Fabricated Metal Products Industry is generally concentrated in Egypt in the immediate vicinity of towns. In fact since many years, there is a large demand for multi-family housing, office buildings and commercial structures besides leisure activity accommodations along the North coast and the Red Sea. As we know the success of the construction industry is fundamental to the success of the fabricated structural metal industry since the former consumes almost 95 % of the output from the latter. Consequently we expect in the near future an ever-increasing demand for fabricated structural metal industry and general component-producing industries. Let us take the Alexandria governorate where some data are available. A sample of industries was considered representing around 60% of the industries of the ISIC3800 industrial sector in the Alexandria governorate in terms of the total production volume. For this sample:

The total solid and hazardous waste loads emitted by the industries of the sector was:

Paper around	50 tons/y	Organic Mat. (Max)	5 tons/y
Metals around	750 tons/y	Hazardous Waste Load	3.6 tons/y
Plastic (max)	53 tons/y	Others (max)	34 tons/y

The total water pollutants load emitted by the considered sample of industries of that sector was:

Total dissolved solids TDS (max)	22 000 kg/y
Total suspended solids TSS (max)	5 500 kg/y
Biological Oxygen Demand BOD (max)	3 800 kg/y
Chemical Oxygen Demand COD (max)	7 800 kg/y
Oil & Grease O & G (max)	2 100 kg/y

Let us take another example: a large fabricated metal products factory near Cairo where some data are available . The total particulate concentration at the head level of workers exceeds the upper limit allowed by law No 4-1994 (which is 5 mg/m3), in the primer spray area (14 mg/m3), in the painting spray area (16 mg/m3), in the fiberglass machining area (35 mg/m3) and in the wood cutting area (9 mg/m3).

The CO concentration in the welding and cutting areas (75 ppm), the Xylene concentration in the primer dipping area (115 ppm) exceeds the upper limit allowed by law 4-1994 for full day exposure (50 ppm and 100 ppm respectively).

2. DESCRIPTION OF THE INDUSTRY

In view of the high cost of most new equipment and the relatively long lead-time necessary to bring new equipment into operation, changes in production methods and products are made only gradually i.e. even new process technologies that fundamentally change the industry are only adopted over long periods of time. The fabricated metal products are usually intermediate products that constitute parts of larger products. Each intermediate product can be produced in small, medium or large facilities or can be a plant in a large facility (e.g. vehicle, refrigerator and air conditioning assembly facilities).

This section contains a description of commonly used production processes, the associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This manual, coupled with schematic drawings of the identified processes, provides a concise description of where wastes may be produced in the process. This section also describes the potential fate (air, water, land) of these waste products.

2.1 Raw Materials, Chemicals and Other Inputs

Table (1) presents the material inputs to each operation in metal shaping, surface preparation and metal finishing processes.
Metalworking fluids (cutting oils) are applied to either the tool or the metal being tooled to facilitate the shaping operation. Metalworking fluid (e.g. ethylene glycol) is used to:

- Control and reduce the temperature of tools and aid lubrication,
- Control and reduce the temperature of workpieces and aid lubrication,
- Provide a good finish,
- Wash away chips and metal debris
- Inhibit corrosion and surface oxidation.

Metal fabrication facilities are major users of solvents (e.g. trichloroethane, methyl ethyl ketone) for degreasing. In cases where solvents are used solely in degreasing (not used in any other plant operations), records of the amount and frequency of purchases provide enough information to estimate emission rates, based on the assumption that all solvent purchased is eventually emitted.
Acids and alkalis are also used for cleaning the metal surface. The current trend in the industry is to use aqueous non-VOCs to clean the metal, whenever possible. The use of 1,1,1, trichloroethane and methyl ethyl ketone is declining.

Steam is generated in boilers that use either mazot (fuel oil), solar (gas oil) or natural gas as fuel. Steam is used for providing heat requirements and in some plants for electric power generations. Water is used for cleaning equipment and floor washing, as boiler feed water, as cooling water and for domestic purposes. Boiler grade water is pretreated in softeners to prevent scale formation.

Water sources may be supplied from public water lines, wells or canal water. The type of water will dictate the type of pretreatment.
Some plants manufacture their own containers. Big facilities could also include a housing complex generating domestic wastewater.

Note: Defining the Inputs and outputs helps predict the expected pollutants.

Table (1) Material Inputs to Each Operation in Metal Fabrication

Process	Material Inputs
Metal shaping	
Metal cutting/ forming	Cutting oils (ethylene glycol), degreasing and cleaning solvents (trichloro-ethane, methyl-ethyl-ketone, acetone.), alkalis and acids.
Surface preparation	
Solvent degreasing Emulsion degreasing Alkaline/acid cleaning	Solvents Organic solvents dispersed in water (kerosene, mineral oil, glycol) Alkali hydroxides, acids, organic and inorganic additives, surfactants
Surface finishing	
Anodizing	Acids (chromic acid, sulfuric acid and boric-sulfuric mixture), sealants (chromic acid, nickel acetate, nickel-cobalt acetate)
Chemical conversion coating	Solutions of hexavalent chromium, phosphate salts, phosphoric acid, nitric acid and sodium dichromate.
Electroplating	Acid/ alkaline solutions, heavy metals bearing solutions, cyanide bearing solutions.
Plating	Metal salts, complexing agents, alkalis
Painting	Solvents and paints
Other techniques	Metal salts and acids

2.2 Production Processes

Table (2) presents the various production processes and service units that could be present in a facility. Figure (1) illustrates the various processes and the affected media.

Table (2) Production Processes and Service Units in Fabricated Metal Industry

Production Processes	Service Units
Metal Shaping Casting Shearing Forming Operations Machining ***Surface Preparation*** Degreasing Pickling (acid cleaning)	Boilers Cooling towers Laboratory Mechanical & electrical workshops Garage Storage facilities. Wastewater Treatment Plant

Surface Finishing Anodizing Chemical Conversion Coating Electroplating Electroless Plating Painting Other Metal Finishing Techniques	Restaurant and Housing complex

Note: Knowledge of the different steps involved in each production process allows the prediction of pollution hazards and expected violations and helps determine possibilities for implementing cleaner technology.

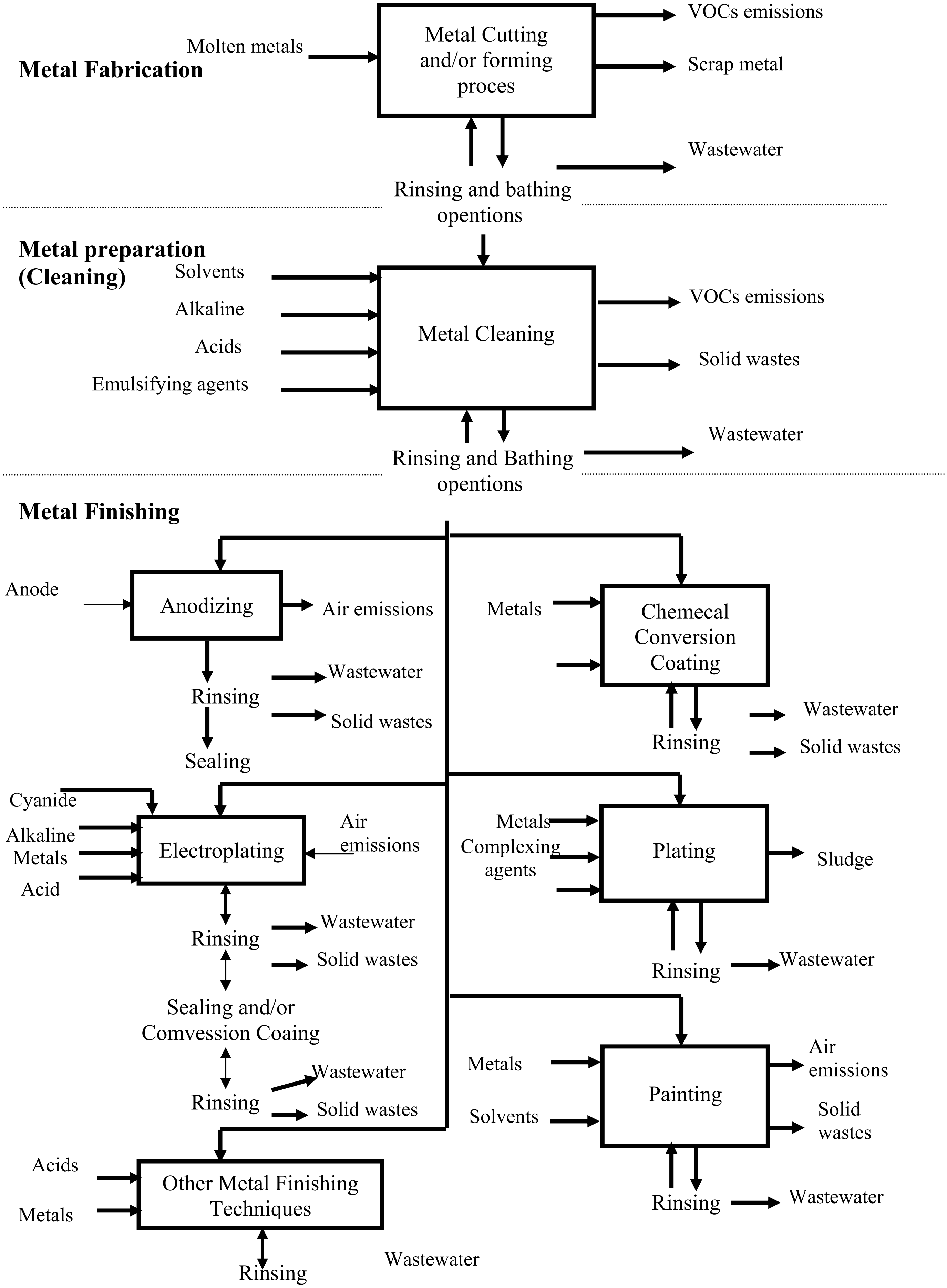


Fig (1) Fabricated Metal Products Manufacturing Processes

2.2.1 Metal Shaping

This section identifies some of the many forming and shaping methods used by the metal fabrication industry. In general, the metal may be heat-treated or remain cold. Heat-treating is the modification of the physical properties of a workpiece through the application of controlled heating and cooling cycles. Applying direct physical pressure to the metal forms cold metal.

The following presents the main operations in this process, the inputs to the process and the pollution sources. These operations are:

Casting Once molten metal (ferrous or nonferrous) containing the correct metallurgical properties has been produced, it is cast into a form that can enter various shaping processes. Recently, manufacturers have been using continuous casting techniques that allow the molten metal to be formed directly into sheets, eliminating interim forming stages.

Shearing Once molten metal is formed into a workable shape, shearing and forming operations are usually performed. Shearing operations cut materials into a desired shape and size, while forming operations bend or conform materials into specific shapes.

Cutting or shearing operations include punching, piercing, blanking, cutoff, parting, shearing, and trimming. Basically, these operations produce holes or openings, or produce blanks or parts. The most common hole-making operation is punching. Cutoff, parting, and shearing are similar operations with different applications. The rate of production is highest in hot forging operations and lowest in simple bending and spinning operations.

Forming Operations Forming operations shape parts by bending, forming, extruding, drawing, rolling, spinning, coining, and forging the metal into a specific configuration. Bending is the simplest forming operation; the part is simply bent to a specific angle or shape. Other types of forming operations produce both two- and three-dimensional shapes.

Extruding is the process of forming a specific shape from a solid blank by forcing the blank through a die of the desired shape. Extruding can produce complicated and intricate cross-sectional shapes.

In rolling the metal passes through a set or series of rollers that bend and form the part into the desired shape. Coining is a process that alters the form of the part by changing its thickness to produce a three-dimensional relief on one or both sides of the part, like a coin. In drawing, a punch forces sheet stock into a die, where the desired shape is formed in the space between the punches and die. In spinning, pressure is applied to the sheet while

it spins on a rotating form, forcing the sheet to acquire the shape of the form.
Forging operations produce a specific shape by applying external pressure that either strikes or squeezes a heated blank into a die of the desired shape. Forging operations may be conducted on hot or cold metal using either single- or multi-stage dies.

Machining

Once shearing and forming activities are complete, the material is machined. Machining refines the shape of a workpiece by removing material from pieces of raw stock with machine tools. The principal processes involved in machining are drilling, milling, turning, shaping/planking, broaching, sawing, and grinding.
Pollution sources: Each of the metal shaping processes can result in wastes containing chemicals of concern. For example, the application of solvents to metal and machinery results in air emissions. Additionally, wastewater containing acidic or alkaline wastes and waste oils, and solid wastes, such as metals and solvents, are usually generated during this process.
Fluids resulting from this process typically become spoiled or contaminated with extended use and reuse. In general, metal working fluids can be petroleum-based, oil-water emulsions, and synthetic emulsions. When disposed, these fluids may contain high levels of metals (e.g., iron, aluminum, and copper). Additional contaminants present in fluids resulting from these processes include acids and alkalis (e.g., hydrochloric, sulfuric, nitric), waste oils, and solvent wastes.
Scrap metal may consist of metal removed from the original piece (e.g., steel), and may be combined with small amounts of metalworking fluids (e.g., solvents) used prior to and during the metal shaping operation that generates the scrap. Quite often, this scrap is reintroduced into the process as a feedstock. The scrap and metalworking fluids, however, should be tracked since they may be regulated as hazardous wastes.

2.2.2 Surface Preparation

The surface of the metal may require preparation prior to applying a finish. Surface preparation, cleanliness, and proper chemical conditions are essential to ensuring that finishes perform properly. Impurities to be cleaned from metal surface could be grease, oil or abraded iron fines. Without a properly cleaned surface, even the most expensive coatings will fail to adhere or prevent corrosion.

Surface preparation techniques range from simple abrasive blasting to acid washes to complex, multi-stage chemical cleaning processes. Surface preparation processes to be used depend mainly on the type of the surface to be treated, the type of the product to be manufactured as well as the following surface finishing processes to be used.

A relatively simple surface preparation technique consists of mechanical treatment by brushing, grinding and sand blasting for instance. Naturally dust emissions from sand blasting and other blasting materials present a certain silicoses risk. Solid wastes containing pigments and heavy metals are generated mainly from mechanical surface preparation occurring in repair workshops.
Preparing metal for electroplating is a good example of chemical treatment. First we can use acid pickling followed by rinsing, then surface cleaning is done by one or multistage alkaline cleaning each time followed by thoroughly rinsing.

The following presents the processing steps for surface preparation and the potential pollution sources. These processes are:

Degreasing

Degreasing removes oils and greases present on the metal surface. Degreasing processes can be divided in water-based and organic solvent based degreasing . Emulsion degreasing (cleaning) can be counted under the heading of water-based degreasing, even if an organic solvent (e.g. kerosene, mineral oil) can be present in the bath. As far as technically acceptable for the degree of metal surface cleanliness required, water-based degreasing should be applied. If organic solvents are used, preference should be given to non-chlorinated solvents.
<u>Alkaline degreasing</u> often takes place at temperatures of 80-95 ^{o}C and it is often assisted by mechanical action, ultrasonic, or by electrical potential (e.g., electrolytic cleaning). Most alkaline degreasing solutions contain three major types of components:

Builders, such as alkali hydroxides and carbonates, which make up the largest portion of the cleaner;

Organic or inorganic additives, which promote better cleaning or act to affect the metal surface in some way;

Surfactants (surface-active substances acting as detergents).

<u>Emulsion degreasing</u> uses common organic solvents (e.g., kerosene, mineral oil, and glycol) dispersed in an aqueous medium with the aid of an emulsifying agent. Emulsion cleaning uses fewer chemicals than solvent degreasing because the concentration of solvent is lower.
Organic solvents to be used in degreasing can be grouped for example into following groups; halogenated solvents, petroleum- based solvents and other organic solvents.
The most frequent halogenated hydrocarbons are trichloroethylene, perchloroethylene, 1,1,1-trichloroethane, methylene chloride and

trifluorotrichloroethane. They are used for cleaning metals, as cold-degreasants, as dry-cleaning fluids, etc. Petroleum products are used as degreasants and cleaning agents. The most commonly used are paraffin, white spirit, and petroleum spirits, thinner and mineral turpentine. They contain varying amounts of aromatics, and are moreover flammable.

