

**Ministry of State for Environmental Affairs**

Egyptian Environmental Affairs Agency (EEAA)

Egyptian Pollution Abatement Project (EPAP)

## **Self Monitoring Manual Motor Vehicles Industry**



**Motor Vehicles Assembly 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 to cover the aspects common to all industrial sectors.

On the other hand, EPAP realized the need to introduce -monitoring. The textile industry was chosen as a case study for implementing and testing the manual and a self-monitoring manual for this industry was developed.

## **1.1 Preface**

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

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

### **1.1.1. Project objectives**

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

With respect to the motor vehicles assembly 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 motor vehicles assembly 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 motor vehicles assembly industry and its environmental impacts.

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

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

The establishments considered are engaged primarily in the manufacture and assembly of equipment for the transportation of passengers and cargo by land. Due to the broad scope of the subject the focus will be on the motor vehicles and vehicle equipment industry also known as the automotive industry.

The following automotive products are not covered in this manual: diesel engines, tires, automobile stampings, vehicle lighting equipment, carburetors, pistons and ignition systems. The diverse nature of parts required to produce a car requires the support of many industries such as primarily the fabricated metal products industry.

### 1.2.1 Product characterization

The motor vehicles and motor vehicle equipment industry produces a wide range of diverse products from ambulances and automobiles to the cylinder heads, ball joints, and horns that go into these vehicles. The motor vehicles and motor vehicle equipment industry is organized into four primary areas based on the types of products. These are:

- ☐ Passenger cars and light trucks
- ☐ Medium and heavy duty trucks
- ☐ Truck trailers
- ☐ Automotive parts and accessories.

The automotive parts industry is further broken down into two sectors, original equipment suppliers that provide parts directly to automakers and aftermarket suppliers that provide exclusively replacement parts.

### 1.2.2 Egyptian particularities

Fifty years ago, Egypt was making an Egyptian car, Ramses, whose production was protected by imposing customs and duties on imported cars and car parts. Later, an agreement was made with Fiat Consortium (Italy) to produce a Fiat car in Egypt starting with the production of a certain percentage of the car and increasing that percentage according to a specified timetable to reach almost 60% of the parts. The rest being imported for assembly. Unfortunately, the schedule was not respected.

El Nasr Automotive Company established in 1960, produces buses and trucks. Presently the annual production is about 1000 buses, 1100 trucks, 12000 passenger cars and 1000 agricultural tractors. Ghabbour Company specializes in the fabrication of bus frames of any size. There are a number of foreign cars being assembled in Egypt, e.g. Opel, Fiat, Cherokee, Mercedes, BMW....etc, with varying percentages of the car parts being produced locally. The following are examples of the available pollution data:

#### ***In a large fabricated metal products factory specializing in bus parts production:***

The total particulate concentration at the head level of workers exceeds the upper limit allowed by law No 4-1994 (which is 5 mg/m<sup>3</sup>), in the primer spray area (14 mg/m<sup>3</sup>), in the painting spray area (16 mg/m<sup>3</sup>), in the fiberglass machining area (35 mg/m<sup>3</sup>) and in the wood cutting area (9 mg/m<sup>3</sup>). 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).

***In a large motor vehicle factory:***

The wastewater pollution levels in mg/l, are given in table (1).

**Table (1) Pollutants Concentration in Wastewater  
from A Motor Vehicle Plant**

<b>Pollution Parameters</b>	<b>Concentration, mg/ l</b>
COD	1677 (<1100)
O&G	188 (<100)
Cyanide	57.7 (<0.1)
Zinc	22.5 (<10)
TSS	3044 (<800)
Phosphates	18 (30)
Iron	10.4 (1)

Limits set by law for discharge to sewer are given between brackets.



## **2. DESCRIPTION OF THE INDUSTRY**

This section describes the major industrial processes within the Motor Vehicles and Motor Vehicle Equipment industry, including the materials and equipment used, and the processes employed. The aim is to gain a general understanding of the industry, and in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile: pollutant outputs, pollution prevention opportunities, and Egyptian regulations.

In fact the section specifically contains a description of commonly used production processes, associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide 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. Due to the fact that motor vehicles industry has common processes with the metal fabrication industry, the reader will certainly benefit consulting the inspection manual of the fabricated metal products sub-sector of the engineering industry.

### **2.1 Raw materials, products and utilities**

Motor vehicle parts and accessories include both finished and semi-finished components. Approximately 8,000 to 10,000 different parts are ultimately assembled into approximately 100 major motor vehicle components, including suspension systems, transmissions, and radiators. These parts are eventually transported to an automotive manufacturing plant for assembly.

Material selection plays a vital role in the production process. Materials are ultimately selected based on factors such as performance (strength vs. durability, surface finish, and corrosion resistance), cost, component manufacturing, consumer preference and competitive responses. In the past, automobiles have been composed primarily of iron and steel. Steel has remained a major component because of its structural integrity and ability to maintain dimensional geometry throughout the manufacturing process

According to Automotive industries (AAMA Motor Vehicle Facts and Figures '94), the average composition of a car, in 1994, there was:

70.2% ferrous metals (sheet metal, forged steel parts, cast iron...)

8.7% non-ferrous metals (aluminum, copper, lead, zinc)

21.1% non-metals (plastic 38%, rubber 21%, fluid 12%, glass 14%,...)

In response to increasing demands for more fuel efficient cars, the past fifteen years have seen changes in the composition of materials used in automobiles. Iron and steel use has steadily decreased, while plastics and aluminum has steadily increased. Aluminum and plastics are valuable car components not only for their lighter weight, but also because of their inherent corrosion resistance. Although the use of plastics in the automotive industry is increasing, expansion in this area is finite because of limitations in current plastic materials.

The manufacturing processes used to produce the thousands of discrete parts and accessories vary depending on the end product and materials used. Different processes are employed for the production of metal components versus the production of plastic components. Most processes, however, typically include casting, forging, molding, extrusion, stamping, and welding.

Table (2) presents the primary materials used for producing each major part and the production process involved.

**Table (2) Materials and processes used in the production of auto parts**

<b>Auto part</b>	<b>Primary Material</b>	<b>Process</b>
<b><i>Engine</i></b>		
Block	Iron, Aluminum	Casting
Cylinder head	Iron, Aluminum	Casting, machining
Intake manifold	Plastic, Aluminum	Casting, molding, machining
Connecting rods	Powder metal, steel	Molding, forging machining
Pistons	Aluminum	Forging machining
Camshaft	Iron, Steel, Powder metal	Molding, forging machining
Valves	Steel, magnesium	Stamping, machining
Exhaust systems	Iron, Aluminum, stainless steel	Extruding, stamping
<b><i>Transaxle</i></b>		
Transmission case	Aluminum, magnesium	Casting, machining
Gear Sets	Steel	Blanking, machining
Torque converter	Magnesium, steel	Stamping, casting
CV joint assemblies	Steel, rubber	Casting, forging, extruding, stamping
<b><i>Body Structure</i></b>		
Body panels	Steel, plastic, aluminum	Stamping, molding
Bumper assemblies	Steel, plastic, aluminum	Stamping, molding
<b><i>Chassis/Suspension</i></b>		
Steering gear/column	Steel, magnesium, aluminum	Casting, stamping, forging, machining
Rear axle assembly	Steel, plastic	Stamping, molding
Front suspension	Steel, aluminum	Stamping, forging
Wheels	Steel, aluminum	Stamping, forging
Brakes	Steel, friction material	Stamping, forging
<b><i>Seats/ Trims</i></b>		
Seats	Steel, fabric, foam	Stamping, molding
Instrument panel	Steel, fabric, foam	Stamping, molding
Headliner/carpeting	Synthetic fiber	Molding
Exterior trim	Plastic, aluminum, Zinc die casting	Stamping, molding, casting
<b><i>HVAC system</i></b>		
AC compressor	Steel, aluminum, plastic	Stamping, molding, casting
Radiator/Heater core	Copper, aluminum, plastic	Extruding, molding
Engine fan	Steel, plastic	Stamping, molding

***In the foundry*** the main raw materials used are silica sand and clay for mold production. Binders such as resins, phenols and formaldehyde are used. Additives such as organic materials are added to the mold materials whereas calcium carbide and magnesium could be added to the molten metal.

In the ***metal workshop*** the input materials depend on the operation performed. Table

(3) presents the material inputs to each operation in metal shaping, surface preparation and metal finishing processes. For more details see the fabricated metal products inspection manual.

**Table (3) Material inputs to each operation in metal fabrication**

Process	Material inputs
<b><i>Metal shaping</i></b>	
Metal cutting/ forming	Cutting oils (ethylene glycol), degreasing and cleaning solvents (trichloro-ethane, methyl-ethyl-ketone, acetone ..), alkalis and acids.
<b><i>Surface preparation</i></b>	
Solvent degreasing	Solvents Organic solvents dispersed in water (kerosene, mineral oil, glycol) Alkali hydroxides, acids, organic and inorganic additives, surfactants
Emulsion degreasing	
Alkaline/acid cleaning	
<b><i>Surface finishing</i></b>	
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

Metal workshops also use solvents (e.g. trichloroethane, methyl ethyl ketone) for degreasing. 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.

***In the paint plant*** zinc phosphate and chromic acid are used for surface preparation. Organic solvents are also added in small amounts to the primer bath. Polyvinyl chloride is used as a sealant to ensure waterproofing. Surface coating consists of pigments, polyester or epoxy ester resins and solvents. The chemical composition of the pigment varies according to its color as illustrated in table (4).

