Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency (EEAA)

Inspection Manual

Fabricated Metals Industry

2002

Table of Contents

1. Introduction

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

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

The three guidelines were later summarized into one that will be referred to as the General Inspection Manual GIM (EPAP, 2002), which was developed, in order to cover the aspects common to all industrial sectors.

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

1.1 Preface

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

- Food Industry with specific reference to the five sub-sectors of Dairy products, Vegetables and Fruit processing, Grain Milling, Carbonated Beverages and Confectionery.
- Pulp and Paper Industry
- Metallurgical Industry with specific reference to the two sub-sectors of Iron and Steel and Aluminum.
- Engineering Industry including the fabricated metal products and the motor vehicle assembly sub-sectors.
- Textile Industry.

1.1.1 Project Objectives

The Egyptian Environmental Affairs Agency – EEAA is striving to create an environmental management and policy culture within the local administration. Under this overall objective, the Technical and Institutional Support Component of the Egyptian Pollution Abatement Project – EPAP, funded by the governments of Finland and Egypt, is working out to initiate inspection and self monitoring manuals for specific industrial sectors and sub-sectors 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 engineering industry, each sub-sector has two distinct manuals, one for inspection and the other for self-monitoring. Description of the industry, pollution aspects and relevant environmental laws is similar for both manuals. Each manual is intended to be, as much as possible a stand-alone with occasional cross-reference to General Guidelines previously developed to avoid undue repetitions.

1.1.2 Organization of the Inspection Manual

The inspection manual for the fabricated metal products industry includes ten chapters. The first chapter represents an introduction to the whole project and to the specific sub-sector. Chapters two to five deal with the fabricated metal products industry and its environmental impacts.

The description of the industry in chapter two includes the inputs to each operation, a description of the different production processes with their specific inputs and 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 three describes the environmental and health impacts of the various pollutants whereas chapter four gives a summary of the articles in the Egyptian environmental laws relevant to the industry. Chapter five gives examples of pollution abatement techniques and measures applicable to the fabricated metal products industry.

The inspection procedures are described in chapters six to ten starting with a brief description of the inspection process in chapter six. The planning aspects that should be considered at the inspectorate level are explained in chapter seven. The different tasks at the inspectors level specific to the fabricated metal products industry are described in chapters eight to eleven. The tasks before field inspection are presented in chapter eight whereas the general inspection tasks for actually performing the field visit are defined in chapter nine. Chapter ten is concerned with the conclusion of the field visit including inspection report writing, supporting the enforcement case and following-up the compliance status of the facility.

1.2 Introduction to the Fabricated Metal Products Industry

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

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

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

1.2.1 Product Characterization

Fabricated structural metal products, metal forging and stamping, metal cans and shipping containers, cutlery, hand-tools and general hardware, screw machine products, bolts, nuts, screws, rivets and washers, heating equipment and plumbing fixtures, coating, engraving and related services and miscellaneous fabricated metal products.
The International Standard Industrial Classification –ISIC gives the code 3800 for metal products, machinery and equipment.

1.2.2 Egyptian Particularities

The Fabricated Metal Products Industry is generally concentrated in Egypt in the immediate vicinity of towns. In fact since many years, there is a large demand for multi-family housing, office buildings and commercial structures besides leisure activity accommodations along the North coast and the Red Sea. As we know the success of the construction industry is fundamental to the success of the fabricated structural metal industry since the former consumes almost 95 % of the output from the latter. Consequently we expect in the near future an ever-increasing demand for fabricated structural metal industry and general component-producing industries.
Let us take the Alexandria governorate where some data are available [1]. A sample of industries was considered representing around 60% of the industries of the ISIC3800 industrial sector in the Alexandria governorate in terms of the total production volume. For this sample:

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

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

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

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

Let us take another example: a large fabricated metal products factory near Cairo where some data are available [8].
The total particulate concentration at the head level of workers exceeds the upper limit allowed by law No 4-1994 (which is 5 mg/m3), in the primer spray

area (14 mg/m3), in the painting spray area (16 mg/m3), in the fiberglass machining area (35 mg/m3) and in the wood cutting area (9 mg/m3).
The CO concentration in the welding and cutting areas (75 ppm), the Xylene concentration in the primer dipping area (115 ppm) exceeds the upper limit allowed by law 4-1994 for full day exposure (50 ppm and 100 ppm respectively).

2. Description of the Industry

In view of the high cost of most new equipment and the relatively long lead-time necessary to bring new equipment into operation, changes in production methods and products are made only gradually i.e. even new process technologies that fundamentally change the industry are only adopted over long periods of time.

The fabricated metal products are usually intermediate products that constitute parts of larger products. Each intermediate product can be produced in small, medium or large facilities or can be a plant in a large facility (e.g. vehicle, refrigerator and air conditioning assembly facilities).

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

2.1 Raw Materials, Chemicals and Other Inputs

Table (1) presents the material inputs to each operation in metal shaping, surface preparation and metal finishing processes.

Metalworking fluids (cutting oils) are applied to either the tool or the metal being tooled to facilitate the shaping operation. Metalworking fluid (e.g. ethylene glycol) is used to:

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

Metal fabrication facilities are major users of solvents (e.g. trichloroethane, methyl ethyl ketone) for degreasing. In cases where solvents are used solely in degreasing (not used in any other plant operations), records of the amount and frequency of purchases provide enough information to estimate emission rates, based on the assumption that all solvent purchased is eventually emitted.

Acids and alkalis are also used for cleaning the metal surface. The current trend in the industry is to use aqueous non-VOCs to clean the metal, whenever possible. The use of 1,1,1, trichloroethane and methyl ethyl ketone is declining.

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

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

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

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

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

2.2 Production Processes

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

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

Production Processes	Service Units
Metal Shaping Casting Shearing Forming Operations Machining ***Surface Preparation*** Degreasing	Boilers Cooling towers Laboratory Mechanical & electrical workshops Garage Storage facilities.

Pickling (acid cleaning) ***Surface Finishing*** Anodizing Chemical Conversion Coating Electroplating Electroless Plating Painting Other Metal Finishing Techniques	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.