Pickling (acid cleaning)

Acid cleaning, or pickling, can also be used to prepare the surface of metal products by chemically removing oxides and scale from the surface of the metal. The objective of the pickling operation is to obtain a chemically reactive surface of the metal. For instance, most carbon steel is pickled with sulfuric or hydrochloric acid, while stainless steel is pickled with hydrochloric or hydrofluoric acids, although hydrochloric acid may embrittle certain types of steel.

The metal generally passes from the pickling bath through a series of rinses. Acid pickling is similar to acid cleaning, but is usually used to remove the scale from semi-finished mill products, whereas acid cleaning is usually used for near-final preparation of metal surfaces before electroplating, painting, and other finishing processes.

Pollution sources: Surface preparation activities usually result in air emissions, contaminated wastewater, and solid wastes. The primary air emissions from cleaning are due to the evaporation of chemicals from solvent degreasing and emulsion cleaning processes. These emissions may result through volatilization of solvents during storage, fugitive losses during use, and direct ventilation of fumes.

Wastewaters generated from cleaning are primarily rinse waters, which are usually combined with other metal finishing wastewaters (e.g., electroplating) and treated on-site by conventional hydroxide precipitation.

Solid wastes (e.g., wastewater treatment sludge, still bottoms, cleaning tank residues, machining fluid residues, etc.) may also be generated by the cleaning operations. For example, solid wastes are generated when cleaning solutions become ineffective and are replaced. Solvent-bearing wastes should be typically pre-treated to comply with any applicable Egyptian Pollutant Discharge System permit and then sent off-site, while aqueous wastes from alkaline and acid cleaning, which do not contain solvents, are often treated on-site.

In table (3) different kinds of pickling liquors are summarized as well as the item pickled.

Table (3) Pickling Liquor Used for Various Metals

Pickling Liquors	Pickled Metals
Hydrochloric acid	The most common pickling acid. Used for pickling steel, zinc, tin and aluminum.
Sulfuric acid	Used for pickling low-alloy steel and copper.
Nitric acid	Not as common as hydrochloric acid and sulfuric acid. Used for copper and magnesium. Often used in mixtures with other acids and mostly for special steels.
Hydrofluoric acid	Seldom used alone but for the most part in mixtures for pickling alloy steel, cast-iron and aluminum. Used mainly for special steels.
Chromic acid	Used for pickling copper.
Alkaline pickling	Works on aluminum and aluminum alloys. The pickling baths consists of sodium hydroxide. A milder alkaline pickling bath contains sodium carbonate and sodium chloride.
Ferrous chloride (II) + hydrochloric acid	An alternative to hydrochloric acid for pickling iron. The spent acid can be used straight away for PO4 reduction.

2.2.3 Surface Finishing

The production units of this sector can be separate (job shops) or divisions in an industrial complex (integrated or captive shops). Metal finishing usually involves a combination of metal deposition operations and numerous finishing operations. The metal finishing process consists generally in plating, then the utilization of drag-out tanks, followed by thorough rinsing before using the appropriate finishing treatment followed again by rinsing.

Wastes typically generated during these operations are associated with the solvents and cleaners applied to the surface and the metal-ion-bearing aqueous solutions used in the plating tanks. Metal-ion-bearing solutions are commonly based on hexavalent chrome, trivalent chrome, copper, gold, silver, cadmium, zinc, and nickel. Many other metals and alloys are also used, although less frequently. The cleaners (e.g., acids) may appear in process wastewater; the solvents may be emitted into the air, released in wastewater, or disposed of in solid form; and other wastes, including paints, metal-bearing sludge, and still bottom wastes, may be generated in solid form.

Many metal finishing operations are typically performed in (baths) tanks and are then followed by using cycles. Figure (2), illustrates a typical chemical or electrochemical process step in which a workpiece enters the process bath containing process chemicals that are carried out to the rinse water (drag-out).

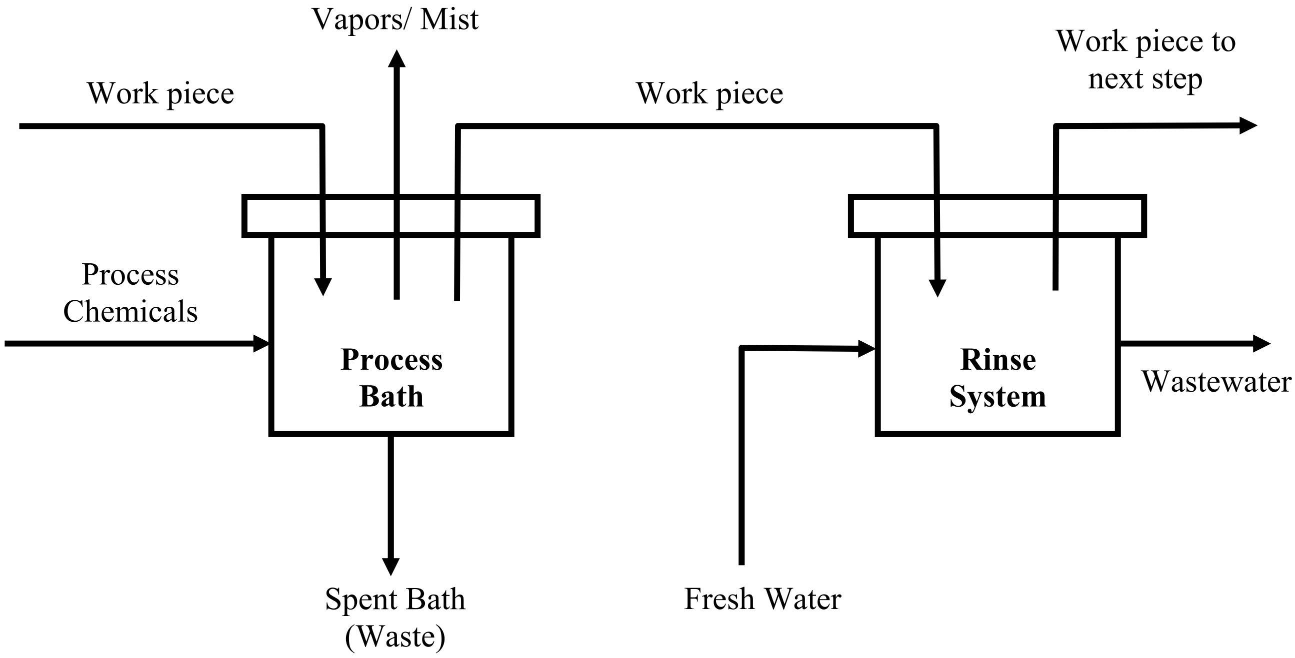


Fig (2) Typical Metal Finishing Process Step

Several of the many metal-finishing operations are described in the following:

Anodizing

Anodizing is an electrolytic process that converts the metal surface to an insoluble oxide coating. Anodized coatings provide corrosion protection, decorative surfaces, a base for painting and other coating processes, and special electrical and mechanical properties. Aluminum is the most frequently anodized material. Common aluminum anodizing processes include chromic acid anodizing, sulfuric acid anodizing, and boric-sulfuric anodizing. The sulfuric acid process is the most common method.

Following anodizing, parts are typically rinsed, and then proceed through a sealing operation that improves the corrosion resistance of the coating. Common sealant includes chromic acid, nickel acetate, nickel-cobalt acetate, and hot water.

Pollution sources: Anodizing operations produce air emissions, contaminated wastewaters, and solid wastes. Mists and gas bubbles arising from heated fluids are a source of air emissions, which may contain metals or other substances present in the bath. When dyeing of anodized coatings occurs, wastewaters produced may contain nickel acetate, non-nickel sealers, or substitutes from the dye. Other potential pollutants include complexes and metals from dyes and sealers.

Wastewaters generated from anodizing are usually combined with other metal finishing wastewaters and treated on-site by conventional hydroxide precipitation. Wastewaters containing chromium must be pretreated to reduce hexavalent chromium to its trivalent state. The conventional treatment process generates a sludge that is usually sent off-site for metals reclamation and/or disposal.

Solid wastes generated from anodizing include spent solutions and wastewater treatment sludge. Anodizing solutions may be contaminated with the base metal being processed due to the anodic nature of the process. These solutions eventually reach an intolerable concentration of dissolved metal and require processing to remove the dissolved metal to a tolerable level or treatment/disposal.

Chemical Conversion Coating

Chemical conversion coating includes chromating, phosphating, metal coloring, and passivating operations. Chromate conversion coatings are produced on various metals by chemical or electrochemical treatment. Solutions, usually containing hexavalent chromium and other compounds, react with the metal surface to form a layer containing a complex mixture of compounds consisting of chromium, other constituents, and base

metal.
Phosphate coatings may be formed by the immersion of steel, iron, or zinc-plated steel in a dilute solution of phosphate salts, phosphoric acid, and other reagents to condition the surfaces for further processing. They are used to provide a good base for paints and other organic coatings, to condition the surfaces for cold forming operations by providing a base for drawing compounds and lubricants, and to impart corrosion resistance to the metal surface.
Metal coloring involves chemically converting the metal surface into an oxide or similar metallic compound to produce a decorative finish such as a green or blue patina on copper or steel, respectively.
Passivating is the process of forming a protective film on metals by immersion into an acid solution, usually nitric acid or nitric acid with sodium dichromate. Stainless steel products are often passivated to prevent corrosion and extend the life of the product.
Pollution sources Chemical conversion coating generally produces contaminated wastewaters and solid waste. Pollutants associated with these processes enter the wastestream through rinsing and batch dumping of process baths. The process baths usually contain metal salts, acids, bases, and dissolved basis materials. Wastewaters containing chromium are usually pretreated to reduce hexavalent chromium to its trivalent state.
The conventional treatment process generates a sludge that is sent off-site for metals reclamation and/or disposal. Solid wastes generated from these processes include spent solutions and wastewater treatment sludge. Conversion coating solutions may also be contaminated with the base metal being processed. These solutions will eventually reach an intolerable concentration of dissolved metal and require processing to remove the dissolved metal to a tolerable level.

Electroplating

Electroplating is the production of a surface coating of one metal upon another by Electro-deposition. Electroplating activities involve applying predominantly inorganic coatings onto surfaces to provide or improve corrosion resistance, hardness, wear resistance, anti-frictional characteristics, electrical or thermal conductivity, or decoration. Figure (3), illustrates the important parts of typical electroplating equipment.
The most commonly electroplated metals and alloys include brass (copper-zinc), cadmium, chromium, copper, gold, nickel, silver, tin, and zinc.
In electroplating, metal ions in either acid, alkaline, or neutral solutions are reduced on the workpieces being

plated. The metal ions in the solution are usually replenished by the dissolution of metal from solid metal anodes fabricated of the same metal being plated, or by direct replenishment of the solution with metal salts or oxides. Cyanide, usually in the form of sodium or potassium cyanide, is usually used as a complexing agent for cadmium and precious metals electroplating, and to a lesser degree, for other solutions such as copper and zinc baths.

The sequence of steps in an electroplating includes: cleaning, often using alkaline and acid solutions; stripping of old plating or paint; electroplating; and rinsing between and after each of these operations. Sealing and conversion coating may be employed on the metals after electroplating operations.

Pollution sources: Electroplating operations produce air emissions, contaminated wastewaters and solid wastes. Mists arising from electroplating fluids and process gases can be a source of air emissions, which may contain metals or other substances present in the bath.

The industry has recently begun adding fume suppressants to electroplating baths to reduce air emissions of chromium, one of the most frequently electroplated metals. The fume suppressants lower the surface tension of the bath, which prevents hydrogen bubbles in the bath from bursting and producing a chromium-laden mist. The fume suppressants are highly effective when used in decorative plating, but less effective when used in hard-chromium plating.

Contaminated wastewaters result from workpiece rinsing and process cleanup waters. Rinse waters from electroplating are usually combined with other metal finishing wastewaters and treated on-site by conventional hydroxide precipitation.

Wastewaters containing chromium must be pretreated to reduce hexavalent chromium to its trivalent state. These wastewater treatment techniques can result in solid-phase wastewater treatment sludge.

Other wastes generated from electroplating include spent solutions which become contaminated during use, and therefore, diminish performance of the process.

In addition to these wastes, spent process solutions and quench bathes may be discarded periodically when the concentrations of contaminants inhibit proper function of the solution or bath.

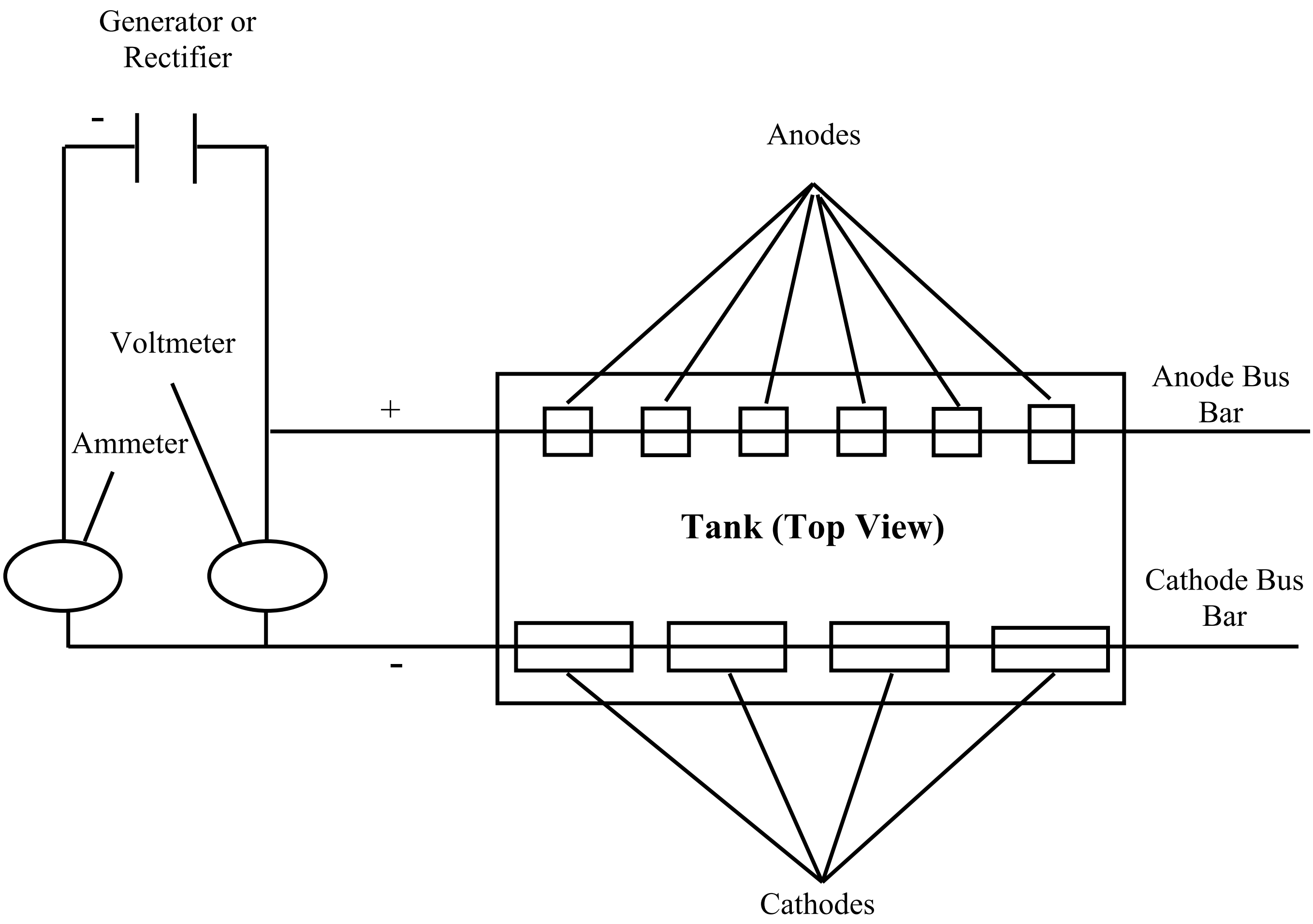


Fig (3) Typical Electroplating Equipment

Electroless plating

Electroless plating is the chemical deposition of a metal coating onto a plastic object, by immersion of the object in a plating solution. Copper and nickel electroless plating is commonly used for printed circuit boards. Basic ingredients in an electroless plating solution are:

- A source of metal (usually a salt);
- A reducer;
- A complexing agent to hold the metal in solution; and
- Various buffers and other chemicals designed to maintain bath stability and increase bath life.