**Table (4) Chemical components of pigments found in paint**

<b>Pigment Color</b>	<b>Chemical Compounds</b>
White	Titanium dioxide, white lead, zinc oxide
Red	Iron oxides, calcium sulfate, cadmium, selenide
Orange	Lead chromate-molybdate
Brown	Iron oxides
Yellow	Iron oxides, lead chromate, calcium, sulfide
Green	Chromium oxide, copper, phosphotungstic acid, phosphomolybdic acid
Blue	Ferric ferrocyanide, copper
Purple	Manganese phosphate
Black	Black iron oxide
Metallic	Aluminum, bronze, copper, lead, nickel, stainless steel, silver, powdered zinc

**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.

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

## **2.2 Production processes**

Numerous processes are employed to manufacture motor vehicles and motor vehicle equipment. This section will focus on the significant production processes including those used in the foundry, metal fabrication plant, assembly line, and paint shop. The following presents the various productions processes and service units that could be present in a facility.

<b>Production processes</b>	<b>Service Units</b>
Foundry Metal fabrication plant Assembly line Paint plant Post production motor vehicle dismantling	Boilers Cooling towers Softeners Laboratory Electrical workshops Garage Storage facilities. Wastewater Treatment Plant 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.*

### **2.2.1 Foundry operations**

Foundries, whether they are integrated with automotive assembly facilities or independent shops, cast metal products, which play a key role in the production of motor vehicles and motor vehicle equipment.

The main steps in producing cast iron motor vehicle products (Figure. 1) are as follows:

- ☐ Pattern design and production
- ☐ Sand formulation
- ☐ Mold and core production
- ☐ Metal heating and alloying
- ☐ Metal molding
- ☐ Mold shakeout
- ☐ Product finishing and heat treating
- ☐ Inspection.

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

***Mold production***

The process begins with the mixing of moist silica sand with clay (3 to 20 percent) and water (two to five percent) to produce the "green sand," which forms the basis of the mold. Other additives, including organics such as "sea-coal", may be added to the green sand to help prevent casting defects. The core is then created using molded sand and often includes binders, such as resins, phenol, and/or formaldehyde. The core is the internal section of a casting used to produce the open areas needed inside such items as an engine or a drive train. After the core has been molded, it is baked to ensure its shape, and then combined with the rest of the casting mold in preparation for casting.

Pollution sources: Dust is created during sand preparation, molding and shakeout of the cast. Bag-house dust is a source of solid waste. If wet scrubbers are used as air pollution control, the wastewater generated will be contaminated with heavy metals.

***Casting***

At the same time the core is being created, iron is being melted. The iron charge, whether it is scrap or new iron, is combined with coal (as a fuel) and other additives such as calcium carbide and magnesium, and fed into a furnace, which removes sulfur, (usually an electric arc, an electric induction, or a cupola furnace). Calcium carbide may be added for certain kinds of iron casting, and magnesium is added to produce a more ductile iron. Once the iron reaches the appropriate temperature, it is poured into the prepared mold. The mold then proceeds through the cooling tunnel and is placed on a grid to undergo a process called "shakeout. " During shakeout the grid vibrates, shaking loose the mold and core sand from the casting. The mold and core are then separated from the product, which is ready for finishing.

Pollution sources: Fuel combustion in melting furnace generates flue gases that may cause air pollution.

Slag is quenched using cooling water to cool it as well as to palletize it. The wastewater generated from this process could contain cadmium and lead.

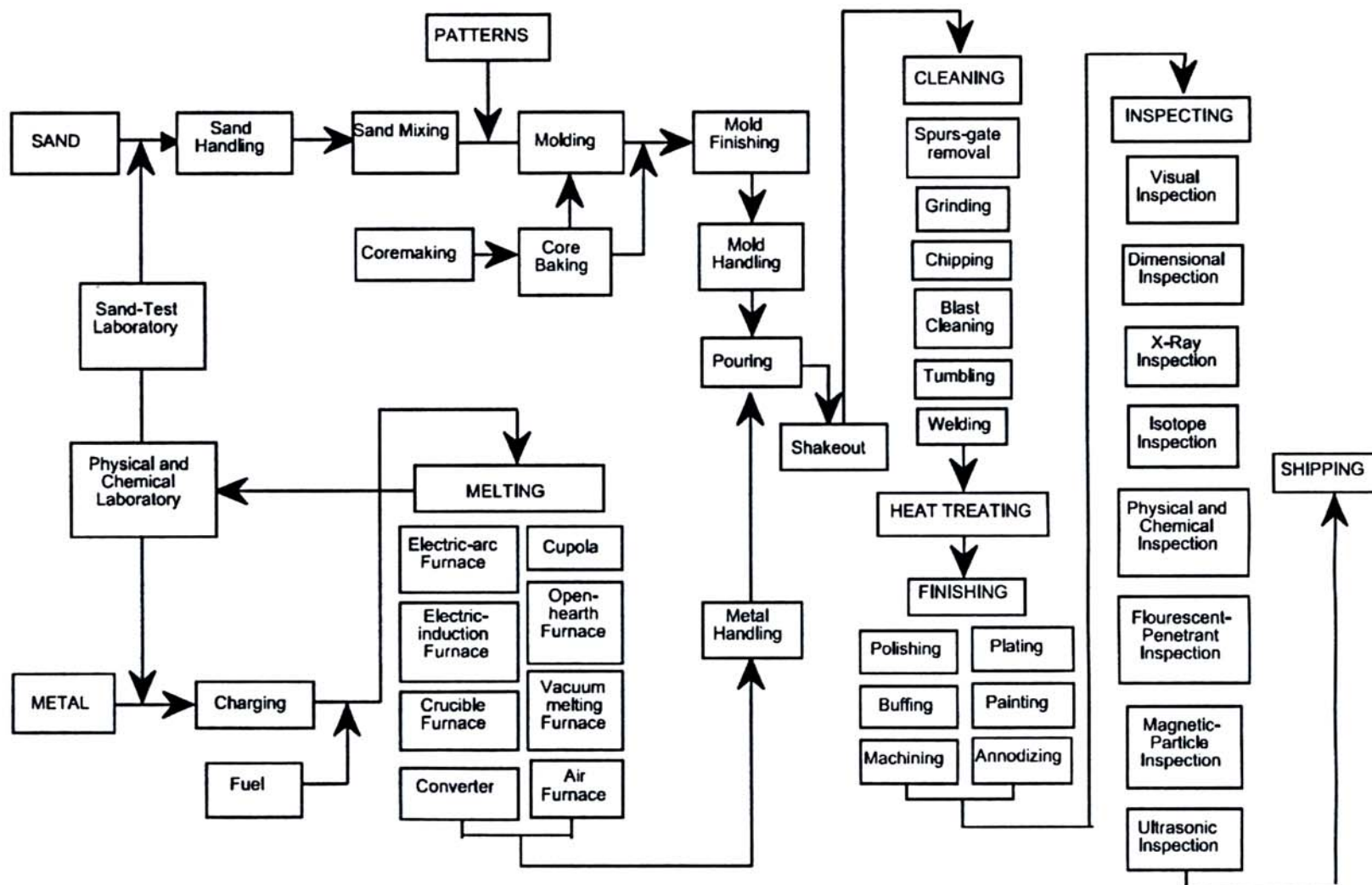
Wet scrubbers are usually used as air pollution control devices connected to the furnaces that melt the metal. The discharged wastewater is usually contaminated with heavy metals.

Calcium carbide de-sulfurization slag is a hazardous solid waste since it reacts with water to create acetylene gas.

### ***Finishing***

The finishing process is made up of many different steps depending upon the final product. The surface may be smoothed using an oxygen torch to remove any metal snags or chips, it may be blast-cleaned to remove any remaining sand, or it may be pickled using acids to achieve the correct surface. If necessary, the item may be welded to ensure the tightness of any seams or seals. After finishing, the item undergoes a final heat treatment to ensure it has the proper metallurgical properties. The item is then ready for inspection.

Inspection may take place in any number of ways be it visually, by x- or gamma ray, ultrasonic, or magnetic particle. Once an item passes inspection, it is ready to be shipped to the assembly area. Pollution sources: Solvents can be used for cleaning and some of them could be characterized as hazardous materials. Oxygen torch and blasting are also sources of particulate emissions to air.



### 2.2.2 Metal fabrication plant

Another major process in the manufacturing automotive parts is metal fabrication. Metal fabrication involves the shaping of metal components. Many automotive parts, including fenders, hubcaps, and body parts are manufactured in metal fabricating shops. A typical large-scale production of these items starts with molten metal (ferrous or nonferrous) containing the correct metallurgical properties. Once the metal has been produced, it is cast into a shape that can enter the rolling process. Shearing and forming operations are then performed to cut materials into a desired shape and size and bend or form materials into specified shapes. Details about metal fabrication processes and their related pollution sources can be found in the Inspection Manual for Fabricated Metal Products Industry (EPAP, 2001).

### 2.2.3 Motor vehicle assembly

Assembly is performed in two stages: Body assembly prior painting and finishing operations, then hard trim installation followed by soft trim installation then installation of final parts..

#### ***Body assembly***

Once the various automotive parts are produced, they are ready to be brought together for assembly. Automotive assembly is a complex process that involves many different steps. Assembly begins with parts, which arrive in the assembly plant “just-in-time.” “Just-in-time” is a concept, which means that parts arrive only when they are needed for assembly; only enough product is sent for a given day’s work. This concept, which revolutionized the automotive industry, has improved productivity, lowered costs, and provided for better quality management. Although techniques used to assemble an automobile vary from manufacturer to manufacturer, the first major step in assembly is the body shop. At this stage the car begins to take shape as sides are welded together and then attached to the underbody of the car.