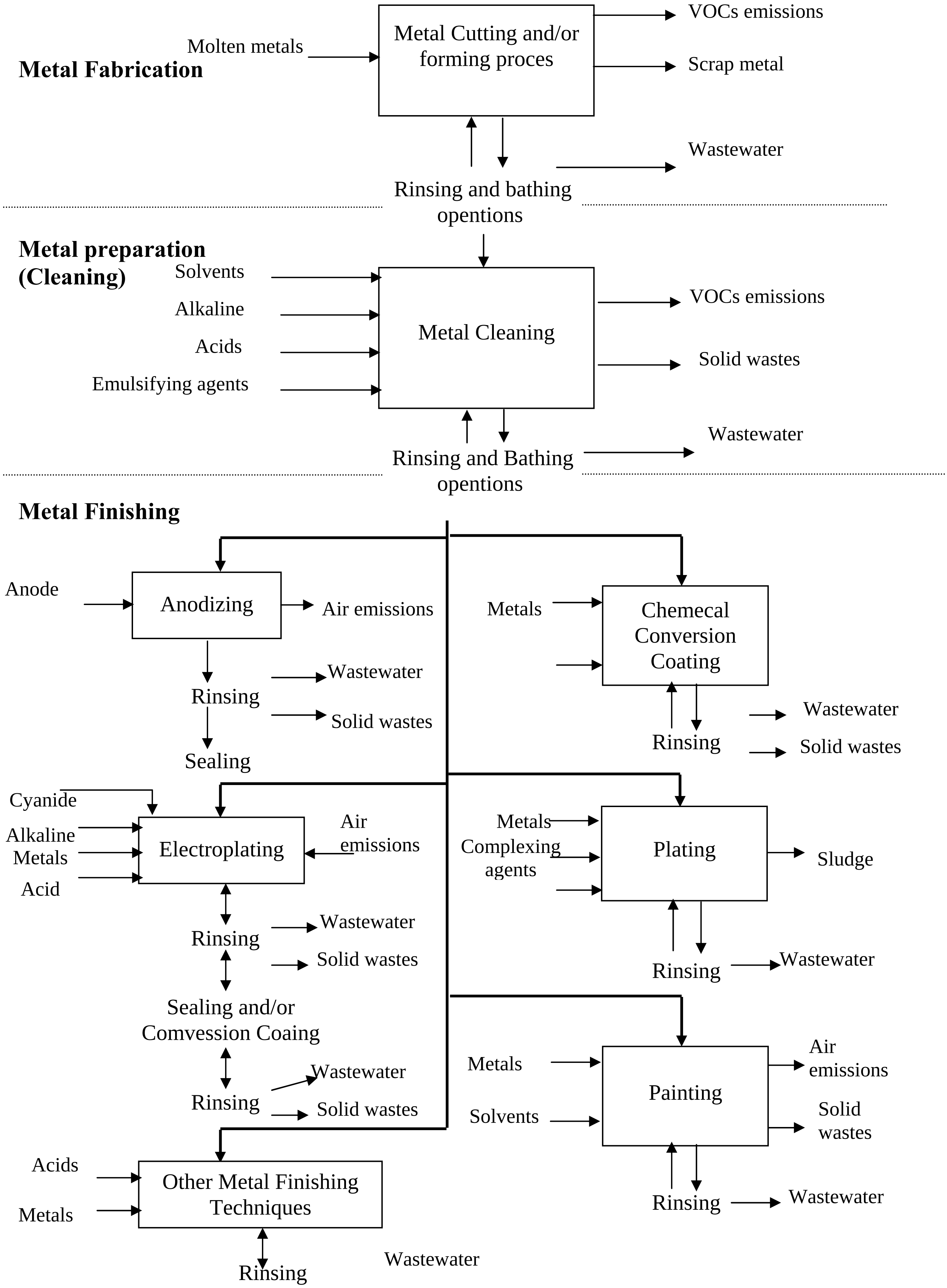

Fig (1) Fabricated Metal Products Manufacturing Processes

2.2.1 Metal Shaping

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

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

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

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

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

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

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

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

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

Machining

Once shearing and forming activities are complete, the material is machined. Machining refines the shape of a workpiece by removing material from pieces of raw stock with machine tools. The principal processes involved in machining are drilling, milling, turning, shaping/planking, broaching, sawing, and grinding.

Pollution sources: Each of the metal shaping processes can result in wastes containing chemicals of concern. For example, the application of solvents to metal and machinery results in air emissions. Additionally, wastewater containing acidic or alkaline wastes and waste oils, and solid wastes, such as metals and solvents, are usually generated during this process.

Fluids resulting from this process typically become spoiled or contaminated with extended use and reuse. In general, metal working fluids can be petroleum-based, oil-water emulsions, and synthetic emulsions. When disposed, these fluids may contain high levels of metals (e.g., iron, aluminum, and copper). Additional contaminants present in fluids resulting from these processes include acids and alkalis (e.g., hydrochloric, sulfuric, nitric), waste oils, and solvent wastes.

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

2.2.2 Surface Preparation

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

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

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

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

Degreasing

Degreasing removes oils and greases present on the metal surface. Degreasing processes can be divided in water-based and organic solvent based degreasing [2]. Emulsion degreasing (cleaning) can be counted under the heading of water-based degreasing, even if an organic solvent (e.g. kerosene, mineral oil) can be present in the bath. As far as technically acceptable for the degree of metal surface cleanliness required, water-based degreasing should be applied. If organic solvents are used, preference should be given to non-chlorinated solvents [3].

Alkaline degreasing often takes place at temperatures of 80-95 ^{o} C and it is often assisted by mechanical action, ultrasonic, or by electrical potential (e.g., electrolytic cleaning). Most alkaline degreasing solutions contain three major types of components:

- Builders, such as alkali hydroxides and carbonates, which make up the largest portion of the cleaner;
- Organic or inorganic additives, which promote better cleaning or act to affect the metal surface in some way;
- Surfactants (surface-active substances acting as detergents).

Emulsion degreasing uses common organic solvents (e.g., kerosene, mineral oil, and glycol) dispersed in an aqueous medium with the aid of an emulsifying agent. Emulsion cleaning uses fewer chemicals than solvent degreasing because the concentration of solvent is lower.

Organic solvents to be used in degreasing can be grouped for example into following groups; halogenated solvents, petroleum- based solvents and other organic solvents. The most frequent halogenated hydrocarbons are trichloroethylene, perchloroethylene, 1,1,1-

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

Pickling (acid cleaning)

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

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

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

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

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

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

Table (3) Pickling Liquor Used for Various Metals

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

2.2.3 Surface Finishing

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

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

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

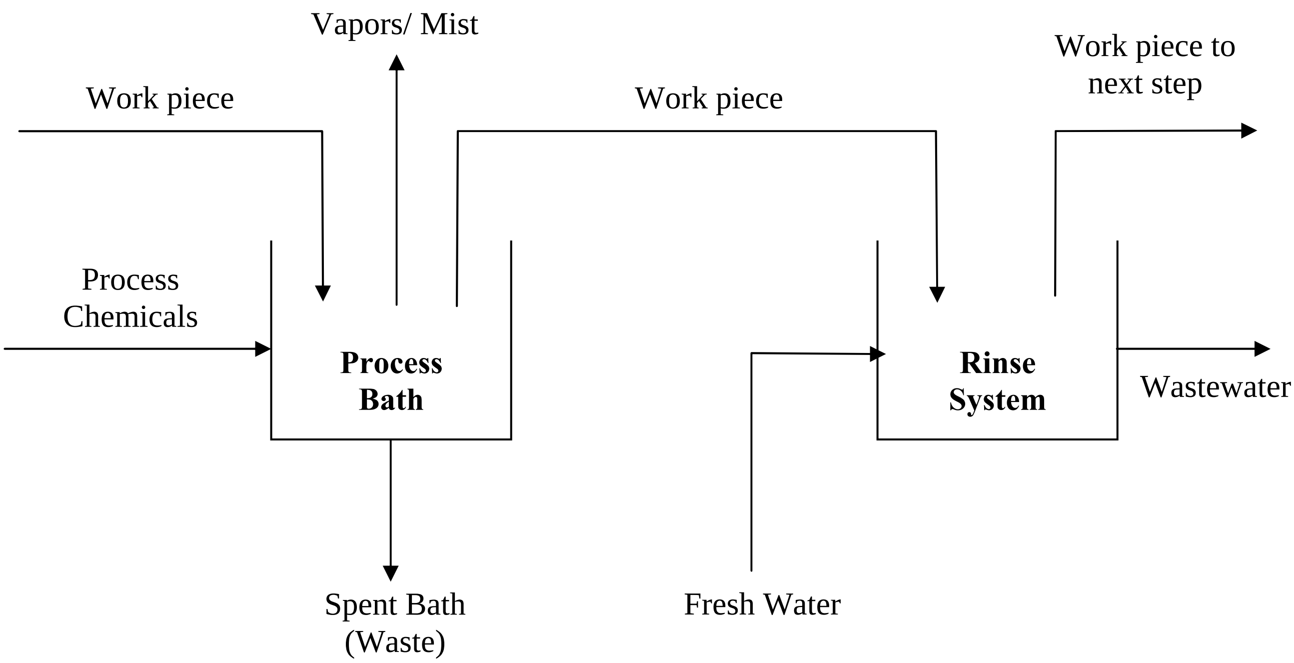

Fig (2) Typical Metal Finishing Process Step

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

Anodizing

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

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

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

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

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

Chemical Conversion Coating

Chemical conversion coating includes chromating, phosphating, metal coloring, and passivating operations.