Immersion plating produces a thin metal deposit, commonly zinc or silver, by chemical displacement. Immersion plating baths are usually formulations of metal salts, alkalis, and complexing agents (e.g., lactic, glycolic, malic acid salts).

Pollution sources: Electroless plating and immersion plating commonly generate more waste than other plating techniques, but individual facilities vary significantly in efficiency. Figure (4), illustrates a typical plating process where the drag-out is the carrying of process chemicals to the rinse water.

Electroless plating produces contaminated wastewater and solid wastes. The spent plating solution and rinse water is usually treated chemically to precipitate out the toxic metals and to destroy the cyanide. Electroless plating solutions can be difficult to treat; settling and simple chemical precipitation are not effective at removing the chelated metals used in the plating bath. The extent to which plating solution carry-over adds to the wastewater and enters the sludge depends on the type of article being plated and the specific plating method employed. However, most sludge may contain significant concentrations of toxic metals, and may also contain complex cyanides in high concentrations if cyanides are not properly isolated during the treatment process.

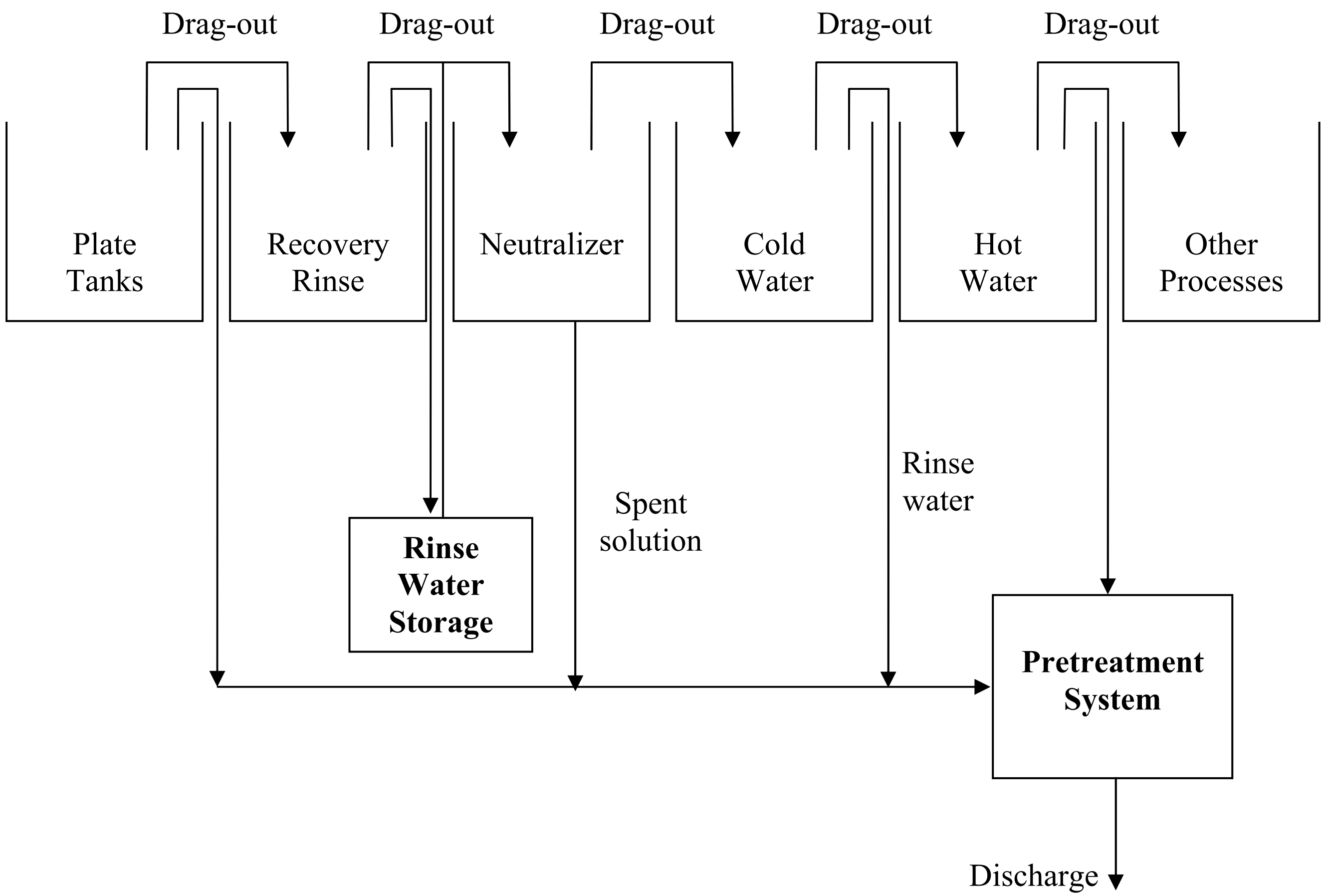


Fig (4) Electrolysis Plating Process

Painting

Painting involves the application of predominantly organic coatings to a workpiece for protective and/or decorative purposes. It is applied in various forms, including dry powder, solvent-diluted formulations, and water-borne formulations. Various methods of application are used, the most common being spray painting and electrodeposition.

Spray painting is a process by which paint is placed into a pressurized cup or pot and is atomized into a spray pattern when it is released from the vessel and forced through an orifice.

When applying the paint as a dry powder, some form of heating or baking is necessary to ensure that the powder adheres to the metal.

Pollution sources: Painting operations result in emissions, contaminated wastewaters, and the generation of liquid and solid wastes. Atmospheric emissions consist primarily of the organic solvents used as carriers for the paint. Emissions also result from paint storage, mixing, application, and drying. In addition, cleanup processes can result in the release of organic solvents used to clean equipment and painting areas.

Wastewaters are often generated from painting processes due primarily to the discharge of water from water curtain booths. On-site treatment processes to treat contaminated wastewater generate a sludge that is sent off-site for disposal.

Sources of solid- and liquid-phase wastes include:

- Paint application emissions control devices (e.g., paint booth collection systems, ventilation filters, etc.)
- Equipment washing
- Disposal materials used to contain paint and over-spray
- Excess paints discarded upon completion of a painting operation or after expiration of the paint shelf life.

These solid and liquid wastes may contain metals from paint pigments and organic solvents, such as paint solvents and cleaning solvents. Still bottoms also contain solvent wastes. The cleaning solvents used on painting equipment and spray booths may also contribute organic solid waste to the wastes removed from the painting areas.

The processes involved in the application of paint as dry powder also result in solvent waste (and associated still bottom wastes generated during solvent distillation), paint sludge wastes, paint-bearing wastewaters, and paint solvent emissions.

Other Metal Finishing Techniques

Polishing, hot dip coating and etching are processes that are also used to finish metal.

Polishing is an abrading operation used to remove or smooth out surface defects (scratches, pits, or tool marks) that adversely affect the appearance or function of a part. Following polishing, the area cleaning and washdown can produce metal-bearing wastewaters.

Hot dip coating is the coating of a metallic workpiece with another metal to provide a protective film by immersion into a molten bath. Galvanizing (hot dip zinc) is a common form of hot dip coating. (Figure.5)

Water is used for rinses following precleaning and sometimes for quenching after coating. Wastewaters generated by these operations often contain metals.

Etching produces specific designs or surface appearances on parts by controlled dissolution with chemical reagents or etchants. Etching solutions commonly comprise strong acids or bases with spent etchants containing high concentrations of spent metal. The solutions include ferric chloride, nitric acid, ammonium persulfate, chromic acid, cupric chloride, and hydrochloric acid.

Pollution sources: Wastewater is often generated during other metal finishing processes. For example, following polishing operations, area cleaning and washdown can produce metal-bearing wastewaters. Hot dip coating techniques, such as galvanizing, use water for rinses following pre-cleaning and sometimes for quenching after coating. Hot dip coatings also generate solid waste, oxide dross that is periodically skimmed off the heated tank. These operations generate metal-bearing wastewaters. Etching solutions contains strong acids (e.g., ferric chloride, nitric acid, ammonium persulfate) or bases.

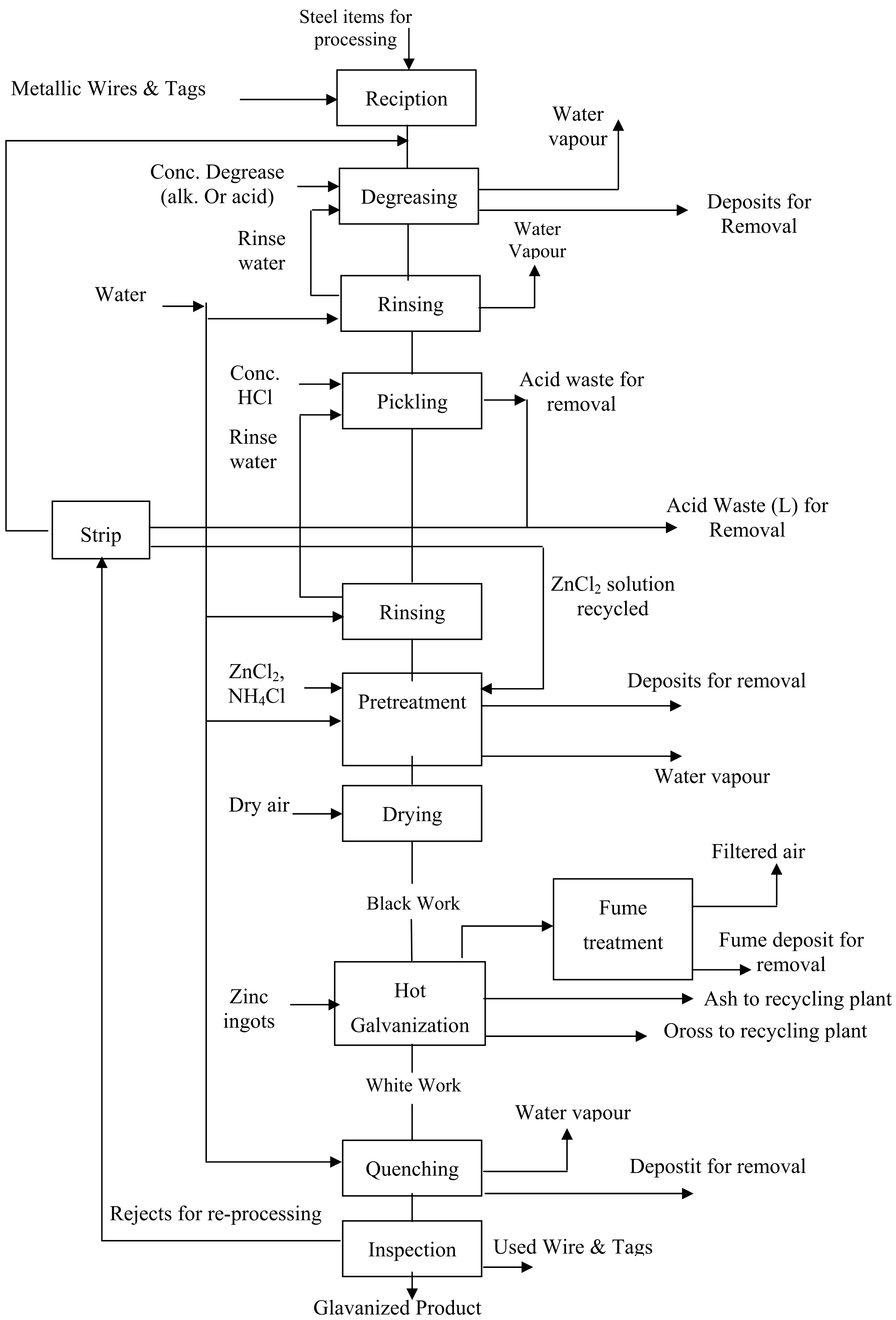


Fig (5) Material Flow Sheet for Galvanizing Plants

2.3 Service Units: Description and Potential Pollution Sources

Medium and large size plants will have some/all of the following service and auxiliary units. These units can be pollution sources and therefore should be inspected and monitored. Figure (6) shows the various units with their corresponding raw materials and potential pollution sources.

2.3.1 Boilers

Boilers can be used to produce steam for:

- Heat supply to the processes
- Electric power generation

Conventional steam-producing thermal power plants generate electricity through a series of energy conversion stages. Fuel is burned in boilers to convert water to high-pressure steam, which is then used to drive the turbine to generate electricity.

The gaseous emissions generated by boilers are typical of those from combustion processes. The exhaust gases from burning fuel oil (Mazot) or diesel oil (solar) contain primarily particulates (including heavy metals if they are present in significant concentrations in the fuel), sulfur and nitrogen oxides (SO_x and NO_x) and volatile organic compounds (VOCs).

The concentration of these pollutants in the exhaust gases is a function of firing configuration (nozzle design, chimney height), operating practices and fuel composition.

Gas-fired boilers generally produce negligible quantities of particulates and pollutants.

Wastewater is generated as 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.

In the case of power plants, water is used for cooling the turbines and is also generated as steam condensate. 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.

2.3.2 Water Treatment Units

There are different types of water used in industry. Depending on the application and the water source, different treatment processes are applied.

a) ***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.

b) ***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 filer 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.

c) ***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

Cooling water is used extensively in industry. During the cooling process, water heats up and can only be reused if cooled. 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.

2.3.4 Laboratories

Laboratories are responsible for:

- Testing raw materials, chemicals, water, wastewater, , etc.
- Quality control of the different products and comparing the findings with the standard specifications for raw materials and final products
- The measured parameters are physical properties, chemical composition

Chemicals used for testing could be hazardous. Proper handling and storage are required for compliance with environmental law.

2.3.5 Workshops and Garage

Large facilities have electrical and mechanical workshops for maintenance and repair purposes. Environmental violations could be due to:

- Noise
- Rinse water contaminated with lube oil

Pollution in the garage area 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 lines or selling it to recycling stations.

2.3.6 Storage Facilities

The specifications for the storage facilities depend on the stored material.

- Chemicals are used as solvents for the process, for washing and for the lab. Some of the chemicals could be hazardous and require special handling, storage and management procedures as required by law.
- Fuel is used for the boilers and for the cars and delivery trucks. It is stored in underground or over ground tanks. The types of fuel usually used are fuel oil (Mazot), gas oil (solar), natural gas and gasoline.

2.3.7 Wastewater Treatment Plants

Although a WWTP is a pollution abatement measure, it has to be inspected and monitored for potential pollution. Pollution may be due to malfunctioning or improper management. A metal fabrication facility discharges wastewater, high in oil and grease and suspended solids. From time to time peak load will be discharged. They may be due to internal processes, to seasonal fluctuations, to lack of control or a "force majeur" situation such as power collapse.

The potential pollution sources from the WWTP are:

- Metal bearing Sludge which could represent a hazardous waste problem
- Treated water could represent a water pollution problem if not complying with relevant environmental laws

2.3.8 Restaurants, Washrooms and Housing Complex

These facilities will generate domestic wastewater as well as domestic solid waste.

Fig (6) 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
Fuel Chemicals	Storage	Spills Hazardous material
Wastewater	Wastewater Treatment Units	Treated water Sludge
Water	**Restaurant and restrooms**	Sanitary Wastewater

2.4 Emissions, Effluents and Solid Wastes

Table (4) summarizes the major polluting processes, their outputs and the violating parameters.

2.4.1 Air Emissions

The main sources of air emission in the fabricated metal products industry are:

- Volatile organic compounds are generated from metal cutting and forming, degreasing and painting.
- Oil mists and fumes are generated from alkaline degreasing, while acid mists are generated from anodizing, chemical coating, plating, electroplating and metal finishing techniques.
- Acid fumes are generated from pickling and metal finishing techniques.
- Hot dip coating generates chloride mist, dust and gaseous compounds.
- Exhaust gases resulting from fuel consumption used to generate steam from boilers. The violating parameters would be: particulate matters, (PM10), sulfur oxides, nitrogen oxides, and carbon monoxide.
- Steam leaking from heating tubes or used as live steam has a negative impact on air quality

2.4.2 Effluents

The major pollution load of the industry is the wastewater from the various sources:

- Metal cutting and forming, pickling, anodizing, chemical coating and other metal finishing techniques generates acidic or alkaline wastewater.
- The use of cutting oils and degreasing produces oily wastewater.
- Organic solvents used in degreasing and painting pollute the wastewater.
- Metals and metal salts used in pickling, anodizing, coating, plating, electroplating and other metal finishing techniques.
- Cyanide, which is generated from plating.
- Blowdowns from the cooling tower and boilers as well as backwash of softeners are high in TDS and TSS.
- Spent lube oil from garage and workshops if discharged to sewer will give oily wastewater (O&G).
- Floor and equipment washing and sanitation produces a wastewater containing organic matter, oil and grease, and traces of the chemicals used for neutralization and sanitation.