The underbody is composed of three primary pieces of galvanized steel, which include the floor pan and components for the engine and trunk. After the underbody has been welded together by robotics, it is tested for dimensional and structural accuracy. It is then joined together in a tab-slot fashion with the side frame and various other side-assemblies. A worker then taps tabs into slots, and a robot clamps the tabs. Roof supports and the roof are now ready for installation. The car is now ready for final welding. Approximately 3,500-4,000 spots require welding. Robots do most welding, with workers doing only spot jobs. Trunk lids and hoods will then be installed. After assembling the automobile body painting operations takes place as described in the next section.

***Pollution sources:*** Due to advances in technology, well-designed operating procedures, and the implementation of strategies to limit waste from assembly, little hazardous waste is generated



during the actual assembly of an automobile (with the exception of painting/finishing, which is discussed in the following section).

The majority of wastes generated during assembly are solid wastes resulting from parts packaging. Parts packaging can be grouped into two categories - returnable and expendable. Returnable packaging (containers) is shipped back to the original suppliers once empty. It includes such items as: metal racks, metal skids, returnable bins, and rigid plastic racks. Expendable packaging is used once and recycled, for the most part. Examples include Styrofoam peanuts, wood skids, plastic, corrugated boxes, and shrink-wrap. Advances in packaging design, changes in purchasing, and the elimination of unneeded materials have greatly reduced the amount of expendable waste generated. Additional wastes generated from assembly operations may be attributed to general plant operations, cleaning and maintenance, as well as the disposal of faulty equipment and parts.

***Hard trim installation***

After painting and finishing, two types of trim are installed - hard and soft. Hard trim, such as instrument panels, steering columns, and body glass, is installed first. The car body is then passed through a water test where, by using phosphorous and a black light, leaks are identified.

***Soft trim installation***

Soft trim, including seats, door pads, roof panel insulation, carpeting, and upholstery, is then installed. The only VOC emissions resulting from this stage of the process originate from the use of adhesives to attach items, such as seat covers and carpeting.

***Final installations***

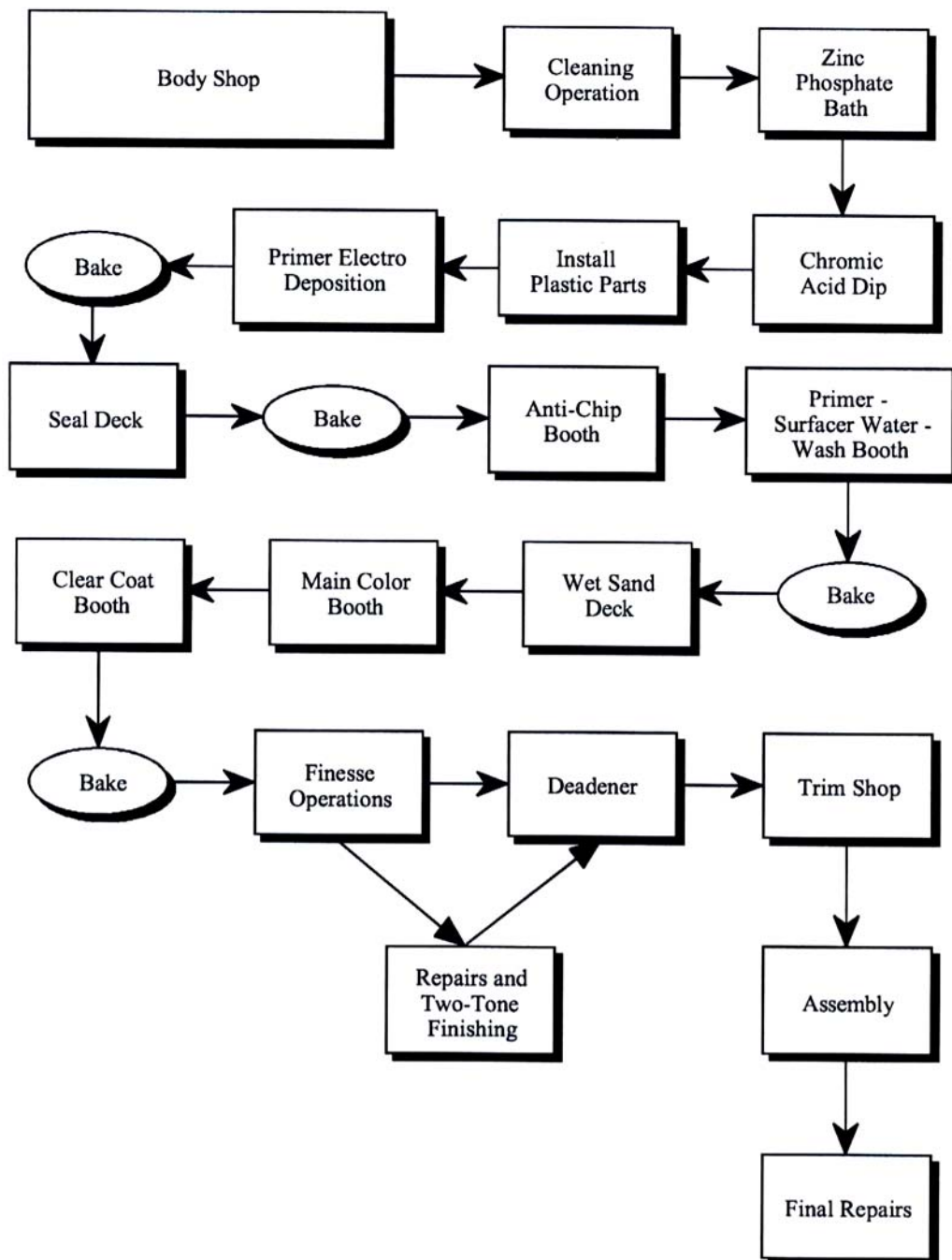
Next, the automobile body is fitted with the following: gas tank, catalytic converter, muffler, tail pipe, and bumpers. Concurrently, the engine goes through a process known as "dressing," which consists of installing the transmission, coolant hoses, the alternator, and other components. The engine and tires are then attached to the body, completing the assembly process.

#### **2.2.4 Motor vehicle painting/finishing**

Automotive finishing is a multi-step process subdivided into four categories:

- ☐ Anti-corrosion operations, consisting of cleaning applications, a phosphate bath, and a chromic acid bath;
- ☐ Priming operations, consisting of an electrodeposition primer bath, an anti-chip application, and a primer-surface application;
- ☐ Joint sealant application;
- ☐ Finishing operations, consisting of a color coat application, a clear coat application, and any painting necessary for two-tone color or touch-up applications.

The stages of the automotive finishing process are illustrated in Figure (2).



**Fig. 2 Car Painting Process**

***Anti-corrosion operations***

After the automobile body has been assembled, anti-corrosion operations prepare the body for the painting/finishing process. Initially, the body is sprayed with and immersed in a cleaning agent, typically consisting of detergents, to remove residual oils and dirt. The body is then dipped into a phosphate bath, typically zinc phosphate, to prevent corrosion. The phosphate process also improves the adhesion of the primer to the metal. The body is then rinsed with chromic acid, further enhancing the anti-corrosion properties of the zinc phosphate coating. The anti-corrosion operations conclude with another series of rinsing steps.

***Priming operations***

Priming operations further prepare the body for finishing by applying various layers of coatings designed to protect the metal surface from corrosion and assure good adhesion of subsequent coatings. Prior to the application of these primer coats, however, plastic parts to be painted and finished with the body, are installed. As illustrated in Figure.(3), a primer coating is applied to the body using an electrodeposition method, creating a strong bond between the coating and the body to provide a more durable coating. In electrodeposition, a negatively charged auto body is immersed in a positively charged 225 to 300 m3 bath of primer for approximately three minutes. The coating particles, insoluble in the liquid and positively charged, migrate toward the body and are, in effect, "plated" onto the body surface.

Prior to baking, excess primer is removed through several rinsing stages. The rinsing operations use various systems to recover excess electrodeposited primer. Once the body is thoroughly rinsed, it is baked for approximately 20 minutes at 175 to 195 degrees Centigrade. VOC emissions resulting from the baking stage should be incinerated.

***Pollution sources:*** Although the primer bath is mostly water-based with only small amounts of organic solvent (less than five to ten percent), fugitive emissions consisting of volatile organic compounds (VOCs) can occur. However, the amount of these emissions is quite small. In addition to solvents and pigments, the electrodeposition bath contains lead, although the amount of lead used has been decreasing over the years.

### ***Sealant application***

Next, the body is further waterproofed by sealing spot-welded joints of the body. Waterproofing is accomplished through the application of a paste or putty-like substance. This sealant usually consists of polyvinyl chloride and small amounts of solvents. The body is again baked to ensure that the sealant adheres thoroughly to the spot-welded areas.

After waterproofing, the automobile body proceeds to the anti-chip booth. Here, a substance usually consisting of a urethane or an epoxy ester resin, in conjunction with solvents, is applied locally to certain areas along the base of the body, such as the front of the car. This anti-chip substance protects the lower portions of the automobile body from small objects, such as rocks, which can fly up and damage automotive finishes.