<u>Chromate conversion coatings</u> are produced on various metals by chemical or electrochemical treatment. Solutions, usually containing hexavalent chromium and other compounds, react with the metal surface to form a layer containing a complex mixture of compounds

consisting of chromium, other constituents, and base metal.

Phosphate coatings may be formed by the immersion of steel, iron, or zinc-plated steel in a dilute solution of phosphate salts, phosphoric acid, and other reagents to condition the surfaces for further processing. They are used to provide a good base for paints and other organic coatings, to condition the surfaces for cold forming operations by providing a base for drawing compounds and lubricants, and to impart corrosion resistance to the metal surface.

Metal coloring involves chemically converting the metal surface into an oxide or similar metallic compound to produce a decorative finish such as a green or blue patina on copper or steel, respectively.

Passivating is the process of forming a protective film on metals by immersion into an acid solution, usually nitric acid or nitric acid with sodium dichromate. Stainless steel products are often passivated to prevent corrosion and extend the life of the product.

Pollution sources Chemical conversion coating generally produces contaminated wastewaters and solid waste. Pollutants associated with these processes enter the wastestream through rinsing and batch dumping of process baths. The process baths usually contain metal salts, acids, bases, and dissolved basis materials. Wastewaters containing chromium are usually pretreated to reduce hexavalent chromium to its trivalent state.

The conventional treatment process generates a sludge that is sent off-site for metals reclamation and/or disposal. Solid wastes generated from these processes include spent solutions and wastewater treatment sludge. Conversion coating solutions may also be contaminated with the base metal being processed. These solutions will eventually reach an intolerable concentration of dissolved metal and require processing to remove the dissolved metal to a tolerable level.

Electroplating

Electroplating is the production of a surface coating of one metal upon another by Electro-deposition. Electroplating activities involve applying predominantly inorganic coatings onto surfaces to provide or improve corrosion resistance, hardness, wear resistance, anti-frictional characteristics, electrical or thermal conductivity, or decoration. Fig (3), illustrates the important parts of typical electroplating equipment.

The most commonly electroplated metals and alloys include brass (copper-zinc), cadmium, chromium, copper, gold, nickel, silver, tin, and zinc.