2.4.3 Solid Wastes

The main sources of solid wastes are:

- The main solid waste is scales and metal chips generated from metal cutting, forming, degreasing, pickling and electroplating.
- Solvent still bottom wastes.
- Residues in spent solutions from various processes.
- Polishing and etching sludge.

> ***Note:***
> Scrap metal may consist of metal removed from the original piece (e.g., steel), and may be combined with small amounts of metalworking fluids (e.g., solvents) used prior to and during the metal shaping operation that generates the scrap. Quite often, this scrap is reintroduced into the process as a feedstock. The scrap and metalworking fluids, however, should be tracked since they may be regulated as hazardous wastes.

Table (4) Material Inputs and Pollution Sources

Process	Material Input	Air Emission	Process Wastewater	Solid Waste
Metal Shaping				
Metal Cutting and/or Forming	Cutting oils, degreasing and cleaning solvents (e.g., 1,1,1-trichloroethane, acetone, xylene, toluene, etc.), acids, alkalis, and heavy metals, water/oil emulsions)	Volatile organic compound (VOC) emissions	Wastewater contains oils (e.g., ethylene glycol) and suspended solids, acidic (e.g. hydrochloric, sulphuric, nitric) and alkaline wastewater, and water containing solvents	Scales and metal chips (e.g., scrap steel and aluminum), metal-bearing, cutting fluid sludge, and solvent still-bottom wastes, waste oils
Surface Preparation				
Alkaline Degreasing	Caustic soda, soda ash, alkaline silicates, phosphates, inhibitors, emulsifiers, complexing agents, tensides, gluconates	Oil mist and fumes	Alkaline wastewater containing oil and grease, metal, suspended solids	Scale and metal chips (e.g., scrap steel and aluminum) and still bottom wastes, waste oils, spend degreasing baths
Organic solvent based degreasing	Organic solvents	Volatile organic compound (VOC) emissions	Solvents containing wastewater	Ignitable wastes, solvent wastes, and still bottoms
Pickling (acid cleaning)	Different kinds of acids (e.g., hydrochloric, sulphuric, nitric, hydrofluoric)	Acid fumes	Acidic wastewater containing metals	Scale and metal chips (e.g., scrap steel and aluminum) and still bottom wastes, waste oils, spent pickling liquors
Surface Finishing				
Anodizing	Acids	Metal-ion-bearing mists and acid mists	Acidic wastewater & wastewater containing metals	Spent solutions and base metals
Chemical Conversion Coating	Metals and Acids	Metal-ion-bearing mists and acid mists	Metal salts, acid, and base wastewater	Spent solutions and base metals
Electroplating	Acidalkaline, heavy metal bearing and cyanide bearing solutions	Metal-ion-bearing mists and acid mists	Acid/alkaline, cyanide, and meta wastewater	Metal and reactive wastes

Table (4) Material Inputs and Pollution Sources (Cont.)

Process	Material Input	Air Emission	Process Wastewater	Solid Waste
Plating	Metal (e.g., salts), complexing agents, and alkalis	Metal-ion-bearing mists	Cyanide and metal wastewater	Cyanide and metal wastes
Painting	Solvents and paints	Volatile organic compound (VOC) emissions	Solvent wastes	Still bottoms, sludge, paint solvents, and metals
Hot dip coating, metal to be coated with molten zinc	Flux bath containing zinc chloride and ammonium chloride, wetting agents	Chloride mist, dust and gaseous compounds from molten metal kettle	Wastewater containing metals	Hot dip tank dross and other zinc containing residues, spent process solutions, oily wastes
Other Metal Finishing Techniques (Including Polishing and Etching)	Metals and acids	Metal fumes and acid fumes	Metal and acid wastewater	Polishing sludge and etching sludge

3. Impact of Pollutants on Health and Environment

Metals and chemicals used in the surface finishing industry can affect, to a wide range, environmental species as well as cause serious human health effects. Some effects occur immediately, others may take some years to manifest themselves. Health effects are often closely linked to pollution.

Processes, which involve the use of chemicals, should always be examined for their possibility to cause pollution. Loss of chemicals can occur from rinsing operations, from spills, or discarding the spent solutions. Also, a number of ancillary operations may give rise to loss of chemicals to the environment. Ancillary operations include storage of chemicals, transfer and handling or chemicals, wastewater treatment and discharge, discharges from process control laboratories, disposal of residues and reuse or disposal or empty chemical containers.

Chemical pollutants can cause a wide variety of environmental effects, which may vary from one target species to another, and also depend on the particular pathway that a chemical takes in the environment. Chemicals can migrate in the environment from one media to another, e.g. from soil into water, or from water into air. Some chemicals tend to degrade rapidly in the environment, while others are more or less persistent and can, over time, migrate to new locations under the influences of natural forces.

With respect to the workplace it is useful to identify a number of common hazards. Corrosive chemicals (acids, alkalis) eat away at materials and tissues. Strong oxidizing chemicals may cause burns, or cause fires if they into contact with paper, packing materials, timber, or textiles. Many solvents are flammable and can therefore cause a risk for a fire or an explosion.

> ***Note***:
> The potential environmental impacts will vary from situation to situation, depending on the type of industrial process, location, local environmental conditions and so on.

A simple checklist for assessing the potential impact of metal finishing plants includes:

- Occupational exposure of workers to process chemicals and waste residues;
- Water pollution from wastewater or wash water;
- Discharge or chemicals to drains streams, or to soil;
- Impact on public sewer systems, leading to damage to the sewer itself, to the wastewater treatment process, and to the environment near the wastewater outfall; as well as presenting danger to sewer maintenance personnel.
- Contamination or sewage sludge by persistent, bio-accumulative, and toxic residues;
- Groundwater contamination through leakage;
- Disposal of surplus chemicals and/or treatment sludges.

- Soil contamination from spills, at chemical and waste storage areas;
- Transport accidents involving chemicals transported to or from the plant;
- Accidents in the plant involving the release of chemicals;
- Energy and resource consumption;
- Air emissions or chemicals with and subsequent workplace and public exposure

3.1 Top Ten Pollutants of the Engineering Industry

The following is a synopsis of current scientific toxicity and information for the top chemicals (by weight) that facilities within this sector self-reported as released to the environment based upon 1993 TRI (Toxic Release Inventory) data in the USA.

The top TRI release for the ***motor vehicles and motor vehicle equipment*** industry as a whole are as follows: toluene, xylene, methyl ethyl ketone, acetone, glycol ethers, 1,1,1,-trichloroethane, styrene, trichloroethylene, dichloromethane, and methanol.

As a matter of comparison, the top ten TRI releases for the ***Fabricated Metal Products industry*** as a whole, glycol ethers,n-butyl, xylene, methyl ethyl ketone, trichloroethylene, toluene-1, dichloromethane, methyl isobutyl ketone, acetone, and tetrachloroethylene.

Also the top ten TRI releases for ***the coating, engraving and allied services portion of the fabricated metal products industry*** include: methyl ethyl ketone, toluene, glycol ethers, trichloroethylene, xylene (mixed isomers), 1.1,1-trichloroethane, dichloromethane, tetrachloroethylene, hydrochloric acid, and methyl isobutyl ketone.

3.2 Impacts of the Main Pollutants

The main sources for this section are the EPA's annual toxics release inventory public data release book and the hazardous substances data bank (HSDB).

Acetone

Toxicity. Acetone is irritating to the eyes, nose and throat. Symptoms of exposure to large quantities of acetone may include headache, unsteadiness, confusion, lassitude, drowsiness, vomiting, and respiratory depression. Reactions of acetone in the lower atmosphere contribute to the formation of ground-level ozone. Ozone (a major component of urban smog) can affect the respiratory system, especially in sensitive individuals such as asthmatics or allergy sufferers.

Carcinogenicity currently no evidence

Environmental Fate if released into water, acetone will be degraded by microorganisms or will evaporate into the atmosphere. Degradation by _microorganisms will be the

primary removal mechanism. Acetone is highly volatile, and once it reaches the troposphere (lower atmosphere), it will react with other gases, contributing to the formation of ground-level ozone and other air pollutants.
Physical Properties. Acetone is a volatile and flammable organic chemical.

Glycol Ethers

Due to data limitations, data on diethylene glycol (glycol ether) are used to represent at glycol ethers.
Toxicity. Diethylene glycol is only a hazard to human health if concentrated vapors are generated through heating or vigorous agitation or if appreciable skin contact or ingestion occurs over an extended period of time. Under normal occupational and ambient exposures, diethylene glycol is low in oral toxicity is not irritating to the eyes or skin, is not readily absorbed through the skin, and has a low vapor pressure so that toxic concentrations of the vapor cannot occur in the air at room temperatures. At high levels of exposure, diethylene glycol causes central nervous depression and liver and kidney damage. Symptoms of moderate diethylene glycol poisoning include nausea.
Vomiting, headache, diarrhea, abdominal pain, and damage to the pulmonary and cardiovascular systems. Sulfanilamide in diethylene glycol was once used theraopeutically against bacterial infection; it was withdrawn from the market after causing over 100 deaths from acute kidney failure.
Carcinogenicity currently no evidence
Environmental Fate. Dietylene glycol is a water-soluble, volatile organic chemical. It may enter the environment in liquid from via petrochemical plant effluents or as an unburned gas from combustion sources. Diethylene glycol typically does not occur in sufficient concentrations to pose a hazard to human health.

Hydrochloric acid

Toxicity. Hydrochloric acid is primarily a concern in its aerosol form. Acid aerosols have been implicated in causing and exacerbating a variety of respiratory aliments. Dermal exposure and ingestion of highly concentrated hydrochloric acid can result in corrosivity.
Ecologically, accidental releases of solution forms of hydrochloric acid may adversely affect aquatic life by including a transient lowering of pH (i.e., increasing the acidity) of surface waters.
Carcinogenicity. Currently no evidence
Environmental Fate. Releases of hydrochloric acid to surface waters and soils will be neutralized to an extent due to the buffering capacities of both systems. The extent of these reactions will depend on the characteristics if the specific environment.
Physical Properties Concentrated hydrochloric acid is highly corrosive.

Methanol

Toxicity. Methanol is readily absorbed from the gatrointestinal tract and the respiratory tract, and is toxic to humans in moderate to high doses. In the body, methanol is converted into formaldehyde and formic acid. Methanol is excreted as formic acid. Observed toxic effects at high dose levels generally include central nervous system damage and blindness. Long-term exposure to high levels of methanol via inhalation cause liver and blood damage in animals.
Ecologically, methanol is expected to have-low toxicity to aquatic organisms. Concentrations lethal to half the organisms of a test population are expected to exceed 1mg methanol per liter water. Methanol is not likely to persist in water or to bioaccumulate in aquatic organisms.
Carcinogencity currently no evidence
Environmental Fate. Liquid methanol is likely to evaporate when left exposed. Methanol reacts in air to produce formaldehyde, which contributes to the formation of air pollutants. In the atmosphere it can react with other atmospheric chemicals or be washed out by rain. Microorganisms in soils and surface waters readily degrade methanol.
Physical properties. Methanol is highly flammable.

Methylene Chloride (Dichloromethane)

Toxicity. Short-term exposure to dichloromethane (DCM) is associated with central nervous system effects, including headache, giddiness, stupor, irritability, and numbness and tingling in the limbs. More severe neurological effects are reported from longer-term exposure, apparently due to increased carbon monoxide in the blood from the break down of DCM. Contact with DCM causes irritation of the eyes, skin, and respiratory tract.

Occupational exposure to DCM has also been linked to increased incidence of spontaneous abortions in women. Acute damage to the eyes and upper respiratory tract, unconsciousness, and death were reported in workers exposed to high concentrations of DCM. Phosgene (a degradation product of DCM) poisoning has been presence or an open fire.

Populations at special risk from exposure to DCM include obese people (due to accumulation of DCM in fat), and people with impaired cardiovascular systems.

Carcinogenicity. DCM is a probable human-carcinogen via both oral and inhalation exposure, based on inadequate human data and sufficient evidence in animals.

Environmental Fate. When spilled on land, DCM is rapidly lost from the soil surface through volatilization. The remainder leaches through the subsoil into the groundwater. Biodegradation is possible in natural waters but will probably be very slow compared with evaporation. Sediments know little about bioconcentration in aquatic organisms or adsorption but these are not likely to be significant processes. Hydrolysis is not an important process under normal environment conditions. DCM released into the atmosphere degrades via contact with other gases with a half-life of several months. A small fraction of the chemical diffuses to the stratosphere where it rapidly degrades through exposure to ultraviolet radiation and contract with chlorine ions. Being a moderately soluble chemical, DCM is expected to partially return to earth in rain.

Methyl Ethyl Ketone

Toxicity. Breathing moderate amounts of methyl ethyl ketone (MEK) for short periods of time can cause adverse effects on the nervous system ranging from headaches, dizziness, nausea, and numbness in the fingers and toes to unconsciousness. Its vapors are irritating to the skin, eyes, nose, and throat and can damage the eyes. Repeated exposure to moderate to high amounts may cause liver and kidney effects.

Carcinogenicity: Current no agreement over carcinogenicity.

Environmental Fate. Most of the MEK released to the environment will end up in the atmosphere. MEK can

contribute to the formation of air pollutants in the lower atmosphere. Microorganisms living in water and soil can degrade it.
Physical Properties. Methyl ethyl ketone is a flammable liquid.

Toluene

Toxicity. Inhalation or ingestion of toluene can cause headaches, confusion, weakness, and memory loss. Toluene may also affect the way the kidneys and liver function. Reaction of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.
Some studies have shown that unborn animals were harmed when their mothers inhaled high levels of toluene, although the same effects were not seen when the mothers were fed large quantities of toluene. Note that these results may reflect similar conditions in humans.
Carcinogenicity currently no evidence
Environmental Fate. The majority of releases of toluene to land and water will evaporate. Microorganisms may also degrade toluene. Once volatized, toluene in the lower atmosphere will react with other atmospheric components contributing to the formation of ground-level ozone and other air pollutants.
Physical Properties. Toluene is a volatile organic chemical

Trichloroethane

Toxicity. Repeated contact of 1,1,1-trichloroethane (TCE) with skin may cause serious skin cracking and infection. Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. Exposure to high concentrations of TCE causes reversible mild liver and kidney dysfunction, central nervous system depression, gait disturbances, stupor, coma, respiratory depression, and even death.
Exposure to lower concentrations of TCE leads to light-headedness, throat irritation, headache, disequilibrium, impaired coordination, drowsiness, convulsions and mild changes in perception.
Carcinogenicity: Currently no evidence

Environmental Fate. Releases of TCE to surface water or land will almost entirely volatilize. Releases to air may be transported long distances and may partially return to earth in rain. In the lower atmosphere, TCE degrades very slowly by photoozidation and slowly diffuses to the upper atmosphere where photo degradation is rapid. Any TCE that does not evaporate from soils leaches to groundwater. Degradation in soils and water is slow. TCE does not hydrolyze in water, nor does it significantly bioconcentrate in aquatic organisms.

Trichloroethylene

Toxicity. Trichloroethylene was once used as an anesthetic, though its use caused several fatalities due to liver failure. Short-term inhalation exposure to high levels of trichloroethylene may cause rapid coma followed by eventual death from liver, kidney, or heart failure. Short-term exposure to lower concentrations of trichloroethylene causes eye, skin, and respiratory tract irritation.
Ingestion causes a burning sensation in the mouth, nausea, and vomiting and abdominal pain. Delayed effects from short-term trichloroethylene poisoning include liver and kidney lesions, reversible nerve degeneration, and psychic disturbances. Long-term exposure can produce headache, dizziness, weight loss, nerve damage, heart damage, nausea, fatigue, insomnia, visual impairment, mood perturbation, sexual problems, dermatitis, and rarely jaundice.
Degradation products of trichloroethylene (particularly phosgene) may cause rapid death due to respiratory collapse.
Carcinogenicity. Trichloroethylene is a probable human carcinogen via both oral and inhalation exposure, based on limited human evidence and sufficient animal evidence.
Environmental Fate: trichloroethylene breaks down in water in the presence or sunlight and bioconcentratesb moderately in aquatic organisms. The main removal of trichloroethylene from water is via rapid evaporation. Trichloroethylene does not photodegrade in the atmosphere, though it breaks down quickly under smog conditions, forming other pollutants such as phosgene, dichloroacetyl chloride, and formly chloride. In addition, trichloroethylene vapors may be decomposed to toxic levels of phosgene in the presence of an intense heat source such as open arc welder.
When spilled on the land, trichloroethylene rapidly volatilizes from surface soils. The remaining chemical leaches through the soil to groundwater.