### ***Finishing operations***

The primer-surfacer coating, unlike the initial electrodeposition primer coating, is applied by spray application in a water-wash spray booth. The primer-surfacer consists primarily of pigments, polyester or epoxy ester resins, and solvents. Due to the composition of this coating, the primer-surfacer creates a durable finish, which can be sanded. The pigments used in this finish provide additional color layers in case the primary color coating is damaged. The water-wash spray booth is generally 30 to 50 meters long and applies the primer-surfacer in a constant air stream through which the automobile body moves. A continuous stream of air, usually from ceiling to floor, is used to transport airborne particulate and solvents from primer-surfacer over spray. The air passes through a water curtain, which captures a portion of the airborne solvents for reuse or treatment at a wastewater facility. Efforts have been made at certain facilities to recycle this air to reduce VOC emissions.

After the primer-surfacer coating is baked, the body is then sanded, if necessary, to remove any dirt or coating flaws. This is accomplished using a dry sanding technique. The primary environmental concern at this stage of the finishing process is the generation of particulate matter.

The next step of the finishing process is ***the application of the primary color coating***. This is accomplished in a manner similar to the application of primer-surfacer. One difference between these two steps is the amount of pigments and solvents used in the application process. VOC emissions from primary color coating operations can be double that released from primer-surfacer operations. In addition to the pigments and solvents, aluminum or mica flakes can be added to the primary color coating to create a finish with unique reflective qualities. Instead of baking, the primary color coat is allowed to "flash off," in other words, the solvent evaporates without the application of heat. Pigments, used to formulate both primers and paints, are an integral part of the paint formulation, which also contains other substances. The

pigmented resin forms a coating on the body surface as the solvent dries

After the primary color coating is allowed to air-dry briefly, the final coating, a clear coat, is applied. The clear coat adds luster and durability to the automotive finish. This coating generally consists of a modified acrylic or a urethane and is baked for approximately 30 minutes. Following the baking of the clear coat, the body is inspected for imperfections in the finish. Operators finesse minor flaws through light sanding and polishing and without any repainting.

Once the clear coat is baked, a coating known as deadener is applied to certain areas of the automobile underbody. Deadener, generally a solvent-based resin of tar-like consistency, is applied to areas such as the inside of wheel wells to reduce noise. In addition, anti-corrosion wax is applied to other areas, such as the inside of doors, to further seal the automobile body and prevent moisture damage. This wax contains aluminum flake pigment and is applied using a spray wand

### ***Touch-up***

The finished vehicle is then rigorously inspected to ensure that no damage has occurred as a result of the final assembly stages. If there is major damage, the entire body part is replaced. However, if the damage is minor, such as a scratch, paint is taken to the end of the line and applied using a hand-operated spray gun. Because the automobile cannot be baked at temperatures as high as in earlier stages of the finishing process, the paint is catalyzed prior to application to allow for faster drying at lower temperatures.

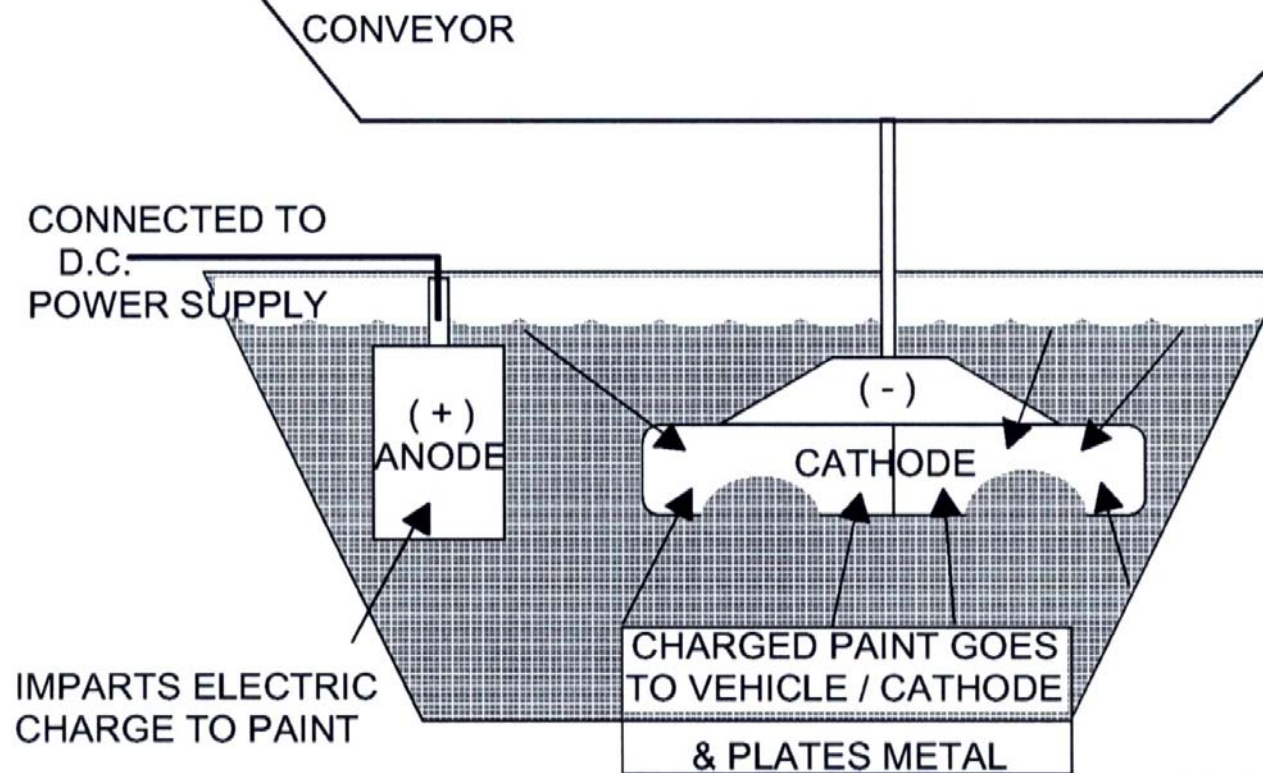
Approximately two percent of all automobiles manufactured require this touch-up work. Because the paint used in this step is applied using a hand-operated spray gun, fugitive air emissions are likely to be generated (depending on system design). Generally, spray and immersion finishing methods are to a certain extent interchangeable, and the application method for various coatings varies from facility to facility. The same variance applies to the number and order of rinsing steps for cleaning, phosphating, and electrodeposition primer operations. Spray rinsing the body prior to immersion rinsing decreases the amount of residues deposited in the bath and allows for greater solvent recovery.

In addition to the above-mentioned uses of solvents as ingredients of coatings, solvents are often used in facility and equipment cleanup operations. Efforts have been made at several facilities to reduce the amount of solvent used for this purpose, thereby reducing fugitive VOC emissions, and to reuse these solvents when preparing batches of coatings used in certain stages of the finishing process.

The expanded use of alternative coating methods, such as electrostatic powder spray, is being researched. Powder coatings are being used instead of solvent-based coatings for some initial coating steps, such as the anti-chip and the primer-surfacer process.

# PLATING OF PAINT SOLIDS FROM SPECIALIZED WATER PAINT FORMULA

CATHODIC ELECTRODEPOSITION



### **2.2.5 Post Production Motor Vehicle Dismantling/Shredding**

Dismantling operations involve both automotive fluids and solids. The fluids, such as engine oil, antifreeze, and air conditioning refrigerant, are recovered to the extent possible, reprocessed for reuse or sent to energy recovery facilities. Many solid parts, such as the radiator and catalytic converter, contain valuable metal materials, which are removed for recycling or reuse. In addition, the dismantler will remove and recycle the battery, fuel tank, and tires to reduce shredder-processing concerns.

The shredder processes the remaining automotive hulk, along with other metallic goods (such as household appliances), into ferrous materials, non-ferrous materials, and shredder residue. The residue is a heterogeneous mix that may include plastics, glass, textiles, metal fines, and dirt. This material should be predominantly landfilled in authorized discharges.

## **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. Table (5) 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 (Mazout) or diesel oil (solar) contain primarily particulates (including heavy metals if they are present in significant concentrations in the fuel), sulfur and nitrogen oxides (SO<sub>x</sub> and NO<sub>x</sub>) 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 filter followed by an activated carbon filter that removes any substances causing odor and taste. A micro filter can then be used to remove remaining traces. A successful method to accelerate precipitation is contacting previously precipitated sludge with the raw water and chemicals. The sludge particles act as seeds for further precipitation. The result is a more rapid and more complete reaction with larger and more easily settled particles.
- 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. 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 (Mazout), 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 majeure” 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.

**Table (5) Service Units and Their Related Pollution Sources**

Inputs	Service Units	Pollution
Water Lime + chemicals	<div>Treatment</div> <div>Softening Units</div>	Sludge Back/wash
Fuel	<div>Boilers</div> <div>Steam</div>	blow-down (TDS) Flue Gases
Hot Water	<div>Cooling Towers</div>	Cooling Tower Blowdown (TDS)
Chemicals	<div>Laboratory</div>	Wastewater Hazardous Materials (handling)
Lube Oil Floor and equipment rinse water Cleaning Chemicals	<div>Electrical &amp; Mechanical Workshops</div>	Oily Rinse Water Solid Wastes
Fuel Oil Rinse Water	<div>Garage</div>	Oily rinse water Solid wastes
Fuel Chemicals	<div>Storage</div>	Spills Hazardous material
Wastewater	<div>Wastewater Treatment Units</div>	Treated water Sludge
Water	<div>Restaurant and restrooms</div>	Sanitary Wastewater

## 2.4 Emissions, Effluents and Solid Wastes

Emissions from the main unit operations i.e. metal shaping, surface preparation and surface finishing are summarized in table (6). Air emissions, effluents and solid waste from production workshops and utilities are detailed in the following text.