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

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

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

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

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

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

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

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

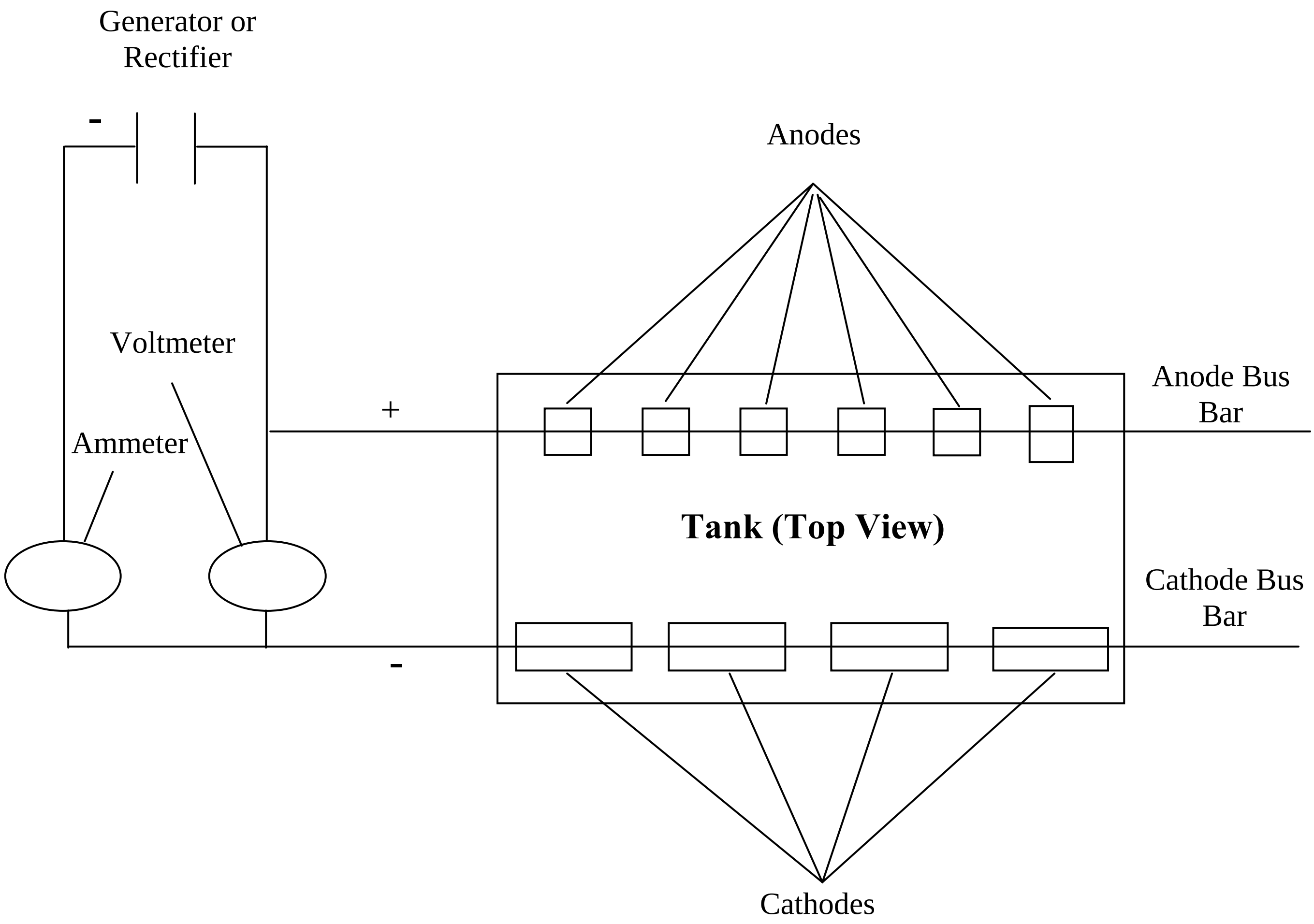

Fig (3) Typical Electroplating Equipment

Electroless plating

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

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

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

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

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

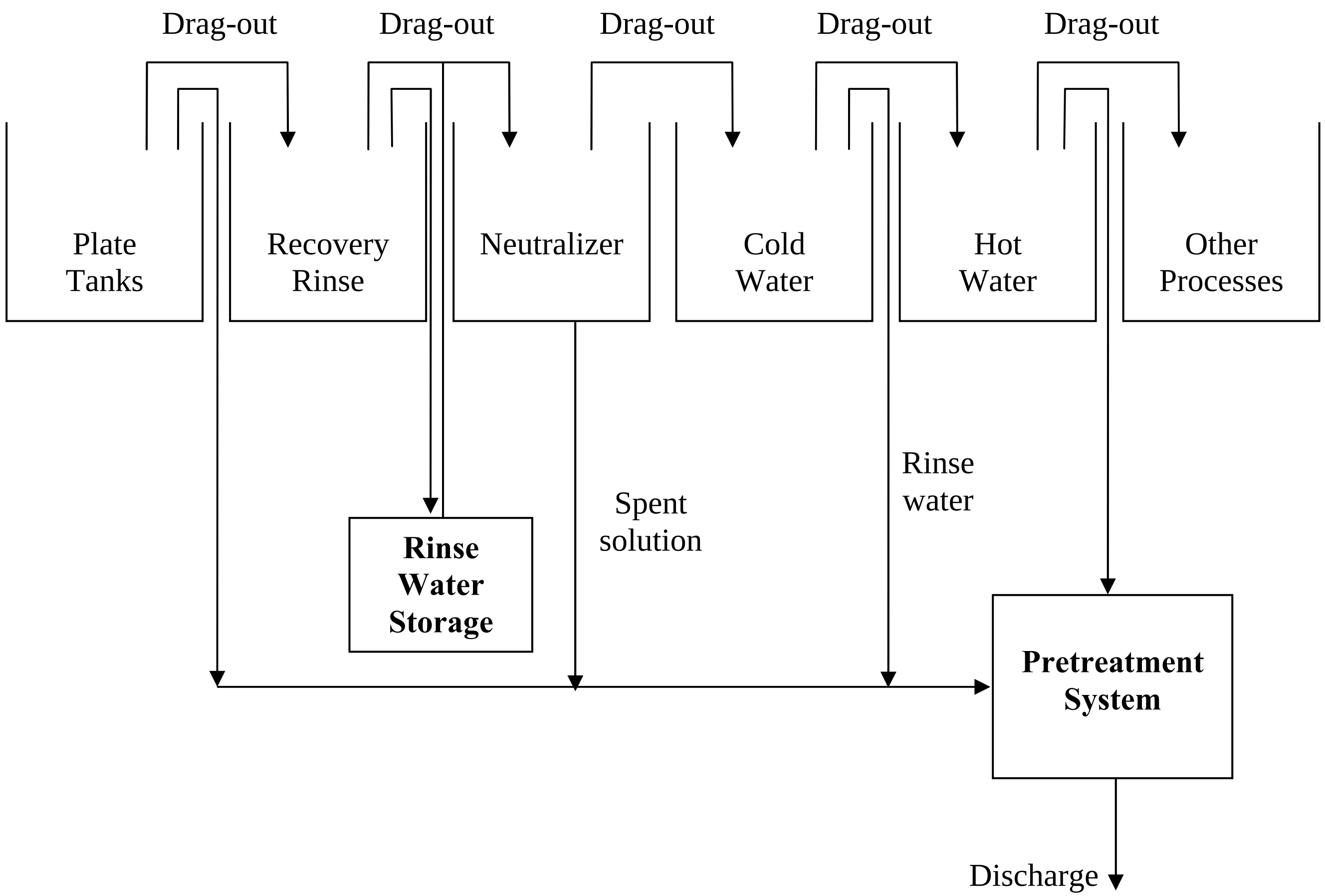

Fig (4) Electroless Plating Process

Painting

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

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

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

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

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

Sources of solid- and liquid-phase wastes include:

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

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

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

Other Metal Finishing Techniques

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

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

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

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

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

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

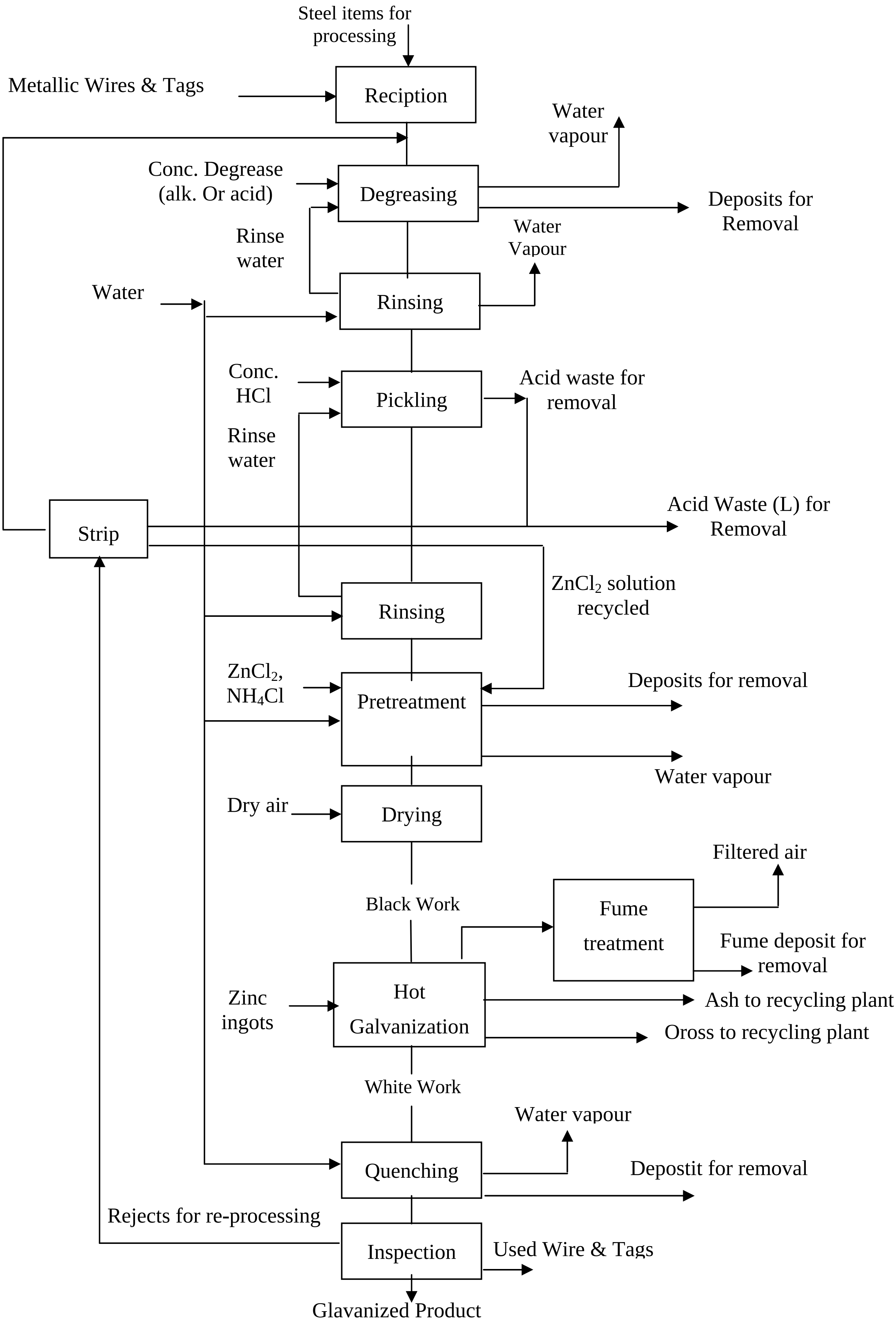

Fig (5) Material Flow Sheet for Galvanizing Plants

2.3 Service Units: Description and Potential Pollution Sources

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

2.3.1 Boilers

Boilers are used to produce steam for:

- Heat supply to the processes
- Electric power generation

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

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

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

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

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

In the case of power plants, water is used for cooling the turbines and is also generated as steam condensate. The amount of wastewater generated depends on whether cooling is performed in open or closed cycle and on the recycling of steam condensate. Contamination may arise from lubricating and fuel oil.

2.3.2 Water Treatment Units

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

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

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

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

2.3.3 Cooling Towers

Cooling water is used extensively in industry. During the cooling process, water heats up and can only be reused if cooled. Cooling towers provide the means for recycling water and thus minimizing its consumption. The cooling effect is performed through partial evaporation. This causes an increase in the concentration of dissolved salts, which is controlled by purifying some water (blowdown). The blowdown will be high in TDS.

2.3.4 Laboratories

Laboratories are responsible for:

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

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

2.3.5 Workshops and Garage

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

- Noise

- Rinse water contaminated with lube oil

Pollution in the garage area will depend upon the services offered. The presence of a gasoline or diesel station implies fuel storage in underground or over the ground tanks that require leak and spill control plans.

Replacing lube oil implies discharge of spent oil to the sewer lines or selling it to recycling stations.