Xylene (Mixed Isomers)

Toxicity: Xylenes are rapidly absorbed into the body after inhalation, ingestion, or skin contact. Short-term exposure of humans to high levels of xylenes can cause irritation of the skin, eye, nose, and throat, difficulty in breathing, impaired lung function, impaired memory, and possible changes in the liver and kidneys. Both short and long-term exposure to high concentrations can cause effects such as headaches, dizziness, confusion, and lack of muscle coordination. Reactions of xylenes in the atmosphere contribute to the formation of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Carcinogenicity   currently no evidence

Environmental Fate. The majority of releases to land and water will quickly evaporate, although some degradation by microogranisms will occur. Xylenes are moderately mobile in soils and may leach into groundwater, where they may persist for several years. Xylenes are volatile organic chemicals. As such, xylenes in the lower atmosphere will react with other atmospheric components, contributing to the formation of ground-level ozone and other air pollutants.

3.3 Other pollutants and their impacts

Particulate matters Recent epidemiological evidence suggests that much of the health damage caused by exposure to particulates is associated with particulate matters smaller than 10 microns. These particles penetrate most deeply into the lungs, causing a large spectrum of illnesses (e.g. asthma attack, cough, bronchitis). Emissions of particulates include ash, soot and carbon compounds, which are often the result of incomplete combustion. Acid condensate, sulphates and nitrates as well as lead, cadmium, and other metal can also be detected in the flue gases.

Sulfur oxides Air pollution by sulfur oxides is a major environment problem. This compound is harmful to plant and animal life, as well as many building materials. Another problem of great concern is acid rain, which is caused by the dissolution of sulfur oxides in atmospheric water droplets to form acidic solutions that can be very damaging when distributed the form of rain. Ac id rain is corrosive to metals, limestone, and other materials.

Nitrogen oxides Nitrogen oxides also dissolve in atmospheric water droplets to form acid rain.

Carbon dioxide Combustion of fossil fuels to produce electricity and heat contribute to the green house by the formation of carbon dioxide (heat radiation from earth is absorbed by the gases causing a surface temperature increase).

Waste waters Typical effluent characteristics of the Egyptian Fabricated Metal products industry are shown in the following data taken from the analysis of the wastewaters of a large plant near Cairo.

BOD	765 mg O_2 /liter
COD	1524 mg O_2/liter
Total	18.2 mg/liter
phosphorus	72 mg/liter
Total zinc	1128 mg/liter
TSS	196 mg/liter
O & G	10
pH	

It must be taken into consideration that the overall wastewater stream is typically extremely variable, even inside the same process. For instance according to a world report, one square meter of surface plated can generate anything between one liter and 500 liters of wastewaters usually high in heavy metals such as cadmium chrome, lead, copper, zinc, nickel and also in cyanides, fluorides and oil and grease.

Spent lube oil from garage and workshop could be a cause for concern if discharged into the sewer system. The organic material in wastewater stimulates the growth of bacteria and fungi naturally present in water, which then consume dissolved oxygen.

The environmental impact of the wastewater depends on the receiving water body. The Egyptian Ministry of Irrigation has set limits for the pollutants in the wastewater discharged into agriculture canals and drains as well as the Nile river for their detrimental effect on agriculture (Decree 8/1983). The parameters of relevance besides BOD, COD, O & G, could be for instance phosphorus, cadmium, chromium (hexavalent and total), copper, lead, mercury, nickel, silver, zinc, total metals, cyanides (free) and fluorides.

The discharge of wastewaters to natural waterways could be damaging the natural ecosystems and impacting on bio-diversity. If the wastewaters are too concentrated and discharged into a public sewer system, it can interfere with the purification system of the wastewater treatment plant and let metals accumulate in the sewage sludge.

Note:

Any or all of the substances used in the processes (as electroplating for instance) can be found in the wastewater, either via rinsing of the product or from spillage and dumping of process baths. In the example already taken of electroplating, the mixing of cyanide (sometimes used) and acidic wastewaters can generate lethal hydrogen cyanide gas!!

Relevant solid waste

Dumping of treatment sludges and chemical wastes into poorly located, badly constructed or carelessly managed landfill sites can lead to groundwater pollution problems.
In the surface treatment plant if present, a considerable amount of solid waste can be dewatered sludge from wastewater treatment, if the wastewaters containing metals are treated by chemical treatment such as hydroxide precipitation. The fate of this dewatered sludge should be known (sold to a metal recuperation society, disposal in an approved and controlled landfill…).
In fact solid waste is mainly scrap that is collected and sold, causing no significant impact.

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 fabricated metal products industry .

4.1 Concerning Air Emissions

Let us first define some technical terms:
Threshold Limit is the concentration of airborne chemical substance to which a person can be exposed day after day without adverse effects to his health. If we consider workers in the factory, we use a working day of 8 hours, five days a week.
Threshold Limit for short periods is the threshold limit for an exposure of an average period of 15 minutes and which may not be exceeded under any circumstances during the day. The exposure should not be repeated more than four times during the same day and the period between each short exposure and the next must be at least sixty minutes.
Ceiling Limit is the concentration of airborne chemical substance, which may not be exceeded even for a moment.

> ***Note:***
> If we consider simple asphyxiate gases which have no significant physiological effects, the decisive factor shall be the concentration of oxygen in the atmosphere which may not be less than 18 % according to law No 4/1994.

According to the law No 4/1994 – Annex (6), the permissible limit for emissions of overall particles in outdoor air, in the case of ferrous industries, is down from 200 to 100 mg/m3 of exhaust.
According to Table (2) of Annex (6) of the above law, the maximum limit of lead, mercury, copper, nickel and total heavy elements in the gas and fume emissions from industrial establishments should be respectively 20, 15, 20, 20, 25 mg/m3 of exhaust.
Article 40 of Law 4/1994, article 42 of the executive regulations and annex 6 deal with gaseous emissions from combustion of fuel. The statutes relevant to the fuel combustion are:

- The use of mazot oil 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 carbon 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 (5 and 6).

Table (5) Maximum Limits of Emissions from Sources of Fuel Combustion (for furnaces)

Pollution	Maximum limit, kg/m^3 of exhaust	
	Existing	New
Sulfur Dioxide.	4000	2500
Carbon Monoxide.	4000	2500
Volatized ashes in urban regions.	250	250
Volatized ashes in remote regions.	500	500
Smoke.	250	250

Table (6) Maximum Limits of Emissions from Sources of Fuel Combustion (for Boilers)

Pollutants	Maximum limit, mg/m^3 of exhaust
Sulphur Dioxide	3400
Carbon Monoxide	250
Smoke	50

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 and heavy metals.

Table (7) 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 (7) 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		
COD	100	<1100	30	40	60	60
pH	6-9	6-9.5	6-9	6-9	80	100
Oil & Grease	15	<100	5	5	6-9	6-9
Temperature (deg.)	10C>avg. temp of receiving body	<43	35	35	10	10
Total Suspended Solids	60	<800	30	30	35	35
Settable Solids	—	<10	—	20	50	50
Total Dissolved Solids	2000	—	800	1200	—	—
Chlorine	—	<10	1	1	—	—
PO_4	5	30	1	1	—	10
Total phosphorus		25				
Fluoride	1	<1	0.5	0.5	—	0.5
Cadmium	0.05	0.2	0.01	0.01	—	—

Table (7) Egyptian Environmental Legal Requirements for Industrial Wastewater (Cont.)

<table>
<tr><th rowspan="3">Parameter
(mg/1 unless otherwise noted)</th><th rowspan="3">Law 4/94:
Discharge Coastal Environment</th><th rowspan="3">Law 93/62
Discharge to Sewer System (as modified by Decree 44/2000)</th><th colspan="4">Law 48/82:
Discharge into :</th></tr>
<tr><th rowspan="2">Underground Reservoir & Nile Branches/Canals</th><th rowspan="2">Nile
(Main Stream)</th><th colspan="2">Drains</th></tr>
<tr><th>Municipal</th><th>Industrial</th></tr>
<tr><td>Chromium</td><td>1</td><td></td><td>—</td><td>—</td><td colspan="2" rowspan="4">Total concentration for theses metals should be:
1 for all flow streams</td></tr>
<tr><td>Chromium Hexavalent</td><td>—</td><td>0.5</td><td>0.05</td><td>0.05</td></tr>
<tr><td>Copper</td><td>1.5</td><td>1.5</td><td></td><td>1</td></tr>
<tr><td>Iron</td><td>1.5</td><td></td><td>1</td><td>1</td></tr>
<tr><td>Lead</td><td>0.5</td><td>1</td><td>0.05</td><td>0.05</td><td></td><td></td></tr>
<tr><td>Mercury</td><td>0.005</td><td>0.2</td><td>0.001</td><td>0.001</td><td>—</td><td>—</td></tr>
<tr><td>Nickel</td><td>0.1</td><td>1</td><td>0.1</td><td>0.1</td><td>—</td><td>—</td></tr>
<tr><td>Silver</td><td>0.1</td><td>0.5</td><td>0.05</td><td>0.05</td><td>—</td><td>—</td></tr>
<tr><td>Zinc</td><td>5</td><td><10</td><td>1</td><td>1</td><td>—</td><td>—</td></tr>
<tr><td>Cyanide</td><td>0.1</td><td><0.1</td><td>—</td><td>—</td><td>—</td><td>0.1</td></tr>
<tr><td>Total heavy metals</td><td>—</td><td>Total metals should not exceed 5 mg/l</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table>

As interesting non-binding information, let us consider the two recommendations PARCOM 92/4 and HELCOM 16/6 concerning wastewater discharges from the metal surface industry in the Baltic sea area presented in Table (8).

Table (8) Maximum Permissible Concentrations in Wastewater Discharges from the Metal Surface Treatment Industry

Substance	Concentration in mg/l	
	HELCOM recommendation 16/6	PARCOM recommendation 92/4
Cadmium	0.2	0.2
Mercury	0.05	0.05
Chromium (total)	0.7	0.5
Chromium IV	0.2	0.1
Copper	0.5	0.5
Lead	0.5	0.5
Nickel	1.0	0.5*
Silver	0.2	0.1
Zinc	2.0	0.5
Tin	-	2.0
Unbound Cyanides	0.2	0.2
Volatile Organic Halogens (VOX)	0.1	0.1

* Only in justified cases a maximum zinc concentration of 2 mg/l may be allowed

4.3 Concerning Solid Wastes

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

> ***Note***:
> Fabricated metal products quite often use other materials than metal in the products. Plastic, rubber, glues, insulation materials are typical inputs, producing also solid wastes besides possible emissions

4.4 Concerning work environment

Violations of work environment could be encountered:

- In the boiler house: 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 (9).
- According to the Annex (8) of the law 4/1994, the maximum limits of some air pollutants of concern for the fabricated metal products industry, inside the work place, are gathered in the Table (10).
- 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.
- Near heavy machinery: noise is regulated by article 42 of Law 4/1994, article 44 of the executive regulations and table 1, and annex (7).
- Ventilation is regulated by article 45 of Law 4/1994 and article 47 of the executive regulations.
- Smoking is regulated by article 46 of Law 4/1994 and article 48 of the executive regulations, and Law 52/1981.
- Work environment conditions are addressed in Law 137/1981 for Labor, Minister of Housing Decree 380/1983, Minister of Industry Decree 380/1982

Table (9) Permissible Limits as Time Average and for Short Periods

Material	Threshold			
	Time average		Exposure limits for short periods	
	ppm	mg/m^3	ppm	mg/m^3
Carbon dioxide	5000	9000	15000	27000
Carbon monoxide	50	55	400	440
Sulfur dioxide	2	5	5	10

Table (10) Threshold Limits for Some Air Pollutants of Concern

Substance	Threshold limit		Threshold limit for short periods	
	ppm	mg/m^3	ppm	mg/m^3
Acetone	750	1780	1000	2375
Aluminum metal and oxides	10		20	
Soldering smoke fumes	5			
Carbon dioxide	5000	9000	15000	27000
Carbon monoxide	50	55	400	440
Ethylene glycol vapor	50	125	50	125
Methyl Ethyl Ketone	200	590	300	885
Trichloro-ethylene	50	270	150	805
Soft timber dust		5		10
Xylene	100	435	150	655
Carbon tetrachloride			5	

4.5 Concerning Hazardous Materials and Wastes

Law 4/1994 introduced the control of hazardous materials and wastes. 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. Keeping the register for the hazardous materials is implicit in article 25 of the executive regulations regarding the application for a license.

4.6 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 part 4.5.

5. POLLUTION ABATEMENT MEASURES

Pollution abatement is the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes. It also includes practices that reduce the use of hazardous materials, energy, water or other resources, and practices that protect natural resources through conservation or more efficient use.

5.1 General Concepts

Three types of interventions will be considered:

- In-plant modifications, which are changes that are performed in the plant to reduce pollutant concentrations in streams through recovery of materials, segregation and/or integration of streams, reducing the flow rate of the wastewater streams that need further treatment to reduce the hold-up of the required WWTP.
- In-Process modifications, which are changes performed on the process such as the introduction of newer technology, substitution of a hazardous raw material, performing process optimization and control.
- End-of-pipe (EoP) measures, which involve treatment of the pollutant or its separation for further disposal. Whereas in-plant and in-process modifications usually have an economic return on investment, end-of-pipe measures will be performed for the sole purpose of compliance with the laws without economic

The term Cleaner Production (CP) refers to the same concepts of pollution reduction through in-process, in-plant and resource conservation, in contradiction to end-of-pipe treatment. In many cases, the adoption of CP can eliminate the need for (EoP) treatment.
Egyptian Environmental Laws do not require water and energy conservation measures. These measures have been considered in this manual since resource depletion and hence conservation is a worldwide-recognized environmental issue that could be implemented in Egypt in the near future. Water conservation measures can lead to higher concentrations of the effluent streams. Both energy and water conservation measures will provide both financial and economic benefits.

> ***Note***:
> Pollution abatement is often cost effective because it may reduce raw material losses and reliance on expensive end-of-pipe treatment technologies and disposal practices. It may also conserve energy, water, chemicals, and other inputs.

Pollution prevention techniques and processes currently used by the metal fabricating and finishing industry can be grouped into seven general categories:

- Production planning and sequencing
- Process or equipment modification

- Raw material substitution or elimination
- Loss prevention and housekeeping
- Waste segregation and separation
- Closed-loop recycling
- Training and supervision

Each of these categories is discussed briefly below.

Production planning and sequencing is used to ensure that only necessary operations are performed and that no operation is needlessly reversed or obviated by a following operation. One example is to sort out substandard parts prior to painting or electroplating. A second example is to reduce the frequency with which equipment requires cleaning by painting all products of the same color at the same time. A third example is to schedule batch processing in a manner that allows the wastes or residues from one batch to be used as an input for the subsequent batch (e.g., to schedule paint formulation from lighter shades to darker) so that equipment need not be cleaned between batches.

Process or equipment modification is used to reduce the amount of waste generated. For example, manufacturers can change to a paint application technique that is more efficient than spray painting, reduce over-spray by reducing the atomizing air pressure, reduce drag-out by reducing the withdrawal speed of parts from plating tanks, or improve a plating line by incorporating drag-out recovery tanks.

Raw material substitution or elimination is the replacement of existing raw materials with other materials that produce less waste, or a non-toxic waste. Examples include substituting alkali washes for solvent degreasers, and replacing oil with lime or borax soap as the drawing agent in cold forming.

Loss prevention and housekeeping is the performance of preventive maintenance and equipment and materials management so as to minimize opportunities for leaks, spills, evaporative losses, and other releases of potentially toxic chemicals. For example, spray guns can be cleaned in a manner that does not damage leather packings and cause the guns to leak; or drip pans can be placed under leaking machinery to allow recovery of the leaking fluid.