### 2.4.1 Air emissions

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

<i>Foundry</i>	The main causes of air pollution are : Dust created during preparation of sand molds Gases containing lead, cadmium, particulate matter, sulfur dioxide during melting of iron Flue gases in melting operation if heating is performed by combustion of fuel
<i>Metal fabrication</i>	Refer to the inspection manual for fabricated metal products for air emissions and noise pollution.
<i>painting/finishing</i>	VOCs result from paint storage, mixing application of paint and drying. Cleaning solvents also result in VOCs, mainly dimethylbenzene, 2 pranone, 4-methyl-2 pentanone, butyl ester, acetic acid, light aromatic solvent naphtha, ethyl benzene, 2 butanone, toluene, butanol
<i>Service units</i>	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.

### 2.4.2 Effluents

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

<i>Foundry</i>	The wastewater generated from slag quenching or from the wet scrubbers used for air pollution control is contaminated with cadmium, lead and iron
<i>Metal fabrication</i>	The quality of effluent depends on the type of metal fabrication operation used. Look-up for the specific operation in the inspection manual for fabricated metal products
<i>painting/finishing</i>	The main sources of water pollution are : Discharging leftover and unused paint Clean up of equipment and paint booth area Paint booth collection system Water curtains used to capture paint over spray The type of pollutant depends on the type of paint used (see table 3). The effluent will be contaminated with the metal constituting the paint pigments.
<i>Service units</i>	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).

### 2.4.3 Solid wastes

The main sources of solid wastes are:

*Foundry  
Operation*

- Calcium carbide desulfurization slag reacts with water to create acetylene gas
- Wastewater sludge generated when suspended solids are precipitated may contain cadmium, lead and iron
- Bad house dust may contain toxic materials such as lead and cadmium

*Motor  
vehicle  
assembly*

- Returnable parts-packaging (metal or plastic racks, metal skids, bins) are stored then shipped back
- Expendable parts-packaging (styrofoam, wood skids, plastic corrugated boxes,...)
- Faulty equipment

*painting/  
finishing*

Paint containers

*Dismantling/  
shredding*

Dismantling valuable parts for recycling or reuse. The rest is sorted into ferrous materials, non-ferrous materials and residues.

*Service units*

- Sludge from wastewater treatment plant
- Scrap from workshops.

**Table (6) Material Inputs and Pollution sources**

<b>Process</b>	<b>Material Input</b>	<b>Air Emission</b>	<b>Process Wastewater and liquids</b>	<b>Other Wastes</b>
<b>Metal Shaping</b>				
<b>Metal Cutting and/or Forming</b>	Cutting oils, degreasing and cleaning solvents, acids, and metals	Solvent wastes (e.g 1,1,1. trichloroethane, acetone, xylene toluene, etc)	Acid/alkaline wastes (e.g. hydrochloric, sulfuric and nitric acids) and waste oils	Metal wastes (e.g., copper, chromium and nickel) and solvent wastes(e.g. 1,1,1 trichloroethane , acetone, xylene toluene, etc)
<b>Heat Treating</b>	Acid/alkaline solutions (e.g. hydrochloric and sulfuric acid) cyanide salts and oils		Acid/alkaline wastes, cyanide wastes, and waste oils	Metal wastes (e.g. copper, chromium and nickel)
<b>Surface Preparation</b>				
<b>Solvent cleaning</b>	Acid/alkaline cleaners and solvents	Solvent wastes (e.g. acetone, xylene, toluene, etc)	Acid/alkaline wastes	Ignitable wastes, solvent wastes (e.g. 1,1,1 trichloroethane , acetone, xylene toluene, etc) and still bottoms
<b>Pickling</b>	Acid/alkaline solutions		Acid/alkaline wastes	Metal wastes

<b>Surface Finishing</b>				
<b>Electroplating</b>	Acid/alkaline, solutions, metal bearing and cyanide bearing solutions		Acid/alkaline wastes, cyanide wastes, plating wastes and wastewaters	Metal wastes, reactive wastes and solvent wastes
<b>Surface finishing</b>	Solvents	Solvent wastes (e.g. 1,1,1 trichloroethane , acetone, xylene toluene, etc)		Metal paint wastes, solvent wastes, ignitable paint wastes and still bottoms
<b>Facility cleanup</b>	Solvents	Solvent wastes (e.g. 1,1,1 trichloroethane , acetone, xylene toluene, etc)		Solvent wastes and still bottoms

### 3. ENVIRONMENTAL AND HEALTH IMPACTS OF POLLUTANTS

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 of chemicals, wastewater treatment and discharge, discharges from process control laboratories, disposal of residues and reuse or disposal of 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 come 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 of 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 of sewage sludge by persistent, bio-accumulative, and toxic residues;
- Groundwater contamination through leakage;
- Disposal of surplus chemicals and/or treatment sludge.
- 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 therapeutically against bacterial infection; it was withdrawn from the market after causing over 100 deaths from acute kidney failure.

***Carcinogenicity:*** currently no evidence

***Environmental Fate:*** Diethylene glycol is a water-soluble, volatile organic chemical. It may enter the environment in liquid form 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 ailments. 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 of the specific environment.

***Physical Properties:*** Concentrated hydrochloric acid is highly corrosive.

***Methanol***

***Toxicity:*** Methanol is readily absorbed from the gastrointestinal 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.

***Carcinogenicity:*** 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. Methanol is readily degraded by microorganisms in soils and surface waters.

***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 present at 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. Little is known about bioconcentration in aquatic organisms or adsorption to sediments 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. It can be degraded by microorganisms living in water and soil.

***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 high levels of toluene were inhaled by their mothers, 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. Toluene may also be degraded by microorganisms. Once volatilized, 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 photooxidation 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 of sunlight and bioconcentrates 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 formyl 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 microorganisms 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. Acid 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 <sub>2</sub> /liter
COD	1524 mg O <sub>2</sub> /liter
Total phosphorus Total	18.2 mg/liter
zinc	72 mg/liter
TSS	1128 mg/liter
O & G	196 mg/liter
pH	10

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 workshops 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. 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 sldges 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 motor vehicles assembly 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/m<sup>3</sup> 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/m<sup>3</sup> 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 mazout 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 (7 and 8).

**Table (7) Maximum limits of emissions from sources of fuel combustion  
(for furnaces)**

Pollution	Maximum limit, mg/m <sup>3</sup> 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 (8) Maximum limits of emissions from sources of fuel combustion  
(for Boilers)**

Pollutants	Maximum limit, mg/m <sup>3</sup> 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 (9) 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.

As interesting non-binding information, let us consider other recommendations concerning wastewater discharges from the metal surface industry in the Baltic Sea area presented in Table (10):

**Table (9) 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 (Grease)	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	—	—

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
PO <sub>4</sub>	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	—	—
Chromium	1		—	—	Total concentration for theses metals should be: 1 for all flow streams	
Chromium Hexavalent	—	0.5	0.05	0.05		
Copper	1.5	1.5		1		
Iron	1.5		1	1		
Lead	0.5	1	0.05	0.05		
Mercury	0.005	0.2	0.001	0.001	—	—

Parameter (mg/l 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
Nickel	0.1	1	0.1	0.1	—	—
Silver	0.1	0.5	0.05	0.05	—	—
Zinc	5	<10	1	1	—	—
Cyanide	0.1	<0.1	—	—	—	0.1
Total heavy metals	—	Total metals should not exceed 5 mg/l	1	1	1	1

**Table (10) Maximum permissible concentrations in wastewater discharges from the metal surface treatment industry**

Substance	Concentration in mg/liter	
	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 waste

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

- Law 38/1967, which addresses public cleanliness, regulates the collection and disposal of solid wastes from houses, public places, commercial and industrial establishments.
- Ministry of Housing, Utilities and Urban Communities (MHUUC) decree No. 134 of 1968, which provides guidelines from domestic and industrial sources, including specifications for collection, transportation, composting, and 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 (11).
- 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 Table (12).
- 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, 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, and Minister of Industry Decree 380/1982.

**Table (11) Permissible limits as time average and for short periods**

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

**Table (12) Threshold limits for some air pollutants of concern**

Substance	Threshold limit		Threshold limit for short periods	
	ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
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 material and waste**

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 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 causing violation of Law 4 that takes into consideration the concentration of the pollutant rather than its load. 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 motor vehicle assembly are presented below. These are options available to facilities, but are not to be considered as requirements. The information is organized by metal shaping, surface preparation, plating, and other finishing operations besides motor vehicle assembly, dismantling/ shredding and auxiliary services such as power generation plants.

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  
Process and  
equipment  
modification***

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

*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 chip wringer to recover excess coolant on aluminum chips.

*Option 5* - Install a coolant recovery system and collection vehicle for machines not on a central coolant sump

*Option 6* - Use an ultra-filtration system to remove soluble oils from wastewater streams.

***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 (degreasing)**

#### ***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 extend 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;

*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***

*Option 1* - Use less hazardous degreasing agents such as

**substitution** 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 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.

#### ***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 electrolysis 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 analyze 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, electrolysis nickel, ammonium silver, halide silver, methanesulfonate-potassium iodide silver, amino or thio complex silver

**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** – Replace galvanizing processes requiring high temperature and flux with one that is low temperature and does not require flux.