2.3.6 Storage Facilities

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

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

2.3.7 Wastewater Treatment Plants

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

The potential pollution sources from the WWTP are:

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

2.3.8 Restaurants, Washrooms and Housing Complex

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

Fig (6) Service Units and their Related Pollution Sources

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

2.4 Emissions, Effluents and Solid Wastes

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

2.4.1 Air Emissions

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

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

2.4.2 Effluents

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

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

2.4.3 Solid Wastes

The main sources of solid wastes are:

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

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

Table (4) Material Inputs and Pollution Sources

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

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

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

3. Impact of Pollutants on Health and Environment

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

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

Chemical pollutants can cause a wide variety of environmental effects, which may vary from one target species to another, and also depend on the particular pathway that a chemical takes in the environment. Chemicals can migrate in the environment from one media to another, e.g. from soil into water, or from water into air. Some chemicals tend to degrade rapidly in the environment, while others are more or less persistent and can, over time, migrate to new locations under the influences of natural forces [5].

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

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

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

- Occupational exposure of workers to process chemicals and waste residues;
- Water pollution from wastewater or wash water;
- Discharge or chemicals to drains streams, or to soil;
- Impact on public sewer systems, leading to damage to the sewer itself, to the wastewater treatment process, and to the environment near the wastewater outfall; as well as presenting danger to sewer maintenance personnel.

- Contamination or sewage sludge by persistent, bio-accumulative, and toxic residues;
- Groundwater contamination through leakage;
- Disposal of surplus chemicals and/or treatment sludges.
- Soil contamination from spills, at chemical and waste storage areas;
- Transport accidents involving chemicals transported to or from the plant;
- Accidents in the plant involving the release of chemicals;
- Energy and resource consumption;
- Air emissions or chemicals with and subsequent workplace and public exposure

3.1 Top Ten Pollutants of the Engineering Industry

The following is a synopsis of current scientific toxicity and information for the top chemicals (by weight) that facilities within this sector self-reported as released to the environment based upon 1993 TRI (Toxic Release Inventory) data in the USA [3].

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 [6].

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[6].

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

Physical Properties. Acetone is a volatile and flammable organic chemical.

Glycol Ethers

Due to data limitations, data on diethylene glycol (glycol ether) are used to represent at glycol ethers.

Toxicity. Diethylene glycol is only a hazard to human health if concentrated vapors are generated through heating or vigorous agitation or if appreciable skin contact or ingestion occurs over an extended period of time. Under normal occupational and ambient exposures, diethylene glycol is low in oral toxicity is not irritating to the eyes or skin, is not readily absorbed through the skin, and has a low vapor pressure so that toxic concentrations of the vapor cannot occur in the air at room temperatures. At high levels of exposure, diethylene glycol causes central nervous depression and liver and kidney damage. Symptoms of moderate diethylene glycol poisoning include nausea.

Vomiting, headache, diarrhea, abdominal pain, and damage to the pulmonary and cardiovascular systems. Sulfanilamide in diethylene glycol was once used theraopeutically against bacterial infection; it was withdrawn from the market after causing over 100 deaths from acute kidney failure.

Carcinogenicity currently no evidence

Environmental Fate. Dietylene glycol is a water-soluble, volatile organic chemical. It may enter the environment in liquid from via petrochemical plant effluents or as an unburned gas from combustion sources. Diethylene glycol typically does not occur in sufficient concentrations to pose a hazard to human health.

Hydrochloric acid	Toxicity. Hydrochloric acid is primarily a concern in its aerosol form. Acid aerosols have been implicated in causing and exacerbating a variety of respiratory aliments. Dermal exposure and ingestion of highly concentrated hydrochloric acid can result in corrosivity. Ecologically, accidental releases of solution forms of hydrochloric acid may adversely affect aquatic life by including a transient lowering of pH (i.e., increasing the acidity) of surface waters. Carcinogenicity. Currently no evidence Environmental Fate. Releases of hydrochloric acid to surface waters and soils will be neutralized to an extent due to the buffering capacities of both systems. The extent of these reactions will depend on the characteristics if the specific environment. Physical Properties Concentrated hydrochloric acid is highly corrosive.
Methanol	Toxicity. Methanol is readily absorbed from the gatrointestinal tract and the respiratory tract, and is toxic to humans in moderate to high doses. In the body, methanol is converted into formaldehyde and formic acid. Methanol is excreted as formic acid. Observed toxic effects at high dose levels generally include central nervous system damage and blindness. Long-term exposure to high levels of methanol via inhalation cause liver and blood damage in animals. Ecologically, methanol is expected to have-low toxicity to aquatic organisms. Concentrations lethal to half the organisms of a test population are expected to exceed 1mg methanol per liter water. Methanol is not likely to persist in water or to bioaccumulate in aquatic organisms. Carcinogencity currently no evidence Environmental Fate. Liquid methanol is likely to evaporate when left exposed. Methanol reacts in air to produce formaldehyde, which contributes to the formation of air pollutants. In the atmosphere it can react with other atmospheric chemicals or be washed out by rain. Microorganisms in soils and surface waters readily degrade methanol. Physical properties. Methanol is highly flammable.

Methylene Chloride (Dichloro-methane)

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

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

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

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

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

Methyl Ethyl Ketone

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

Carcinogenicity: Current no agreement over carcinogenicity.

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

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

Toluene

Toxicity. Inhalation or ingestion of toluene can cause headaches, confusion, weakness, and memory loss. Toluene may also affect the way the kidneys and liver function. Reaction of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Some studies have shown that unborn animals were harmed when their mothers inhaled high levels of toluene, although the same effects were not seen when the mothers were fed large quantities of toluene. Note that these results may reflect similar conditions in humans.

Carcinogenicity currently no evidence

Environmental Fate. The majority of releases of toluene to land and water will evaporate. Microorganisms may also degrade toluene. Once volatized, toluene in the lower atmosphere will react with other atmospheric components contributing to the formation of ground-level ozone and other air pollutants.

Physical Properties. Toluene is a volatile organic chemical

Trichloroethane

Toxicity. Repeated contact of 1,1,1-trichloroethane (TCE) with skin may cause serious skin cracking and infection. Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. Exposure to high concentrations of TCE causes reversible mild liver and kidney dysfunction, central nervous system depression, gait disturbances, stupor, coma, respiratory depression, and even death.

Exposure to lower concentrations of TCE leads to light-headedness, throat irritation, headache, disequilibrium, impaired coordination, drowsiness, convulsions and mild changes in perception.

Carcinogenicity. Currently no evidence

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

Trichloroethylene

Toxicity. Trichloroethylene was once used as an anesthetic, though its use caused several fatalities due to liver failure. Short-term inhalation exposure to high levels of trichloroethylene may cause rapid coma followed by eventual death from liver, kidney, or heart failure. Short-term exposure to lower concentrations of trichloroethylene causes eye, skin, and respiratory tract irritation.

Ingestion causes a burning sensation in the mouth, nausea, and vomiting and abdominal pain. Delayed effects from short-term trichloroethylene poisoning include liver and kidney lesions, reversible nerve degeneration, and psychic disturbances. Long-term exposure can produce headache, dizziness, weight loss, nerve damage, heart damage, nausea, fatigue, insomnia, visual impairment, mood perturbation, sexual problems, dermatitis, and rarely jaundice. Degradation products of trichloroethylene (particularly phosgene) may cause rapid death due to respiratory collapse.

Carcinogenicity. Trichloroethylene is a probable human carcinogen via both oral and inhalation exposure, based on limited human evidence and sufficient animal evidence.

Environmental Fate: trichloroethylene breaks down in water in the presence or sunlight and bioconcentratesb moderately in aquatic organisms. The main removal of trichloroethylene from water is via rapid evaporation. Trichloroethylene does not photodegrade in the atmosphere, though it breaks down quickly under smog conditions, forming other pollutants such as phosgene, dichloroacetyl chloride, and formly chloride. In addition, trichloroethylene vapors may be decomposed to toxic levels of phosgene in the presence of an intense heat source such as open arc welder.