Waste segregation and separation involves avoiding the mixture of different types of wastes and avoiding the mixture of hazardous wastes with non-hazardous wastes. This makes the recovery of hazardous wastes easier by minimizing the number of different hazardous constituents in a given waste stream. It also prevents the contamination of non-hazardous wastes. Specific examples include segregating scrap metal-by-metal type, and segregating different kinds of used oils.

Closed-loop recycling is the on-site use or reuse of a waste as an ingredient or feedstock in the production process. For example, in-plant paper fiber waste can be collected and recycled to make pre-consumer recycled paper products.

Training and supervision provides employees with the information and the incentive to minimize waste generation in their daily duties. This might include ensuring that employees know and practice proper and efficient use of tools and supplies, and that they are aware of, understand, and support the company's pollution prevention goals.

5.2 Pollution Prevention Options

Some of the most important techniques that may be useful to companies specializing in metal fabrication and finishing operations are presented below. These are options available to facilities, but are not to be considered as requirements. Metal shaping, surface preparation, plating, and other finishing operations besides auxiliary services such as power generation plants organize the information.
It should be stressed here that, what is given in the following, are examples of real applications of cleaner production in the fabricated metal products industry and not applications that are in the R & D stage. Through the Internet, interested enterprises can easily obtain the addresses of societies, which have already implemented successfully the suggested modifications.

5.2.1 Metal shaping Operations

Production planning and sequencing

Option 1 - Improve scheduling of processes that require use of varying oil types in order to reduce the number of clean-outs.

Process and equipment modification

Option 1 - Standardize the oil types used for machining, turning, lathing, etc. This reduces the number of equipment clean-outs, and the amount of leftovers and mixed wastes.
Option 2 - Use specific pipes and lines for each set of metals or processes that require a specific oil in order to reduce the amount of clean-outs.
Option 3 - Save on coolant costs by extending machine coolant life through the use of a centrifuge and the addition of biocides.
Option 4 - Install a second high speed centrifuge on a system already operating with a single centrifuge to improve recovery efficiency even more.
Option 5 - Install a chip wringer to recover excess coolant on aluminum chips.
Option 6 - Install a coolant recovery system and collection vehicle for machines not on a central coolant sump
Option 7 - Use a coolant analyzer to allow better control of coolant quality.
Option 8 - Use an ultra-filtration system to remove soluble oils from wastewater streams.
Option 9 - Use disk or belt skimmers to remove oil from machine coolants and prolong coolant life. Also, design sumps for ease of cleaning.

Raw material substitution	*Option 1* - In cold forming or other processes where oil is used only as a lubricant, substitute hot lime bath or borax soap for oil. *Option 2* - Use a stamping lubricant that can remain on the piece until the annealing process, where it is burned off. This eliminates the need for hazardous degreasing solvents and alkali cleaners.
Waste segregation and separation	*Option 1* - If filtration or reclamation of oil is required before reuse, segregate the used oils in order to prevent mixing wastes. *Option 2* - Segregation of metal dust or scrap by type often increases the value of metal for resale (e.g., sell metallic dust to a zinc smelter instead of disposing of it in a landfill. *Option 3* - Improve housekeeping techniques and segregate waste streams (e.g., use care when cleaning cutting equipment to prevent the mixture of cutting oil and cleaning solvent.
Recycling	*Option 1* - Where possible, recycle oil from cutting/machining operations. Often oils need no treatment before recycling. *Option 2* - Oil scrap mixtures can be centrifuged to recover the bulk of the oil for reuse. *Option 3* - Follow-up magnetic and paper filtration of cutting fluids with ultrafiltration. By so doing, a much larger percentage of cutting fluids can be reused. *Option 4* - Perform on-site purification of hydraulic oils using commercial "off-the-shelf" cartridge filter systems. *Option 5* - Use a settling tank (to remove solids) and a coalescing unit (to remove tramp oils) to recover metalworking fluids.

5.2.2 Surface Preparation Operations

a) Solvent Cleaning

Training and supervision	:*Option 1*: Improve solvent management by requiring employees to obtain solvent through their shop foreman. Also, reuse waste solvents from cleaner up-stream operation in down- stream, machines shop type processes.
Production planning and sequencing	*Option 1* - Pre-cleaning will extent the life of the aqueous or vapor degreasing solvent (wipe, squeeze, or blow part with air, shot, etc.). Aluminum shot can be used to pre-clean parts. *Option 2* - Use countercurrent solvent cleaning (i.e., rinse initially in previously used solvent and progress to new, clean solvent). *Options 3* - Cold clean with a recycled mineral spirits stream to remove the bulk of oil before final vapor

degreasing.
Option 4 - Only degrease parts that must be cleaned. Do not routinely degrease all parts.

Process or equipment modifications

Option 1 - The loss of solvent to the atmosphere from vapor degreasing equipment can be reduced by:

- Increasing the freeboard height above the vapor level to 100 percent of tank width;
- Covering the degreasing unit (automatic covers are available);
- Installing refrigerator coils (or additional coils) above the vapor zone;
- Rotating parts before removal from the vapor degreaser to allow all condensed solvent to return to degreasing unit;
- Controlling the speed at which parts are removed (3 meters or less per minute is desirable) so as not to disturb the vapor line;
- Installing thermostatic heating controls on solvent tanks; and
- Adding in-line filters to prevent particulate buildup in the degreaser.

Option 2 - Reduce grease accumulation by adding automatic oilers to avoid excess oil applications.
Option 3 - Use plastic blast media for paint stripping rather than conventional solvent stripping techniques

Raw material substitution

Option 1 - Use less hazardous degreasing agents such as petroleum solvents or alkali washes. For example, replace halogenated solvents (e.g., trichloroethylene) with liquid alkali cleaning compounds. (Note that compatibility of aqueous cleaners with wastewater treatment systems should be ensured.)
Option 2 – Prefer water-based surface cleaning agents where feasible, instead of organic cleaning agents, some of which are considered toxic. Try to optimize bath operation to enhance efficiency, e.g. by agitation.
Option 3 - Substitute chromic acid cleaner with non-fuming cleaners such as sulfuric acid and hydrogen peroxide.
Throughput Information: rinse water flow rate of 2 gallons per minute.
Option 4 - Substitute less polluting cleaners such as tri-sodium phosphate or ammonia for cyanide cleaners.

Recycling

Option 1 - Recycle spent degreasing solvents on site using batch stills
Option 2 – Acid mists and vapors should be scrubbed with water before venting and recycled solvent collected from air pollution control systems. In some cases VOC levels of the vapors are reduced by the use of carbon filters,

which allow the reuse of solvents.
Option 3 - When on-site recycling is not possible, agreements can be made with supply companies to remove old solvents.
Option 4 - Arrange a cooperative agreement with other small companies to centrally recycle solvent.
Option 5 – Manage properly the residue from solvent recovery (e.g. blending with fuel and burning in a combustion unit with proper controls for toxic metals).
Option 6 – Clean degreasing solutions to extend lifespan (by skimming, centrifuge, etc.) and recirculation, reutilization of oily sludge.

b) Chemical Treatment

Process or equipment modification

Option 1- Increase the number of rinses after each process bath and keep the rinsing counter-current in order to reduce drag-out losses.
Option 2 - Recover unmixed acids in the wastewater by evaporation.
Option 3 - Reduce rinse contamination via drag-out by:

- Slowing and smoothing removal of parts, rotating them if necessary;
- Using surfactants and other wetting agents;
- Maximizing drip time;
- Using drainage boards to direct dripping solutions back to process tanks;
- Installing drag-out recovery tanks to capture dripping solutions;
- Using a fog spray rinsing technique above process tanks;
- Using techniques such as air knives or squeegees to wipe bath solutions off of the part; and
- Changing bath temperature or concentrations to reduce the solution surface tension.

Option 4 - Instead of pickling brass parts in nitric acid, place them in a vibrating apparatus with abrasive glass marbles or steel balls. A slightly acidic additive is used with the glass marbles, and a slightly basic additive is used with the steel balls
Option 5 - Use mechanical scraping instead of acid solution to remove oxides of titanium.
Option 6 - For cleaning nickel and titanium alloy, replace alkaline etching bath with a mechanical abrasive system that uses a silk and carbide pad and pressure to clean or "brighten" the metal.
Option 7 - Clean copper sheeting mechanically with a rotating brush machine that scrubs with pumice, instead of cleaning with ammonium persulfate, phosphoric acid, or sulfuric acid which may generate non-hazardous waste sludge.

Option 8- Reduce molybdenum concentration in wastewater by using a reverse osmosis/precipitation system.
Option 9 - When refining precious metals, reduce the acid/metals waste stream by maximizing reaction time in the gold and silver extraction process.

Raw material substitution

Option 1 - Change copper bright-dipping process from a cyanide dip and chromic acid dip to a sulfuric acid/hydrogen peroxide dip. The new bath is less toxic and copper can be recovered.
Option 2 - Use alcohol instead of sulfuric acid to clean copper wire. One ton of wire requires 4 liters of alcohol solution, versus 2 kilograms of sulfuric acid.
Option 3 - Replace caustic wire cleaner with a biodegradable detergent.
Option 4 - Replace barium and cyanide salt heat-treating with a carbonate/chloride carbon mixture, or with furnace heat-treating.
Option 5 - Replace thermal treatment of metals with condensation of saturated chlorite vapors on the surface to be heated

Recycling

Option 1 - Sell waste pickling acids as feedstock for fertilizer manufacture or neutralization/precipitation.
Option 2 - Recover metals from solutions for resale.
Option 3 - Send used copper pickling baths to a continuous electrolysis process for regeneration and copper recovery.
Option 4 - Recover copper from brass bright dipping solutions using a commercially available ion exchange system.
Option 5 - Treat industrial wastewater high in soluble iron and heavy metals by chemical precipitation.
Option 6 - Oil quench baths may be recycled on site by filtering out the metals.
Option 7 - Alkaline wash life can be extended by skimming the layer of oil (the skimmed oil may be reclaimed).

5.2.3 Surface Finishing Operations

a) Plating

Training and supervision

Option 1 - Educate plating shop personnel in the conservation of water during processing and in material segregation.

Production planning and sequencing

Option 1: Pre-inspect parts to prevent processing of obvious rejects

Process or equipment modification	*Option 1* - Modify rinsing methods to control drag-out by: • Increasing bath temperature • Decreasing withdrawal rate of parts from plating bath • Increasing drip time over solution tanks; racking parts to avoid cupping solution within part cavities • Shaking, vibrating, or passing the parts through an air knife, angling drain boards between tanks • Using wetting agents to decrease surface tension in tank. *Option 2* - Utilize water conservation methods including: • Flow restrictors on flowing rinses • Counter current and cascade rinsing systems • Reactive rinsing • Conductivity controllers • Flow control valves. *Option 3* Reduce the drag out: • Minimize drag-out through effective draining of bath solutions from the plated part, e.g. by making drain holes in bucket-type pieces, if necessary. • Use drip bars, and/or drain boards between tanks. • Increase parts drainage time to reduce drag-out, e.g. by allowing dripping time of at least 10-20 seconds before rinsing. • Use fog spraying of parts while dripping. • Maintain the density, viscosity and temperature of the baths to minimize drag-out. • Place recovery tanks before the rinse tanks (also yielding makeup for the process tanks). The recovery tank provides for static rinsing with high drag-out efficiency. • Install ion exchange system, or reverse osmosis system or electrolytic metal recovery, or electrodialysis to reduce generation of drag-out. • Reuse drag-out waste back into process tank. *Option 4* – Rationalize the management of process baths. • Recycle process baths after concentration and filtration. Spent bath solutions should be sent for recovery and regeneration of plating chemicals, not discharge into wastewater treatment units. • Regenerate plating bath by activated carbon filtration to remove built up organic contaminants. • Regularly analyses and regenerate process solutions to maximize useful life. • Clean racks between baths to minimize contamination. *Option 5* - Install pH controller to reduce the alkaline and acid concentrations in tanks. *Option 6* - Improve control of water level in rinse tanks, improve sludge separation, and enhance recycling of supernatant (floating on the surface) to the process by aerating the sludge.

Raw material substitution

Option 1 - Substitute cyanide plating solutions with alkaline zinc, acid zinc, acid sulfate copper, pyrophosphate copper, alkaline copper, copper fluoborate, electroless nickel, ammonium silver, halide silver, methanesulfonate-potassium iodide silver, amino or thio complex silver, cadmium chloride, cadmium sulfate, cadmium fluoborate, cadmium perchlorate, gold sulfite, and cobalt harden gold
Option 2 - Substitute sodium bisulfite and sulfuric acid for ferrous sulfate in order to oxidize chromic acid wastes, and substitute gaseous chlorine for liquid chlorine in order to reduce cyanide reduction.
Option 3 - Replace hexavalent chromium with trivalent chromium plating systems.
Option 4 - Replace conventional chelating agents such as tartarates, phosphates, and ammonia with sodium sulfides and iron sulfates in removing metal from rinse water, which reduces the amount of waste generated from precipitation of metals from aqueous waste streams.
Option 5 - Replace methylene chloride, 1,1,1-trichloroethane, and perchloroethylene (solvent-based photochemical coatings) with aqueous base coating of 1 percent sodium carbonate
Option 6 - Replace methanol with nonflammable alkaline cleaners.
Option 7 - Substitute non-cyanide for a sodium cyanide solution used in copper plating baths.

Waste segregation and separation

Option 1 - Wastewater containing recoverable metals should be segregated from other wastewater streams.

Note:
Several different waste streams will generally originate from a single metal finishing plant. The different composition and concentrations of waste streams will require different treatment procedures. Segregation and separate pretreatment of certain effluents is more efficient than trying to treat a complex mixed wastewater stream. Segregation of different types of wastewaters also avoids the possibility that incompatible wastes will undergo undesirable reactions in the storage tanks. Undesirable reactions can be a hazard to personnel by generating toxic gases (lethal hydrogen cyanide gas) or complexes may form, e.g. nickel cyanide, which are difficult to treat. Various options to treat waste effluents should be carefully assessed for each enterprise.

Recycling

Option 1 Reuse rinse water.
Option 2- Reuse drag-out waste back into process tank.
Option 3- Recover process chemicals with fog rinsing parts over plating bath
Option 4- Evaporate and concentrate rinse baths for recycling.
Option 5- Convert sludge to smelter feed

Option 6- Remove and recover lead and tin from boards by electrolysis or chemical precipitation.
Option 7 - Install a closed loop batch treatment system for rinse water to reduce water use and waste volume
Option 8. - Install an electrolytic cell that recovers 92 percent of dissolved copper in drag-out rinses and atmospheric evaporator to recover 95 percent of chromatic acid drag-out, and recycle it into chromic acid etch line.
Option 9. - Implement the electrodialysis reversal process for metal salts in wastewater.
Option 10. - Oxidize cyanide and remove metallic copper to reduce metal concentrations.

b) Painting Operations

Training and supervision

Option 1: Always use proper spraying techniques
Option 2: Improved paint quality, work efficiency, lower vapor emissions can be attained by formal training of operators
Option 3: Avoid buying excess finishing material at one time due to its short shelf-life

Production planning and sequencing

Option 1: Use the correct spray gun for particular applications:
Conventional air spray gun for thin film build requirements
Airless gun for heavy film application
Air assisted airless spray gun for a wide range of fluid output
Option 2: pre-inspect parts to prevent painting of obvious rejects

Process or equipment modification

Option 1: Ensure the spray gun air supply is free of water, oil and dirt
Option 2: Investigate use of transfer methods that reduce material loss such as:

- Dip and flow coating
- Electrostatic spraying
- Electro-deposition

Option 3 - Change from conventional air spray to an electrostatic finishing system.
Option 4 - Use solvent recovery or incineration to reduce the emissions of volatile organics from curing ovens.