***Waste segregation and separation***

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.-** Implement the electro-dialysis reversal process for metal salts in wastewater.

**Option 9.-** 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**

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 Recycling**

Segregate non hazardous paint solid from hazardous paint solvents and thinners

**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 aluminate to liberate free sodium hydroxide and produce a dry, crystalline hydrate alumina byproduct.

**c) 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**

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**

To prevent spray gun leakage. Submerge only the front end (or fluid control) of the gun into the cleaning solvent.

**Waste segregation and separation**

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 energy conservation measures can be adopted to minimize air pollution from flue (exhaust) gases:  
Replace Mazout by solar or natural gas. Mazout 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 to 11, 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.

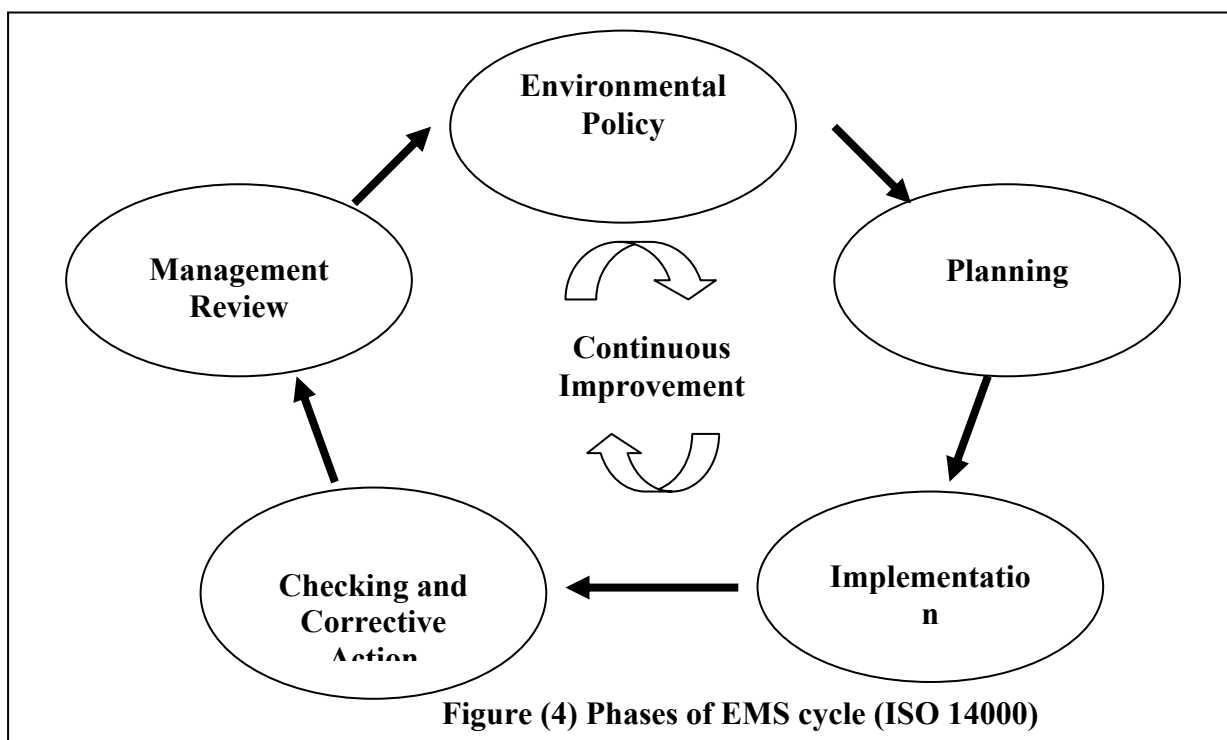
The following sections highlight the concept of EMS, link to SM and link between SM and cleaner production.

### **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 4) 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.



### 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 (5) illustrates relationship and interaction among the main elements of EMS and SMS.

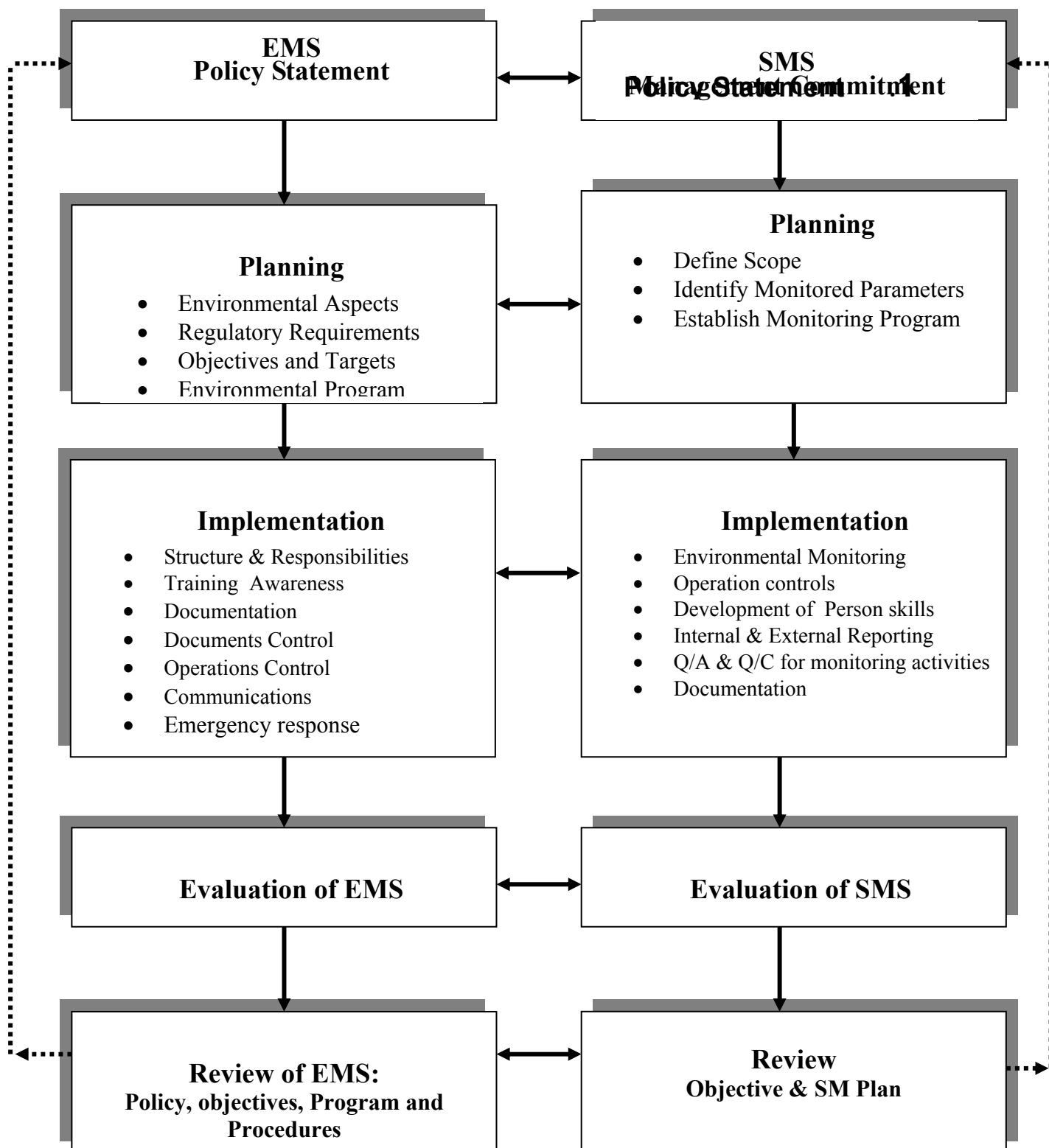


### **6.3.3 SM Link to Pollution Prevention and cleaner production**

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 (5) 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.