When spilled on the land, trichloroethylene rapidly volatilizes from surface soils. The remaining chemical leaches through the soil to groundwater.

Xylene (Mixed Isomers)

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

Carcinogenicity currently no evidence

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

3.3 Other pollutants and their impacts

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

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

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

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

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

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

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

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

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

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

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

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

4. Egyptian Laws and Regulations

There are a number of laws and regulations that address the different environmental violations. The following are the laws applicable to the fabricated metal products industry [9].

4.1 Concerning Air Emissions

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

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

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

- The use of mazot oil and other heavy oil products, as well crude oil shall be prohibited in dwelling zones.
- The sulfur percentage in fuel used in urban zones and near the dwelling zones shall not exceed 1.5%.
- The design of the burner and fire-house shall allow for complete mixing of fuel with the required amount of air, and for the uniform temperature distribution that ensure complete combustion and minimize gas emissions caused by incomplete combustion
- Gases containing carbon dioxide shall be emitted through chimneys rising sufficiently high in order that these gases become lighter before reaching the ground surface, or using fuel that contains high

proportions of sulfur in power generating stations, as well as in industry and other regions lying away from inhabited urban areas, providing that atmospheric factors and adequate distances to prevent these gases from reaching the dwelling and agricultural zones and regions, as well as the water courses shall be observed.

- Chimneys, from which a total emission of wastes reaches 7000 – 15000 kg/hr, shall have heights ranging between 18 – 36 meters.
- Chimneys from which a total emission of gaseous wastes reaches more than 15000 kg/hour, shall have heights exceeding at least two and a half times the height of surrounding buildings, including the building served by the chimney.

The permissible limits of emissions from sources of fuel combustion are given in tables (5 and 6).

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

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

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

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

4.2 Concerning Effluents

Limits for pollutants in wastewater vary depending on the type of receiving water body. The parameters that should be monitored and/or inspected are BOD, COD, pH, temperature, residual chlorine, TSS, TDS, Oil and Grease and heavy metals.

Table (7) presents the permissible limits for discharges to the different recipients (sea, Nile, canals, agricultural drains, public sewer) according to the different relevant laws.
Spent lube oil has a negative impact on water and soil and therefore its disposal should be monitored/inspected. A record should be kept for this purpose.

Table (7) Egyptian Environmental Legal Requirements for Industrial Wastewater

Parameter (mg/1 unless otherwise noted)	Law 4/94: Discharge Coastal Environment	Law 93/62 Discharge to Sewer System (as modified by Decree 44/2000)	Law 48/82: Discharge into :			
			Underground Reservoir & Nile Branches/Canals	Nile (Main Stream)	Drains	
					Municipal	Industrial
BOD (5day,20 deg.)	60	<600	20	30		
COD	100	<1100	30	40	60	60
pH	6-9	6-9.5	6-9	6-9	80	100
Oil & Grease	15	<100	5	5	6-9	6-9
Temperature (deg.)	10C>avg. temp of receiving body	<43	35	35	10	10
Total Suspended Solids	60	<800	30	30	35	35
Settable Solids	—	<10	—	20	50	50
Total Dissolved Solids	2000	—	800	1200	—	—
Chlorine	—	<10	1	1	—	—
PO_4	5	30	1	1	—	10
Total phosphorus		25				
Fluoride	1	<1	0.5	0.5	—	0.5
Cadmium	0.05	0.2	0.01	0.01	—	—

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

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
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	—	—
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

As interesting non-binding information, let us consider the two recommendations PARCOM 92/4 [10] and HELCOM 16/6 [11] concerning wastewater discharges from the metal surface industry in the Baltic sea area presented in Table (8).

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

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

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

4.3 Concerning Solid Wastes

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

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

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

4.4 Concerning Work Environment

Violations of work environment could be encountered:

- In the boiler house: gas emissions, regulated by article 43 of Law 4/1994, article 45 of the executive regulations and annex 8. The limits for the relevant pollutants are presented in Table (9).
- According to the Annex (8) of the law 4/1994, the maximum limits of some air pollutants of concern for the fabricated metal products industry, inside the work place, are gathered in the Table (10).
- Wherever heating is performed: temperature and humidity are regulated by article 44 of Law 4/1994, article 46 of the executive regulations and annex 9.
- Near heavy machinery: noise is regulated by article 42 of Law 4/1994, article 44 of the executive regulations and table 1, and annex (7).
- Ventilation is regulated by article 45 of Law 4/1994 and article 47 of the executive regulations.
- Smoking is regulated by article 46 of Law 4/1994 and article 48 of the executive regulations, and Law 52/1981.
- Work environment conditions are addressed in Law 137/1981 for Labor, Minister of Housing Decree 380/1983, Minister of Industry Decree 380/1982

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

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

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

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

4.5 Concerning Hazardous Materials and Wastes

Law 4/1994 introduced the control of hazardous materials and wastes. The dairy industry does not generate any hazardous 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 There is no explicit articles in Law 4/1994 or in decree 338/1995 (executive regulations), regarding holding a register for the hazardous materials; article 33 is concerned with hazardous wastes. However, keeping the register for the hazardous materials is implicit in article 25 of the executive regulations regarding the application for a license.

4.6 Environmental Register

Article 22 of law 4/1994, states that the owner of the establishment shall keep a register showing the impact of the establishment activity on the environment. Article 17 and Annex 3 of the executive regulations specify the type of data recorded in the register.
The emergency response plan and the hazardous materials register will also be part of the environmental register as stated in part 4.5.

5. Pollution Abatement Measures

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

5.1 General Concepts

Three types of interventions will be considered:

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

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

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

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

- Production planning and sequencing
- Process or equipment modification

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

Each of these categories is discussed briefly below [6].

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

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

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

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

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

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

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

5.2 Pollution Prevention Options

Some of the most important techniques that may be useful to companies specializing in metal fabrication and finishing operations are presented below. These are options available to facilities, but are not to be considered as requirements. Metal shaping, surface preparation, plating, and other finishing operations besides auxiliary services such as power generation plants organize the information.

It should be stressed here that, what is given in the following, are examples of real applications of cleaner production in the fabricated metal products industry and not applications that are in the R & D stage. Through the Internet, interested enterprises can easily obtain from [6], the addresses of societies which have already implemented successfully the suggested modifications.

5.2.1 Metal shaping Operations

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

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

5.2.2 Surface Preparation Operations

a) Solvent Cleaning

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

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

Process or equipment modifications

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

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

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

Raw material substitution

Option 1 - Use less hazardous degreasing agents such as petroleum solvents or alkali washes. For example, replace halogenated solvents (e.g., trichloroethylene) with liquid alkali cleaning compounds. (Note that compatibility of aqueous cleaners with wastewater treatment systems should be ensured.)
Option 2 – Prefer water-based surface cleaning agents where feasible, instead of organic cleaning agents, some of which are considered toxic [12]. Try to optimize bath operation to enhance efficiency, e.g. by agitation.
Option 3 - Substitute chromic acid cleaner with non-fuming cleaners such as sulfuric acid and hydrogen peroxide.
Throughput Information: rinse water flow rate of 2 gallons per minute.
Option 4 - Substitute less polluting cleaners such as tri-sodium phosphate or ammonia for cyanide cleaners.

Recycling

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

which allow the reuse of solvents [12].

Option 3 - When on-site recycling is not possible, agreements can be made with supply companies to remove old solvents.

Option 4 - Arrange a cooperative agreement with other small companies to centrally recycle solvent.

Option 5 – Manage properly the residue from solvent recovery (e.g. blending with fuel and burning in a combustion unit with proper controls for toxic metals).