Raw material substitution

Option 1. Use alternative coatings for solvent based paints to reduce volatile organic materials use and emissions. Such as:

- High solids coatings (this may require modifying the painting process; including high speed/high pressure equipment, a paint distributing system, and paint heaters): Waste savings/reduction: 30 percent net

savings in applied costs per square foot.
- Water based coatings, waste savings/reduction: 87 percent drop in solvent emissions and decreased hazardous waste production
- Powder coatings

Waste segregation and separation	*Option 1*: Segregate non hazardous paint solid from hazardous paint solvents and thinners
Recycling	*Option 1* - Do not dispose of extended shelf life items that do not meet your facility's specifications. They may be returned to the manufacturer, or sold or donated as a raw material. *Option 2* - Use activated carbon to recover solvent vapors, then recover the solvent from the carbon by steam stripping, and distill the resulting water/solvent mixture. *Option 3* - Regenerate caustic soda etch solution for aluminum by using hydrolysis of sodium aluminates to liberate free sodium hydroxide and produce a dry, crystalline hydrate alumina byproduct.

b) Paint Clean-Up

Production planning and sequencing	*Option 1*: Reduce equipment cleaning by painting with lighter colors before darker ones. *Option 2* - Reuse cleaning solvents for the same resin system by first allowing solids to settle out of solution. *Option 3* - Flush equipment first with dirty solvent before final cleaning with virgin solvent. *Option* 4 - Use virgin solvents for final equipment cleaning, then as paint thinner. *Option 5* - Use pressurized air mixed with a mist of solvent to clean equipment.
Raw material substitution	*Option 1* - Replace water-based paint booth filters with dry filters. Dry filters will double paint booth life and allow more efficient treatment of wastewater.
Loss prevention and housekeeping	*Option 1*: To prevent spray gun leakage. Submerge only the front end (or fluid control) of the gun into the cleaning solvent.
Waste segregation and separation	*Option 1*: Solvent waste streams should be kept segregated and free from water contamination.

Recycling

Option 1 - Solvent recovery units can be used to recycle spent solvents generated in flushing operations.

- Install a recovery system for solvents contained in air emissions.
- Use batch distillation to recover xylene from paint equipment cleanup.
- Use a small solvent recovery still to recover spent paint thinner from spray gun cleanups and excess paint batches.
- Install a methyl ethyl ketone solvent recovery system to recover and reuse waste solvents.

Option 2 - Arrange an agreement with other small companies to jointly recycle cleaning wastes.

5.2.4 Auxiliary utilities

a) Fuel Combustion Equipment

Fuel combustion is an important source of pollution and the following measures can be implemented to reduce pollution.

Flue gases

Particulate matter in flue (exhaust) gases is due the ash and heavy metal content of the fuel, low combustion temperature, low excess oxygen level, and high flow rate of flue gases. *Sulfur dioxide* is due to the sulfur content of the fuel. *Nitrogen oxides* are formed when maximum combustion temperature and high excess oxygen. *Carbon monoxide* is formed when incomplete combustion occurs at low air to fuel ratio.

The following measures can be adopted to minimize air pollution from flue (exhaust) gases:

- Replace Mazot by solar or natural gas. Mazot is high in sulfur content.
- Regulate the fuel to air ratio for an optimum excess air that ensures complete combustion of carbon monoxide to dioxide.
- Keep the combustion temperature at a moderate value to minimize particulate matter and nitrogen oxides.

b) Wastewater Treatment Plant

End-of-pipe treatment

- If cyanide is present in the wastewater, its destruction (oxidation of cyanide) must be performed upstream of the other treatment processes.
- If hexavalent chromium exists in the wastewater, the wastewater must be pre-treated to reduce the chromium to a more easily precipitated trivalent form using a reducing agent, such as sulfur compounds (e.g. sulfur dioxide gas, sodium metabisulfite).
- The common wastewater treatment processes are equalization, pH adjustment for precipitation,

flocculation and sedimentation/filtration. The optimum pH for metal precipitation is usually in the range of 8.5 to11, but this depends on the mixture of metals present.

- Wastewaters containing soluble metals can be treated by chemical precipitation either by continuous process or as batch treatment. Normally calcium or sodium hydroxide is used for precipitation and therefore metals are precipitated as metal hydroxides. After precipitation, metals can be separated by clarification and sedimentation and/or filtration. Metal hydroxide sludge can be dewatered e.g. with a filter press.
- The presence of significant levels of oil and grease may affect the effectiveness of the metal precipitation process; hence the level of oil and grease affects the choice of the treatment options and the treatment sequence. It is preferred that the degreasing baths be treated separately. Also the presence of complexing agents may affect the effectiveness of the metal precipitation.
- Flocculating agents are sometimes used to facilitate the filtration of suspended solids. Modern wastewater treatment systems use ion exchange, membrane filtration, and evaporation to reduce the release of toxics and the quality of effluent that needs to be discharged.

c) Water Conservation Measures

- Install water meters;
- Use automatic shut-off nozzles and mark hand-operated valves so that open, close and directed-flow positions are easily identified;
- Use high-pressure, low-volume cleaning systems, such as CIP (clean in place) for washing equipment;
- Install liquid level controls with automatic pump stops where overflow is likely to occur;
- Recycle cooling water through cooling towers;
- Minimize spills on the floor to minimize floor washing.

5.3 Possible Pollution Prevention Future Plans

There are numerous pollution prevention trends in the metal fabrication and finishing industry. These include recycling liquids, employing better waste control techniques, using mechanical forms of surface preparation, and/or substituting raw materials. One major trend is the increased recycling (e.g., reuse) of most process liquids (e.g., rinse water, acids, alkali cleaning compounds, solvents, etc.) used during the metal forming and finishing processes. For instance, instead of discarding liquids, companies are containing them and reusing them to cut down on the volume of process liquids that must eventually be disposed of. Also, many companies are replacing aqueous plating with ion vapor deposition.

Another common approach to reducing pollution is to reduce rinse contamination via drag-out by slowing and smoothing the removal of parts (rotating them if necessary), maximizing drip time, using drainage boards to direct dripping solutions back to process tanks, and/or installing drag-out recovery tanks to capture dripping solutions. By slowing down the processes and developing structures to contain the dripping solutions, a facility can better control the potential wastes emitted.

To reduce the use of acids when cleaning parts, the industry is using and encouraging the use of mechanical scraping/scrubbing techniques to clean and prepare the metal surface. Emphasizing mechanical approaches would greatly diminish the need for acids, solvents, and alkalis. In addition to the mechanical technique for cleaning surfaces, companies are encouraged to substitute acids and solvents with less harmful liquids (e.g., alcohol).

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 7) 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.

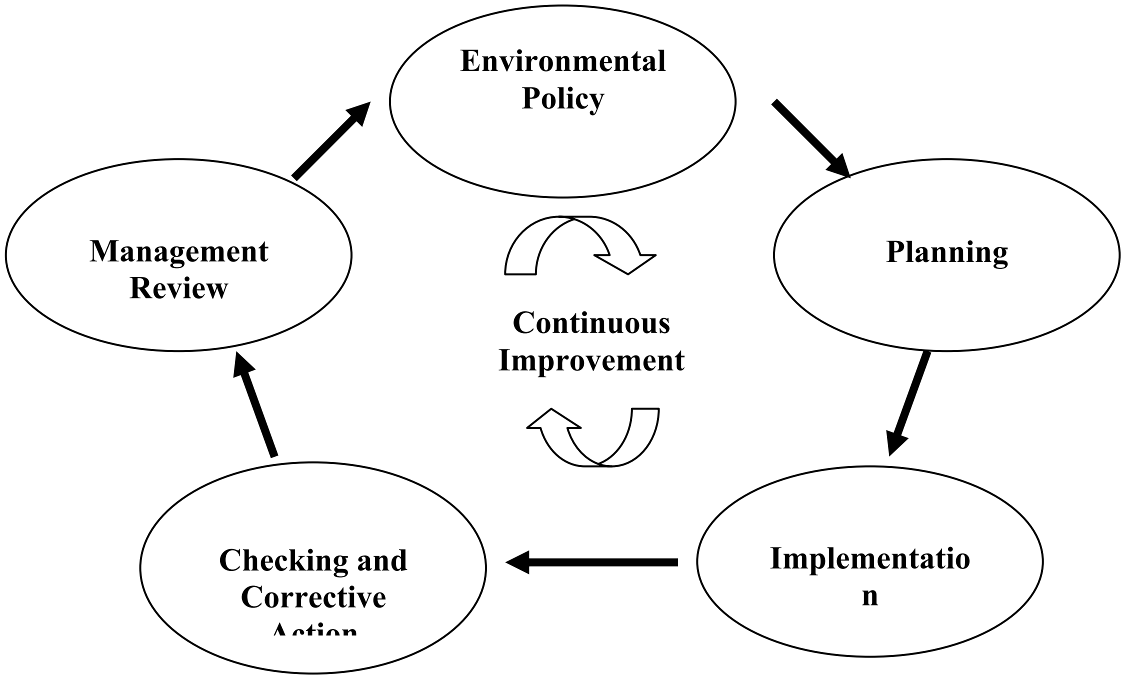


Figure (7) Phases of EMS cycle (ISO 14000)

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 (8) 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.

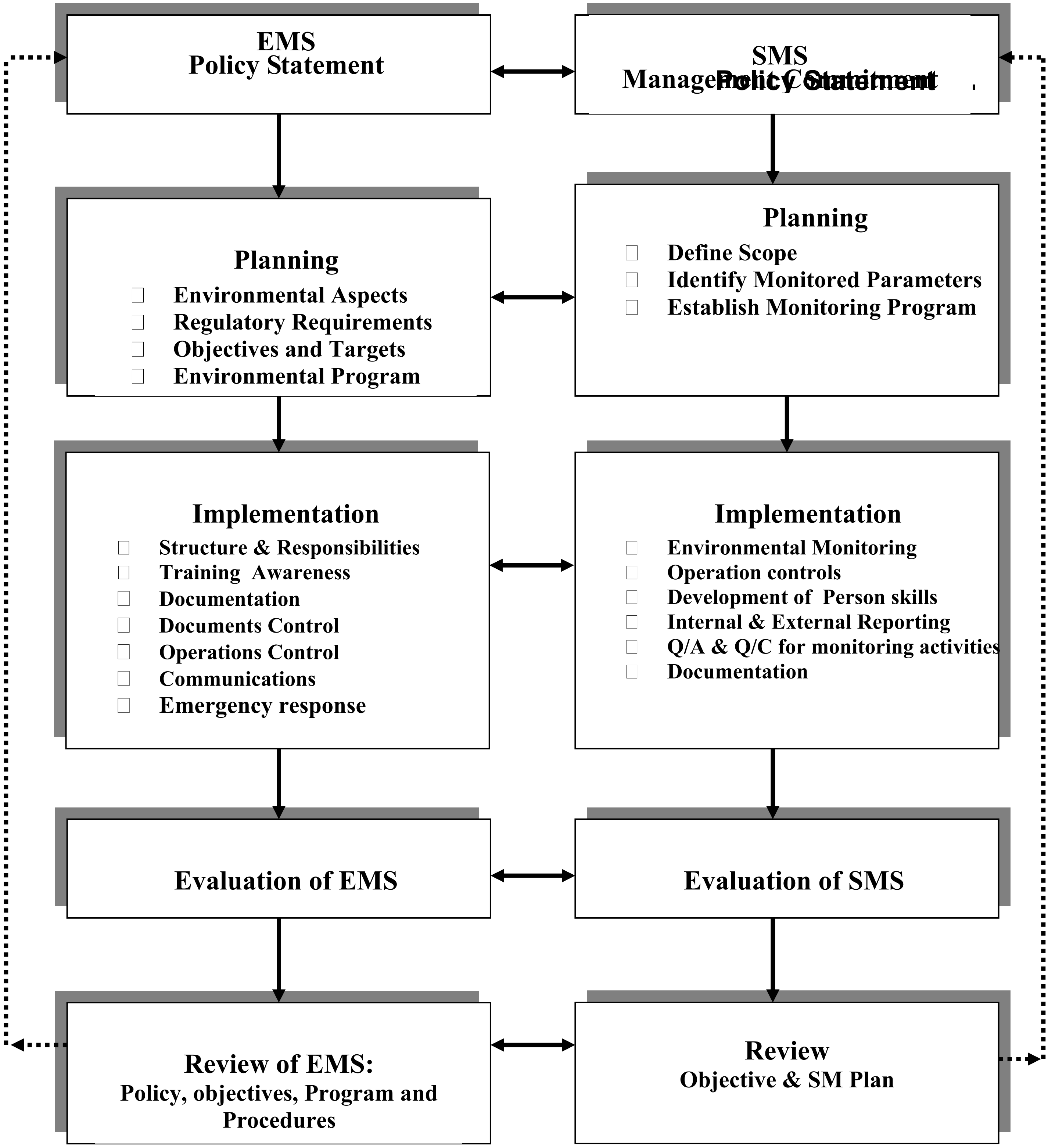


Figure (8) Relationship between EMS and SMS

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).

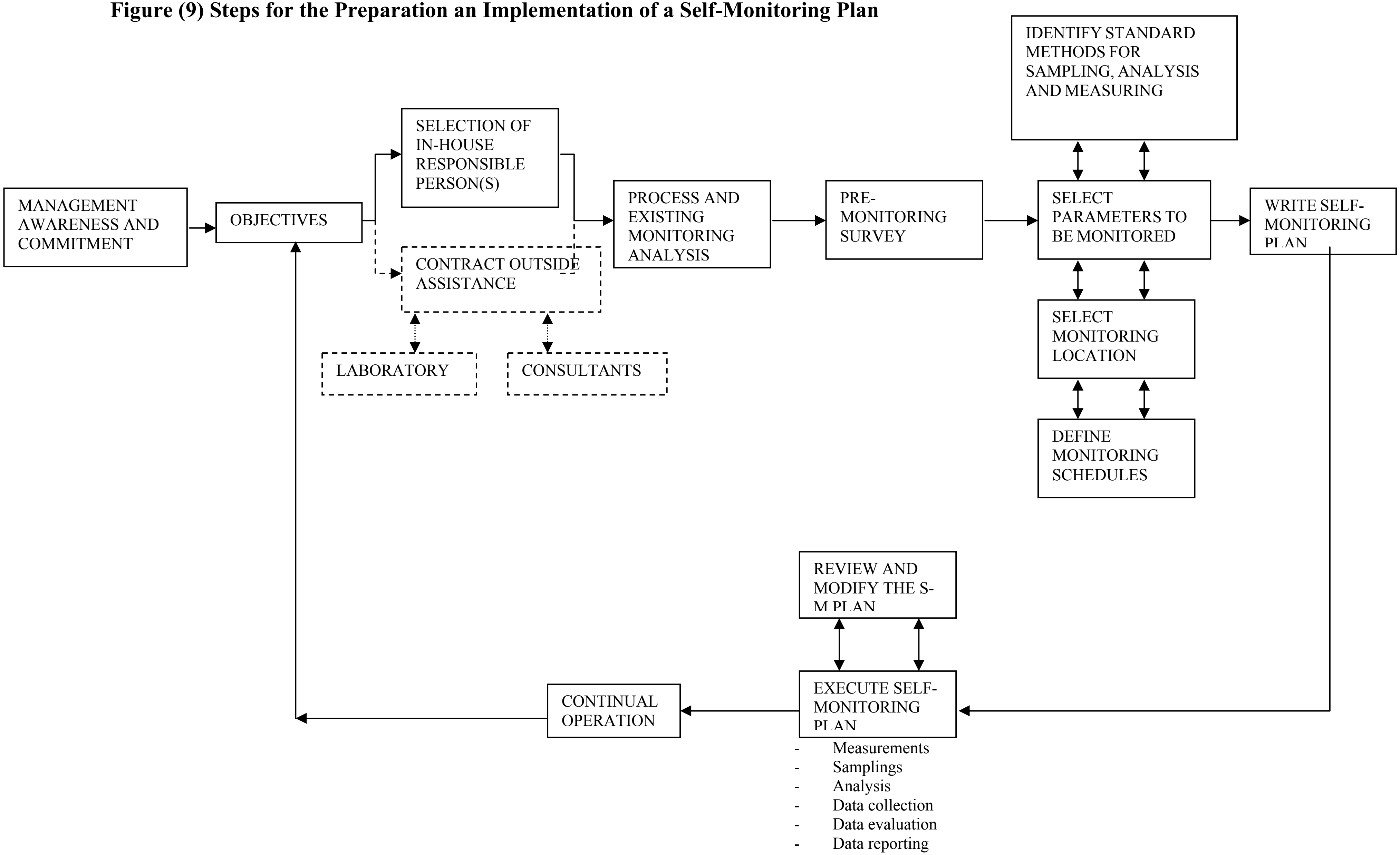
Compliance monitoring requires measurements, analysis and data on end-of-pipe releases, whereas operation controls target the production units that offer pollution prevention opportunities. The environmental manager with the help of various sector managers should carry out the planning activities.
With 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 (9) presents the various steps for the preparation and implementation of a self-monitoring plan.

Figure (9) 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 (11) presents an example of a checklist for existing self-monitoring activities.