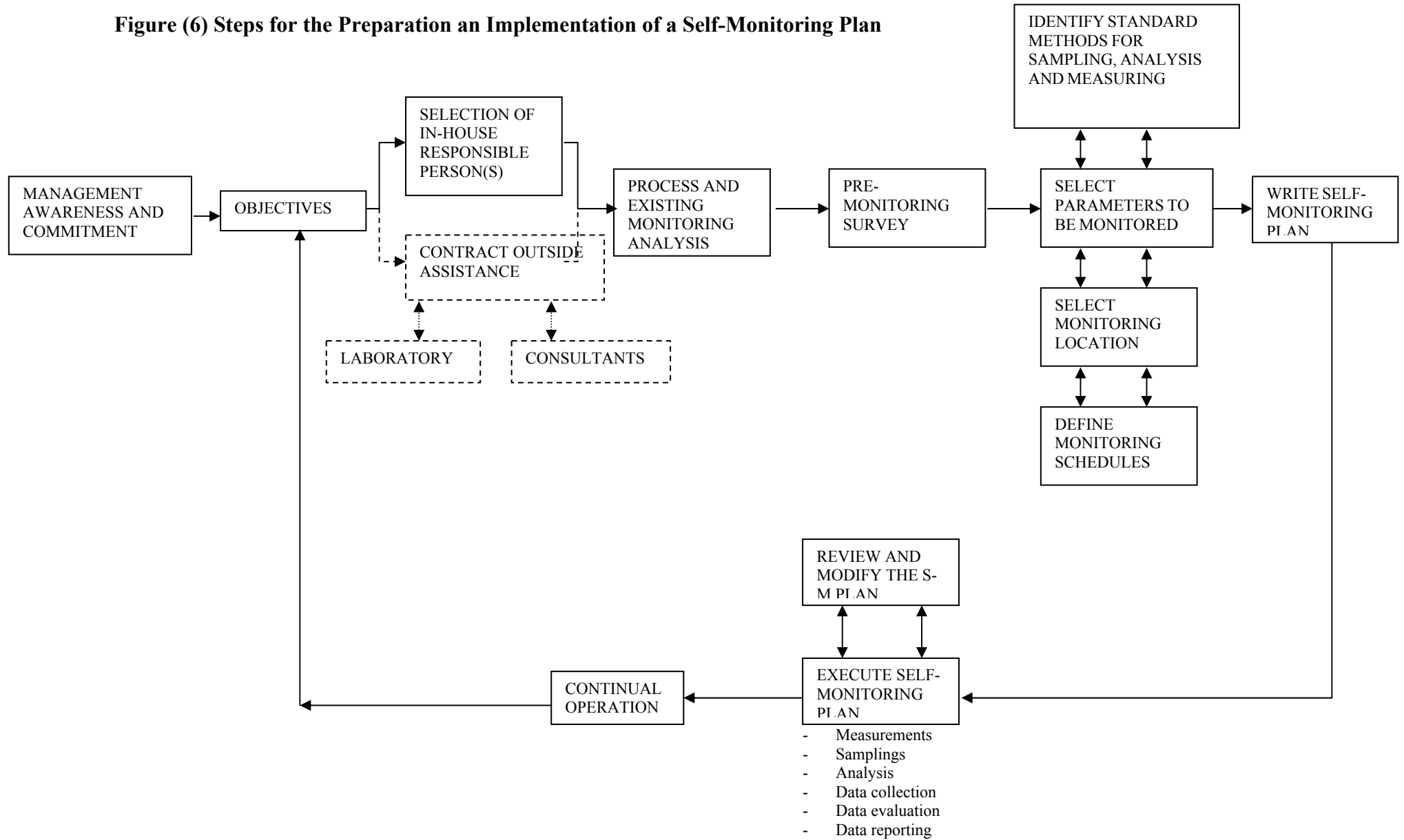
With reference to "Guidebook for Industrial Self-Monitoring", the main elements of the Self-Monitoring Plan, that describes the SMS, include:

- 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 constraints.

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 (6) presents the various steps for the preparation and implementation of a self-monitoring plan.

**Figure (6) 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 (13) presents an example of a checklist for existing self-monitoring activities.

**Table 13. 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, and 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 motor assembly 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 is 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:

<b><i>Normal emissions</i></b>	Occur during normal operation and normal process and abatement technique conditions
<b><i>Diffused and fugitive emissions</i></b>	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.
<b><i>Exceptional emissions</i></b>	<p>Exceptional emissions refer to varying input or process conditions, start-ups, shutdowns, by-pass of a process for malfunctioning and accidental causes.</p> <p>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.</p>

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 (e.g. data provided by the 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 (14).

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<sub>2</sub>, 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 (14) Advantages and disadvantages of surrogate parameters**

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>- Cost savings</li> <li>- More continuous information e.g. continuous opacity vs. periodic dust sampling</li> <li>- Allow more positions form discharge monitoring</li> <li>- Sometimes more accurate e.g. fuel sulfur vs. SO<sub>2</sub></li> <li>- Give early warning of possible abnormal emissions e.g. combustion temperature warns for increase in dioxin emissions.</li> </ul>	<ul style="list-style-type: none"> <li>- Need cost for calibration against direct values.</li> <li>- May provide relative measurement rather than an absolute value</li> <li>- May not valid only for a restricted range of process conditions.</li> </ul>

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>- Causes disruption to process operation.</li> <li>- May combine information from several direct measurements e.g. temperature indicates energy efficiency, emissions and process control.</li> </ul>	<ul style="list-style-type: none"> <li>- May not command as much public confidence as direct values.</li> <li>- Sometimes less accurate.</li> </ul>

### 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 cannot show neither accurate emission amounts, nor their division between emissions into the air, water discharges or solid wastes. Material balance calculations are often based on evaluated process flows and concentrations. Calculating a reliable average emission level for a factory means long term monitoring of the processes and statistical examination.

### 7.5.3. Emission factors

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

**Note**

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

### 7.5.4. Engineering calculations.

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

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

## 8. MONITORING OF RAW MATERIALS, UTILITIES AND PRODUCT

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

### 8.1 Raw materials and chemicals

The amount of raw material and cost/ton are important monitoring parameters. Depending on the type of raw material and chemicals, the quality is assessed by the relevant parameters and tests before acceptance, Table 15. 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 15 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 16

**Table 16 Monitoring of Utilities**

Parameters	Monitoring Method	Indication
Energy consumption per ton produced <ul style="list-style-type: none"> <li>Electricity</li> <li>Fuel</li> </ul>	Consumption measurements and book keeping	Energy use efficiency
	Fuel flow accumulator	
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
<b>Quality of the utilities</b>	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 17.

**Table 17 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 (18) presents the major processes in each production line and the parameters that should be monitored to minimize losses, maximizing productivity and predict maintenance needs.

**Table (18) Operation Control**

Production Process	Cause of Pollution	Affected Media	Parameters to be monitored	Method	Indication	Frequency/ Duration
<b>Foundry Operations</b>						
Mould Production	Dust	Work env.	-Properties of raw sand	Sample analysis Book keeping	Air pollution Noise level Solid waste	Once a day/batch
	Noise	Work env.				
Casting	Combustion	Air	-.Combustion eff			
	Slag	Land		Mass balance		
Finishing	Dust, Noise	Work env.	-Machine speed	Mass balance, speed meter		
<b>Metal Fabrication</b>						
Metal Shaping Surface Preparation Surface Finishing	See Manual on Metal Fabrication	See Manual on Metal Fabrication	See Manual on Metal Fabrication	See Manual on Metal Fabrication	See Manual on Metal Fabrication	See Manual on Metal Fabrication
<b>Motor Vehicle Assembly</b>						
Body Assembly Hard trim installation Soft trim installation	Packaging Clean-up	Land	Rate of disposal	Book keeping	Waste in work place and land fill	Once/week
<b>Motor Vehicle Painting/Finishing</b>						
Anti-corrosion operation Priming Operations Sealant Application Finishing Operations	Evaporation VOC, Lead	Work Env.	Painting pressure Material consumption	Manometer Book keeping	Air pollution in work environment	Once per day/week
<b>Utilities</b>						
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, Once per day/week
	Sludge	Land	Mass	Mass balance	Solid waste	



## 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 (19) 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 (19) Monitoring and preventive maintenance**

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

## 10. ENVIRONMENTAL MONITORING

Environmental monitoring covers emissions to air, effluent and solid and hazardous waste. Section 4 presents the various law and regulations that apply to emissions, effluents and wastes from the motor industry. Expected pollutants and hazardous releases from the industry are specified in section 2.4. For each p

roduction line related pollution aspects are identified in section 2.2. The pollution aspects of service units are presented in section 2.3. The output from the measurements and analysis of the parameters are recorded in the environmental register of the facility. Table (20) presents the compliance monitoring activities for the different aspects of pollution as per environmental laws.

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

### 10.1 Emission to air

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

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

Periodical measurements are carried out as manual single measurements or as short period continuous measurements by the plant itself or by an exterior measurer. Periodical emission measurements are carried out annually for the following emission components: NO<sub>x</sub>, SO<sub>2</sub>, CO, CO<sub>2</sub>, Cl and particles. In all cases, it should be noted that regular maintenance, control and calibration are needed to obtain an acceptable measurement accuracy level.

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

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

## 10.2 Effluents (wastewater)

The regulations set the limits for the concentrations of specific pollutants of in wastewater when discharged to a recipient body. For monitoring purposes, the discharge values for specific substances or parameters are mostly expressed as total amounts per unit time. In some cases these values are given as specific amounts per ton of product or as purification efficiencies. Limit values are set for a large number of parameters such as COD/BOD<sub>5</sub>, TSS, phosphorus and nitrogen.

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

- Wastewater flow (Q), m<sup>3</sup>/d
- Total suspended solids (TSS), mg/l
- Temperature, °C
- Chemical oxygen demand (COD<sub>Cr</sub>)
- Biological oxygen demand (BOD<sub>5</sub>)
- Total nitrogen (N), mg/l
- pH
- Conductivity, mS/m

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

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

**Sampling:** Well realized sampling is essential for determining of wastewater discharges. There are general instructions for wastewater sampling. However, industry-specific problems such as variation of the wastewater quality or flow rate have to be solved on case-by-case basis.