Option 6 – Clean degreasing solutions to extend lifespan (by skimming, centrifuge, etc.) and recirculation, reutilization of oily sludge.

b) Chemical Treatment

Process or equipment modification

Option 1- Increase the number of rinses after each process bath and keep the rinsing counter-current in order to reduce drag-out losses.

Option 2 - Recover unmixed acids in the wastewater by evaporation.

Option 3 - Reduce rinse contamination via drag-out by:

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

Option 4 - Instead of pickling brass parts in nitric acid, place them in a vibrating apparatus with abrasive glass marbles or steel balls. A slightly acidic additive is used with the glass marbles, and a slightly basic additive is used with the steel balls

Option 5 - Use mechanical scraping instead of acid solution to remove oxides of titanium.

Option 6 - For cleaning nickel and titanium alloy, replace alkaline etching bath with a mechanical abrasive system that uses a silk and carbide pad and pressure to clean or “brighten” the metal.

Option 7 - Clean copper sheeting mechanically with a rotating brush machine that scrubs with pumice, instead of cleaning with ammonium persulfate, phosphoric acid, or sulfuric acid which may generate non-hazardous waste sludge.

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

Raw material substitution

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

Recycling

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

5.2.3 Surface Finishing Operations

a) Plating

Training and supervision

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

Production planning and sequencing

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

Process or equipment modification	*Option 1* - Modify rinsing methods to control drag-out by: • Increasing bath temperature • Decreasing withdrawal rate of parts from plating bath • Increasing drip time over solution tanks; racking parts to avoid cupping solution within part cavities • Shaking, vibrating, or passing the parts through an air knife, angling drain boards between tanks • Using wetting agents to decrease surface tension in tank. *Option 2* - Utilize water conservation methods including: • Flow restrictors on flowing rinses • Counter current and cascade rinsing systems • Reactive rinsing • Conductivity controllers • Flow control valves. *Option 3* Reduce the drag out [12]: • Minimize drag-out through effective draining of bath solutions from the plated part, e.g. by making drain holes in bucket-type pieces, if necessary. • Use drip bars, and/or drain boards between tanks. • Increase parts drainage time to reduce drag-out, e.g. by allowing dripping time of at least 10-20 seconds before rinsing. • Use fog spraying of parts while dripping. • Maintain the density, viscosity and temperature of the baths to minimize drag-out. • Place recovery tanks before the rinse tanks (also yielding makeup for the process tanks). The recovery tank provides for static rinsing with high drag-out efficiency. • Install ion exchange system, or reverse osmosis system or electrolytic metal recovery, or electrodialysis to reduce generation of drag-out. • Reuse drag-out waste back into process tank. *Option 4* – Rationalize the management of process baths [12]. • Recycle process baths after concentration and filtration. Spent bath solutions should be sent for recovery and regeneration of plating chemicals, not discharge into wastewater treatment units. • Regenerate plating bath by activated carbon filtration to remove built up organic contaminants. • Regularly analyses and regenerate process solutions to maximize useful life. • Clean racks between baths to minimize contamination. *Option 5* - Install pH controller to reduce the alkaline and acid concentrations in tanks. *Option 6* - Improve control of water level in rinse tanks, improve sludge separation, and enhance recycling of supernatant (floating on the surface) to the process by aerating the sludge.

Raw material substitution

Option 1 - Substitute cyanide plating solutions with alkaline zinc, acid zinc, acid sulfate copper, pyrophosphate copper, alkaline copper, copper fluoborate, electroless nickel, ammonium silver, halide silver, methanesulfonate-potassium iodide silver, amino or thio complex silver, cadmium chloride, cadmium sulfate, cadmium fluoborate, cadmium perchlorate, gold sulfite, and cobalt harden gold

Option 2 - Substitute sodium bisulfite and sulfuric acid for ferrous sulfate in order to oxidize chromic acid wastes, and substitute gaseous chlorine for liquid chlorine in order to reduce cyanide reduction.

Option 3 - Replace hexavalent chromium with trivalent chromium plating systems.

Option 4 - Replace conventional chelating agents such as tartarates, phosphates, and ammonia with sodium sulfides and iron sulfates in removing metal from rinse water, which reduces the amount of waste generated from precipitation of metals from aqueous waste streams.

Option 5 - Replace methylene chloride, 1,1,1-trichloroethane, and perchloroethylene (solvent-based photochemical coatings) with aqueous base coating of 1 percent sodium carbonate

Option 6 - Replace methanol with nonflammable alkaline cleaners.

Option 7 - Substitute non-cyanide for a sodium cyanide solution used in copper plating baths.

Waste segregation and separation

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

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

Recycling

Option 1 Reuse rinse water.

Option 2- Reuse drag-out waste back into process tank.

Option 3- Recover process chemicals with fog rinsing parts over plating bath

Option 4- Evaporate and concentrate rinse baths for recycling.

Option 5- Convert sludge to smelter feed

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

b) Painting Operations

Training and supervision

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

Production planning and sequencing

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

Process or equipment modification

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

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

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

Raw material substitution

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

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

- Water based coatings, waste savings/reduction: 87 percent drop in solvent emissions and decreased hazardous waste production
- Powder coatings

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

b) Paint Clean-Up

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

Recycling

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

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

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

5.2.4 Auxiliary Equipment

a) Fuel Combustion Equipment

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

Flue gases

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

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

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

b) Wastewater Treatment Plant

End-of-pipe treatment

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

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

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

c) Water Conservation Measures

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

5.3 Possible Pollution Prevention Future Plans

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

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

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

6. Industrial Inspection

The inspection of the fabricated metal products industry will follow the procedures described in the General Inspection Manual, GIM (EPAP, 2002). This chapter presents a summary of the inspection process regarding the purpose and scope of various types of inspection, and the proposed inspection procedure for the Fabricated Metal Products Industry.

The overall purpose of inspections is to enforce environmental laws. Table (11) lists the various types of inspections and the objectives that have to be fulfilled for each type.

Table (11) The Different Types of Inspections and their Objectives

Inspection type	Objectives
Site Inspection	
1. Comprehensive	Evaluate compliance status regarding all aspects of Law 4
2. Specific	Evaluate compliance status regarding some aspects of Law 4 (usually complaint driven) Review special conditions set by EEAA in EIA studies. Investigate complaints
3. Follow-up	Check environmental register and implementation of compliance measures
Inspection campaign	
1. Geographic	Check pollution sources to specific receiving media Check pollution sources from facilities in a specific area
2. Sector specific	Check aspects relevant to specific sector

As evident from the above table, comprehensive inspection deals with all aspects of environmental laws and therefore is considered in this manual. Other inspection types can be tailored accordingly.

Developing an inspection strategy and quarterly and/or monthly plans are the responsibility of the inspectorate management. Developing site-specific inspection plans for carrying out the scope of work that fulfills inspection objectives is the responsibility of the inspection team. Planning for inspections is presented in more detail in the General Inspection Manual, GIM (EPAP-2002).

7. Inspection Planning at the Inspectorate Level

The responsibilities of the inspectorate management regarding the specific inspection are to state clearly, in writing, the type of inspection and related objectives as well as the time schedule necessary to carry out inspection. The inspectorate management is also responsible for providing preliminary information about the facility, inspection tools, and logistics.

7.1 Activities Characteristic to the Fabricated Metal Products Industry

Taking the comprehensive inspection as an example, the objectives stated in Table (11) dictate the activities required for covering all aspects of compliance with environmental laws and regulations. The required personnel, equipment and logistics are determined accordingly.

Note to inspectorate management:
Usually small and medium size facilities cannot afford the cost of treatment. Repeated inspections and fines would not solve the problem. Inspectorate management should have a clear plan on how to proceed with these facilities.