Table 11. 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 Fabricated metal 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 (data provided by suppliers) 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 (12).

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 (12) 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	Need cost for calibration against direct values. May provide relative measurement rather than an absolute value

Advantages	Disadvantages
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 emissions. Causes disruption to process operation. May combine information from several direct measurements e.g. temperature indicates energy efficiency, emissions and process control.	May not valid only for a restricted range of process 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:

$$\text{Input} + \text{Generation} = \text{Output} + \text{Consumption}$$

- **Input** refers to the materials (chemicals) entering an operation. For example, chlorine added to process water as a disinfectant would be considered an input to the water treatment operation.
- **Generation** identifies those chemicals that are created during an operation. For example, when nitrogen sources are used in biological wastewater treatment systems, additional ammonia 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 can coating operation, for example, pigments in the paint may leave the operation as part of the product (the coating on the can) and on paint spray booth filters sent for disposal.
- **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 PRODUCTS

Data of the inputs and outputs 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

The amount of fiber raw material and cost/ton are important monitoring parameters. Depending on the type of fiber raw material and chemicals, the quality is assessed by the relevant parameters and tests before acceptance, Table (13). In case of discharging chemical rejects to the sewer, the flow rate should be monitored to make sure that it does not cause an increase in pollutant concentrations in the final discharge beyond limits set by law.

Table (13) Monitoring of Raw Materials and Chemicals

Parameter	Monitoring Method	Indication
Amount of raw materials and chemicals necessary to produce one unit of product.	Weighting, measuring, book keeping and recording	Rationality in the use of raw materials
Quantity of rejected raw material per unit of product	Weighting, measuring, book keeping and recording	Losses, process efficiency, storing or handling problems
Quality of raw material	Specific criteria (e.g. density, solid content of paint, acid concentration,... etc)	Avoiding possible production problems due to bad quality Identifying raw materials harmful for the environment if discharged to the sewer.
Cost of the raw material necessary to one unit of product	Book keeping	Assess economical burden due to non rational use of raw material and possible avoidable extra costs
Proportion of the cost of raw material in the cost of product & its variation	Book keeping	Assess economical burden due to non rational use of raw material

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 (14)

Table (14) 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 unit of product produced.	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
Steam : Pressure level Degree of saturation		
Process water : Pressure, temperature, quality		
Boiler water : Chemical quality		
Electric power : Voltage level		

8.3 Products

The most important parameters that need monitoring are presented in table (15)

Table (15) Monitoring of products

Parameters	Monitoring Method	Indication
Amount produced - Final product(s) - By- products (if exists)	Recording and book keeping	Production statistics
Rejects as a percentage of the total production, per unit of time - Final product (out of specification, expired date) - in- line rejects	Recording (quality control)	Production quality, avoidable expenses

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

Table (16) presents the major processes in each production line and the operations control parameters that can be monitored to minimize environmental impacts, maximize productivity and predict maintenance needs.

Table (16) Operation Control

Production Process	Cause of Pollution	Affected Media	Parameters to be monitored	Method	Indication	Frequency/ Duration
Metal Shaping						
Metal Cutting Metal Forming	- Discharge to wastewater	Wastewater	- Consumption of raw materials & chemicals Cutting/forming speed	- Mass balance - Book keeping	Effluent characteristics Solid waste Air pollution Noise level	Once a week/month
	- Scrap: metal & chips	Land				
	- Noise - Evaporation of VOCs	Work env.		-Speed meters		
Surface Preparation						
Degreasing Cleaning	Discharge to wastewater Evaporation	Wastewater	- Consumption rates - pH , Temp.	- Book keeping - pH meter - Thermometer	Effluent characteristics Air pollution	Once a week/month
	Evaporation of VOCs	Work env.				
Surface Finishing						
Anodizing Chemical coating Electroplating Electrolyses plating Painting Other techniques	Discharge to wastewater	Wastewater	Consumption rates Concentrations	- Book keeping - Samples analysis	Effluent characteristics Air pollution Solid waste	Once/batch
	Evaporation of pollutants	Work Env.				
	Sludge	Land				
Utilities						
Boilers	Air emissions	Air	Air/fuel ratio Flue Temp.	Gas analyzer Thermometer	Air pollution	According to mode of operation
Wastewater treatment plant	Discharge to wastewater	Wastewater	Flow, pH, BOD, COD, TSS, Heavy metals	pH meter Standard methods	Effluent characteristics	Continuous,
	Sludge	Land	Mass balance		Solid waste	Once day/week

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 (17) 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
Boilers, steam lines, heaters and dryers	There are many items to be checked to prevent explosion, such as checking operating procedures, detection of flame failure, detection of unburned combustibles. With respect to energy conservation, the maintenance of steam traps, steam valves and insulation of steam lines is important. The following parameters should be monitored: • Water level in the boiler • Water quality to prevent the build up of scales that reduce heat transfer rates • Temperature of metal, gas and water • Pressure • Fuel to air ratio • Check the fuel supply for leaks • Check air supply for leaks • Check the flue gas temperature.

Table (17): 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, effluents and solid and hazardous waste. Section 4 presents the various laws and regulations that apply to emissions, effluents and wastes from the Fabricated Metal industry. Expected pollutants and hazardous releases from the industry are specified in section 2.4. Table (18a) presents the compliance monitoring activities for air emissions and work environment. Whereas, monitoring of solid and hazardous waste is summarized in Table 18b. For each production process related pollution aspects are identified in section 2.4. 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.

Monitoring of pollutants and releases requires careful consideration of the techniques being used because due to 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 the next sections.

10.1 Emissions to Air

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 external measurer. Periodical emission measurements are carried out annually for the following emission components: NOx, SO2, TRS, CO, CO2, Cl and particles.

Continuous measurements: The continuous measurements describe the temporal variations of the concentrations of the emission components during the operation. General requirements for continuous monitoring systems are that the sampling places should be representative and that the monitoring equipment should be suitable for the concentrations to be monitored and for the prevailing circumstances. The emission control data system should preferably be part of the process control system. Sulfur dioxides, TRS, particles, carbon oxide are generally measured continuously.

Emission calculation: Differences between the calculational 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 cannot be recorded by emission measurements can be substantial.

10.2 Effluents (wastewater)

The regulations state the limits for the concentrations of some specific pollutants of the wastewater when discharged to the 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 COD/BOD5, AOX, TSS, phosphorus and heavy metals.

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

- Waste water flow (Q), m3/d
- Total suspended solids (TSS), mg/l
- Temperature, °C
- Chemical oxygen demand (COD_{Cr}), mg O_2/l
- Biochemical oxygen demand (BOD_5), mg O_2/l
- Total nitrogen (N), mg/l
- pH
- Conductivity, mS/m
- Heavy metals (e.g. Cr)

Flow measurement: Measuring of the total waste water flow is required for the operation of the wastewater treatment plant. There have been no provisions on the procedure 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 a venturi 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. Structure of the measurement system, a possible mounting fault or a false choice for measurement area cause errors. Other sources of error or factors disturbing the measurement are dirtying and temperature variations of the measuring equipment. Evaluation of the total error is extremely difficult, as it must include all these factors.

Sampling: Well realized sampling is essential for determination of wastewater discharges. There are general instructions for wastewater sampling. However, the specific problems of Fabricated Metal wastewater sampling, caused by the variation of the wastewater quality have to be solved case-by-case, considering the operational reasons. Samples are either single grap samples, composite samples, or composite samples in proportion to the flow. A single grap sample reveals the composition of the wastewater at the sampling time. With several single samples it is possible to follow the waste water load peaks, quality variation and the easily variable 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 a flow meter.

Sampling period and sample size are considered case-by-case 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 solids 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 programe may be needed for each mill. The programme 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.

Calculation: Wastewater discharges are calculated and reported according to the specifications determined 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 waste water treatment is also controlled by calculating the reduction of organic matter (BOD5, 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 in the points of monitoring before and after the treatment, limits values in force 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 and long term behaviour and the properties of the waste have to be known. The approval of the landfilling of a waste for a certain landfill category is based on the origin and the properties of the waste. The evaluation of the properties of the waste is based on:

- 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 from the waste.

Table (18.a) 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		
Metal Shaping									
Metal Cutting Metal Forming	Work Environment	VOCs Noise	Gas analyzer Noise meter						Depends on needs
Surface Preparation									
Degreasing Cleaning	Work Environment	VOCs	Gas analyzer						Depends on needs
Surface Finishing									
Anodizing Chemical coating Electroplating Electrolyses plating Painting Other techniques	Work Environment	- VOCs - Metal vapors	Gas analyzer						Depends on needs
Boiler									
Energy and Steam Generation	Air Work Environment	SOx, NOx, HC, CO, PM Temperature	Gas analyzer Thermometer						Depends on needs

Table (18b) Compliance Monitoring for Wastewater and Solid Waste

Major Pollution Sources	Impact	Parameter monitored	Method used	Source type	Operating Conditions	Frequency	Remarks
				Point Diffuse	Normal Exceptional		
Metal Shaping							
Metal Cutting Metal Forming	Receiving water body	- Organic substances (COD, BOD): - nitrogen, phosphorus: - suspended solids - metals, salts	Analysis			Depends on needs	- If discharged directly, water pollutants need to be monitored. - Oil-water and synthetic emulsions, acids, alkalis and metals can exist in the wastewater.
	Landfill	- Scrap, Sludge - cleaning and mixed household type waste	Mass balance			Depends on needs	Solid waste include metal scrap and cleaning sludge - Monitoring for pollution prevention
Surface Preparation							
Degreasing Cleaning	Receiving water body	- Organic substances (COD, BOD) - nitrogen, phosphorus - suspended solids - metals, salts	Analysis			Depends on needs	- If discharged directly, water pollutants need to be monitored. - Water from the rinsing operations contain metal finishing operations, chemicals and solids. - Monitoring for pollution prevention
	Landfill	-Sludge from chemical cleaning -Containers of chemicals.				Depends on needs	- Sludge may be considered as hazardous waste
Surface Finishing							
Anodizing Chemical coating Electroplating Electrolyses plating Painting	Receiving water body	- Organic substances (COD, BOD) - suspended solids - metals, salts	Analysis Flow meter			Depends on needs	- If discharged directly, water pollutants need to be monitored. - Water from the rinsing operations contains chemicals and solids. - Monitoring for pollution prevention
	Landfill	- Sludge	Mass balance				
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 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.

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 10. 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

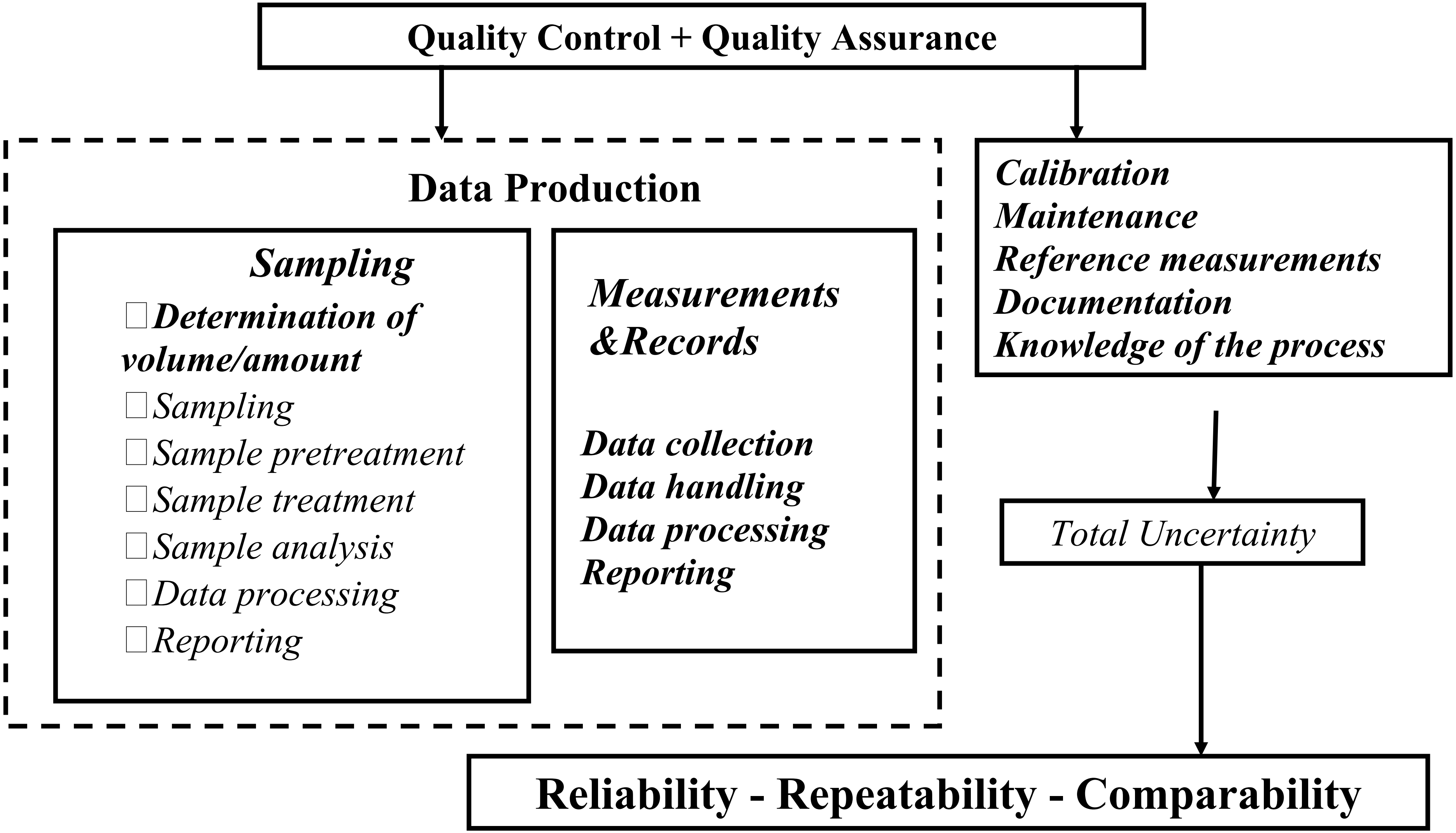
11.2.1 Techniques for summarizing and illustrating data

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 10 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 the 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

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

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- *EPAP Report 60/Inst : Industrial Emissions Inventory in Alexandria and Suez, M.W. Badawi & al, Cairo, November 2000.*

- *Commission of the European Communities. Directorate-General Environment, Nuclear Safety and Civil Protection. Study on the Technical and Economic Aspects of measures to reduce water pollution caused by discharges from the industrial sectors involved in the Surface Treatment of Metal. Final Report. XI/737/93-EN. July 1992.*

- *Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Ferrous Metals Processing Industry. October 2000.*

- *Possible ways of reducing environmental pollution from the Surface-Treatment Industry. Nordiske Seminar- og Arbejdsrapporter. Environment 1993:560. 1993. ISBN 92 9120 242 8.*

- *United States Environmental Protection Agency. Office of Pollution Prevention and Toxics. Emergency Planning Community Right-To-Know Act Section 313 Reporting Guidance for Spray Application and Electrodeposition of Organic Coatings. Washington, DC 20460. December 1998. EPA 745-R-98-014. Figure 4-3. pp. 4-31.*

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- *Environmental aspects of the metal finishing industry: A technical guide. 1989. United Nations Environment Programme (UNEP). Industry and Environment Office. Technical report series no 1. ISBN 92-807-1216-0.*

- *Total particulate concentration, ambient air analysis & noise level at Ghabour plant, Development research and technological planning center, Cairo University, internal report, April 1998.*

- *Law number 4 of 1994 promulgating the Environment Law and its executive regulation, Egypt presidential decree, Egyptian Environmental Affairs Agency, Deposit number16500 /1999 (English).*

- *Parcom recommendation 92/4. Paris Commission. On the reduction of emissions from the electroplating industry. Date of adoption: 1992, Paris.*

- *Helcom recommendation 16/6. Helsinki Commission. Baltic Marine Environment Protection Commission. Restriction of discharges and emissions from the metal surface treatment. Adopted 15 March 1995*

- ***Pollution Prevention and Abatement Handbook. World Bank Group. Electroplating. July 1998.***

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  - ***"Best Available Techniques in the Pulp and Paper Industry", July 2000***
  - ***"Technical Guidance for the Pulp and Paper Sector", November 2000***

- ***"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 Fabricated Metals Industry", August 2002, prepared by Dr. Hassan Elhares.***