**Table 20a. Compliance monitoring for air pollution, and workplace**

Major pollution sources	Impact	Parameter monitored	Method used	Source type	Operating Conditions	Pollution control devices
				Point - Diffuse -	-Normal -Exceptional	
Foundry Operations						
Mould Production	Air Work Env.	Dust (PM), SOx, Pb, Cd Noise	Gas analyzer			
Casting						
Finishing			Noise meter			
Metal Fabrication						
Metal Shaping Surface Preparation Surface Finishing	See Manual on Metal Fabrication	See Manual on Metal Fabrication	See Manual on Metal Fabrication			
Motor Vehicle Assembly						
Body Assembly Hard trim installation Soft trim installation						
Motor Vehicle Painting/Finishing						
Anti-corrosion operation Priming Operations Sealant Application Finishing Operations	.Work Env	VOCs Lead	Gas analyzer			
Boiler						
Energy and Steam Generation	Air	SOx, NOx, HC, CO, PM	Gas analyzer			

**Table 20b Compliance Monitoring for Wastewater and Solid Waste**

Major Pollution Sources	Impact	Parameter monitored	Method used	Source type	Operating Conditions	Remarks
				Point Diffuse	-Normal -Exceptional	
Foundry						
Slag quenching Wet Scrubber	Receiving water body	-Organic substances (COD, BOD) -Lead, iron, cadmium -suspended solids	Analysis			- Wastewater from wet scrubber may include iron, cadmium and lead
	Landfill	-Sludge -Scrap	Mass balance			
Metal Fabrication						
	Receiving water body	See Manual on Metal Fabrication	See Manual on Metal Fabrication			
	Landfill					
Motor Vehicle Assembly						
Assembly Operations	Landfill	Packaging material - Scrap -				
Motor Vehicle Painting/Finishing						
Anti-corrosion, Priming and Sealing operations	Receiving water body	- Organic substances (COD, BOD) -Suspended solids, Heavy metals	Analysis			
	Landfill	Containers, Sludge	Mass balance Book keeping			
Wastewater treatment plant						
Wastewater	Receiving water body	- Organic substances (COD, BOD) -Suspended solids, heavy metals	Analysis			
Solid waste	Landfill	- Sludge, Scrap	Mass balance			

Samples are either single grab samples, composite samples, or composite samples in proportion to the flow. A single grab sample reveals the composition of the wastewater at the sampling time. With several single samples it is possible to follow the wastewater load peaks, quality variation and the variation range of the significant parameters. A composite sample reveals the average composition over a chosen period. A 24-hour composite sample is normally taken in proportion to the flow so that the sampler is controlled by flow meter.

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

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

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

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

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

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

### 10.3 Monitoring of solid waste

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

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

## **11. DATA COLLECTION, PROCESSING AND USAGE**

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

### **11.1 Data collection and processing**

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

The aspects and parameters that are involved in data collection and processing are explained in the Annex A. Figure (7) 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**

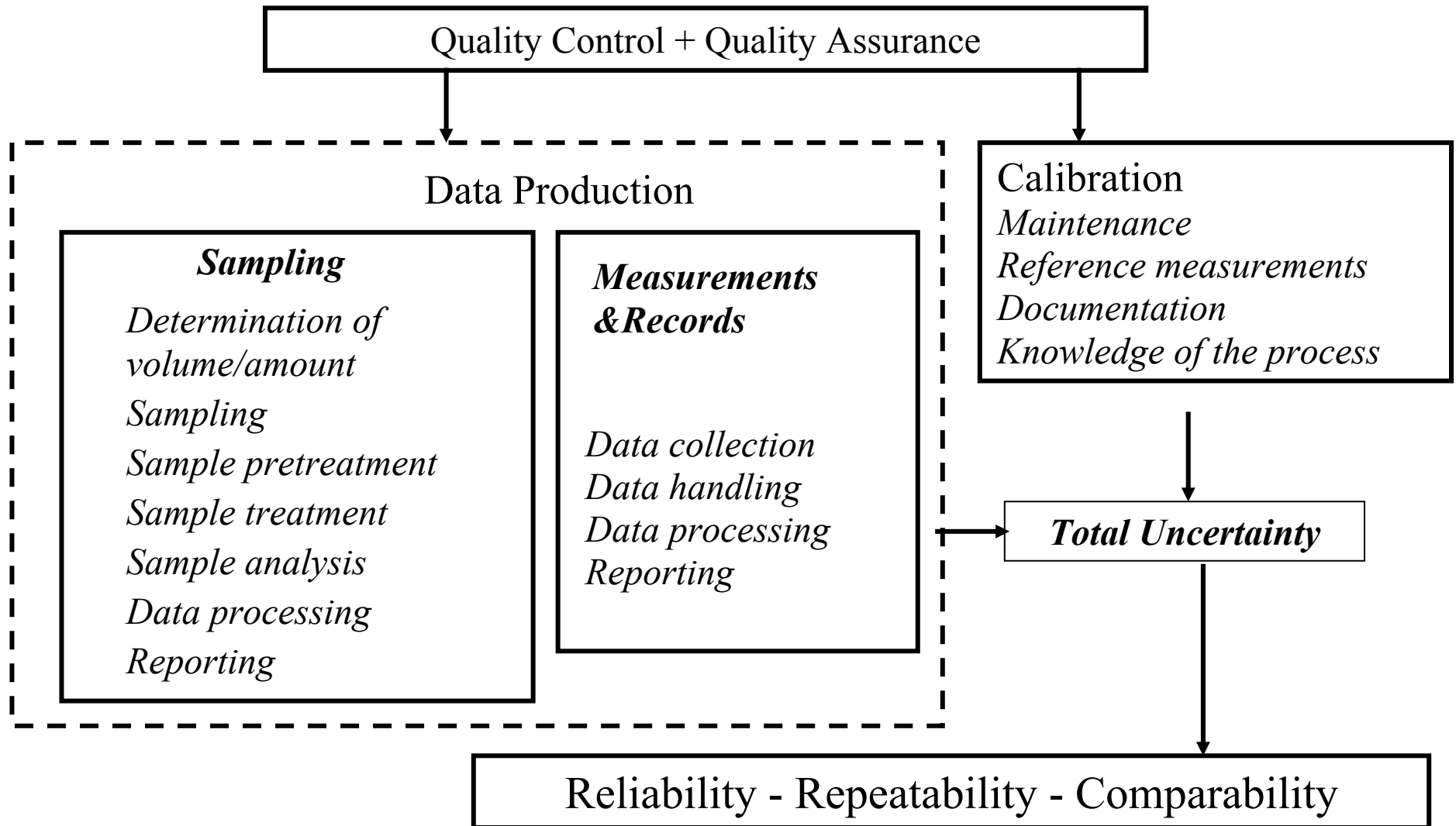
It is best practice to record process and environmental information in a detailed archive or database. It can then be related easily to the monitoring results and used to evaluate, compare and manage aspects of process performance such as:

- 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 (7) Parameters Affecting SM Reliability



### 11.2.2. Environmental register

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

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

### 11.2.3. Reporting

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

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

### 11.2.4. Internal auditing and conclusions on results

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

### 11.2.5. Feedback and decision making

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

In those parts of the monitoring program where compliance is met, possible reduction in frequency of monitoring can be considered and instead move resources to parts that need more accurate monitoring, e.g. borderline or non-compliance situations. Feedback should include all parts of the monitoring program, process, product control, maintenance, environmental management and occupational safety. Detailed requirements should be set for the improvements needed and a date fixed for their implementation.

#### **11.2.6. Using outputs in public relations**

The monitoring data is refined and distributed to the end users such as national and international reporting, research and statistical purposes, citizens, and the media.

The citizens have the right to present complaints about the health or environmental impacts caused by the operation these complaints are directed to the permitting and supervising authority.

Monitoring data is needed e.g. in national research and statistics, for planning and evaluation purposes, by national group organizations and the media.

## *Annex A*

### **DATA COLLECTION AND PROCESSING**

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

#### **1 Reliability**

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

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

***Total uncertainty:*** The results obtained from any measurement have a specific uncertainty. It is important that the uncertainty is estimated and taken into account when the results are used in process management or for regulatory purposes. For example, the measurement result  $10 \text{ g/t} \pm 2 \text{ g/t}$  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<sup>3</sup>, PPM, % O<sub>2</sub>): 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 (°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<sup>3</sup>/year):

Pollutants	Concentration of Pollutants mg/m <sup>3</sup>	Limits of Law 4/94 for Combustion of Fuels mg/m <sup>3</sup>	Limits of Law 4/94 for Emission of production processes mg/m <sup>3</sup>	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 <sup>3</sup>	Conc. of the pollutants after treatment mg/m <sup>3</sup>	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<sup>3</sup>/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 <sup>3</sup> /year	Notes
<ul style="list-style-type: none"> <li>• Paper</li> <li>• Plastics</li> <li>• Glasses</li> <li>• Organic Compound</li> <li>• Metals</li> <li>• Anther Materials</li> </ul>			

- 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 m <sup>3</sup> /year	Notes
<ul style="list-style-type: none"> <li>• Paper</li> <li>• Plastics</li> <li>• Glasses</li> <li>• Organic Compound</li> <li>• Metals</li> <li>• Anther Materials</li> </ul>			

**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
<ul style="list-style-type: none"><li>• Temperature</li><li>• Humidity</li><li>• Noise</li><li>• Heat</li><li>• Vibrations</li><li>• Bacteria &amp; Viruses</li><li>• Odors</li><li>• Other Emissions</li></ul>			

## **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 (NO<sub>x</sub>, Sox, CO<sub>x</sub>, CO, ..... Etc.)
- Sampling Location, Sampling Frequency and Time Table.

Sampling Location	Time between Samples

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

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

Sampling Location	Time between Samples

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

## *Annex C*

### **REFERENCES**

- *“Monitoring and Control Practices of Emissions in Pulp and Paper Industry in Finland”, 1998, Saarinen K., Jouttijarvi T. and Forsius K., Saarinen K. Finnish Environment Institute*
- *“Data Production Chain in Monitoring of Emissions”, 1999, Saarinen K, Finnish Environment Institute.*
- *Draft Document “Self-Monitoring Manual for Motor Vehicles Assembly Industry”, August 2002, prepared by Dr. Hassan El Hares.*