7.2 Providing Information About the Facility

Chapters (2-5) present the technical aspects regarding the industry, its pollution sources and relevant environmental laws. Information regarding compliance history related to other inspecting parties (irrigation inspectors, occupational health inspectors, etc.) can be helpful in anticipating potential violations and preparing necessary equipment. Compliance action plans, Environmental Impact Assessment (EIA) studies and IPIS data bases are also important sources of information.

Other sources of information can be found on the Internet at the following sites:
http://www.eippcb.jrc.es/pages/FActivities.htm;
http://www.epa.gov/oeca/sector;

7.3 Providing Resources

The required personnel, tools and equipment depend on the size of the facility to be inspected. The inspection team leaders, in coordination with the inspectorate management, are responsible for assessing the inspection needs. The number of inspectors required depends on the size of the facility and the planned activities. Usually the team members are split and assigned different tasks during the field visit to allow the required activities to be performed in parallel. Each task is rotated among the inspectors to diversify their experience.

Small facilities

Small fabricated-metal facilities will probably be workshops producing few items with the same type of metal and using the same operation. Such as the production of cast iron items. Painting of metal parts can also be performed in small facilities. Auto body parts are surface-finished and painted in small facilities. Most of the service units described in section (2.3.) will not be present.

Due to the large number of these small facilities, it is recommended to plan inspection campaigns in specific geographic areas and for a specific operation, such as painting of car body parts. The major pollution problem will be identified beforehand and the process well defined to the inspectors. This will probably make better use of human and financial resources. Each production operation will generate the associated pollutants presented in section 2. The inspectors will determine the type of receiving body and its related pollutant limits as set by environmental laws and regulations, check the pollutants concentrations, review the licenses, establish the violation if any, and prepare the legal report.

Medium size facilities

These facilities could have a number of production operations or specialize in one or two products with medium production capacity. Inspection of these facilities will be similar to inspection of large facilities using a smaller inspection team depending on the number of production operations and service units.

Large facilities

Large facilities will typically have many production operations with large production capacity. But a large fabricated metal facility can also produce one item through one process. A large facility in Cairo is producing iron pipes for iron sheets by cutting, bending and welding. These pipes are sold to plants fabricating metallic furniture, or assembling metallic products (air conditioners, refrigerators, ..). The number of affected media depends on the type of process. Some processes do not generate wastewater as shown in chapter 2.

Planning for the comprehensive multi-media inspection will require several inspectors, sampling equipment to provide proper samples for analysis as well as measuring devices. A lab technician will also be needed. The inspectorate management will provide the inspection checklist presented in Annex 1 but they should be tailored to the inspected facility.

8. Preparation for Field Inspection (Inspection Team)

As presented in the General Inspection manual, GIM (EPAP-2002), tasks necessary for preparation for field inspection, are:

- Gathering information about the specific facility to be inspected
- Preparing of the inspection plan
- Preparing the checklists and other inspection tools.

This manual presents the case of a comprehensive multimedia site-inspection of a large dairy facility since it represents the highest level of inspection complexity. Tasks for carrying out less complicated inspections can be easily deduced.

8.1 Gathering and Reviewing Information

The inspection team should review the general information prepared for the fabricated metal products industry (chapters 2-5) and then check - if possible - what production operations and service units are present at the targeted facility. In addition to the required information listed in Annex (C) of the General Inspection Manual, GIM (EPAP-2002), it is important at this stage to determine the following:

- The type of receiving body for the industrial wastewater and review relevant Egyptian laws (Chapter 4).
- The scope of inspection and related activities based on the type and objectives of inspection required by the inspectorate management.
- The potential pollution hazard, as addressed in section 2.4, and accordingly, defines measurement and analyses needs.
- The characteristics of the dairy industry as presented in section 2.5, and their implications on the inspection process of the targeted facility.

8.2 Preparation of the Inspection Plan

An example of an inspection plan is included in Annex (E) of the General Inspection Manual, GIM (EPAP-2002). The plan should take into account the following:

- For large dairy facilities, the inspection team could be divided into smaller groups. Each group will be responsible for inspecting a number of production lines and service units.
- At the beginning of the field visit, the inspection team should check the environmental register for completeness using the checklist provided in Annex (G) of the General Inspection Manual, GIM (EPAP-2002).
- At the end of the field visit, the information included in the environmental register should be checked based on the field visit observations. If not confident with measurements and analyses results, the inspector should make his own.

Notes to inspector:

- *When the final effluent is expected to be in violation of environmental laws, sampling should be planned.*
- *Because of possible shock loads a grab sample at the time of discharge should be performed. If grab samples are taken when no shock load is discharged the results will not reflect the actual pollutants loads.*
- *Make sure that the polluting production lines are in operation since some factory management resort to halting the polluting lines during the inspection.*

8.3 Preparation of the Required Checklists

The checklist for the fabricated metal products industry is presented in Annex (1) of this manual. The checklist has been prepared in such a way that it starts with general information about the facility and its operation. Separate checklists are then filled for each production line/service unit independently for relevant environmental aspects and media. The inspection team will compile the checklists relevant to existing production lines and service units in the targeted facility.

The development of the checklists goes through the following steps:

- Draw the block flow diagrams for the production operations with their pollution sources.
- Identify the areas of possible non-compliance and the parameters that need checking. For example, noise should be checked near machinery's and temperature and light intensity in casting operations.
- Identify what to observe, ask and/or estimate that can convey information about pollutants. For example:
  - The type of working and cutting oil will determine the type of VOC to be checked in air.
  - Oily effluents from production processes or oily cooling water indicates the contamination of the plant effluent with oil,

Note to inspector:
Law 4 does not specify standards for effluent from production lines but only for final disposal points. However, effluent quality from production operations is an important indicator of the final discharge quality.

8.4 Legal Aspects

As evident from chapter 2, a large facility is expected to be in violation of several environmental laws, specifically with respect to workplace air quality if no pollution abatement measures are implemented. The inspection team should be prepared for legally establishing such a violation.

Note to inspector:
Information about the nature and cause of the violation must be well documented and the evidence sound. The case could be contested in court and the inspector will be asked to defend his technical judgment.

9. Performing the Field Inspection

9.1 Starting the Field Visit

The General Inspection Manual, GIM (EPAP-2002) describes the procedures involved for entering an industrial facility. The inspector's attitude and behavior are very important from the start and will dictate the factory's personnel response to the inspection tasks.

> *Note to inspector:*
>
> - *Check the results of effluent analyses, time and place of sampling. If suspicious make your own analyses.*
> - *Get a sketch of the factory layout with sewer lines and final disposal points.*

9.2 Proceeding With the Field Visit

Information gathered during the facility tour is dependent on interviews of facility personnel and visual observation. Annex (H) of the General Inspection Manual, GIM (EPAP-2002) presents some useful interviewing techniques.

Using the facility layout, start by checking the final disposal points and the various plants and/or service units connected to each point. This will determine where and how to take the effluent samples. Visual observations about the condition of the sewer manholes should be recorded. In some facilities the discharge to the receiving body is performed through a bayara (cesspit), septic tanks or holding tanks. If the holding tanks are not properly lined, underground water contamination could occur.

> *Note to inspectors:*
>
> *Cesspits, septic tanks and holding tanks are a form of pre-treatment that generates settled sludge. Check:*
>
> - *The presence of accumulated sludge and related hygienic conditions*
> - *The disposal of the sludge*

Inspection of the production operations should start with the feeding of raw materials and end with the product packaging and storage.

Production operations

Metal Shaping	
Casting	- How is heating performed? If the fuel combustion is the source of heat, check the type of fuel, flue gas composition and chimney specifications. - Check lube oil replacement schedule for machinery. - Check the disposal of spent lube oil. - Notice the presence of oil in spent cooling water effluent. - Record the cooling water flow rate, if available (it is a good indication of effluent quantity). - Measure the temperature and humidity. - If you smell any organic odour, check the presence of VOC emissions during casting, it may be due to coating of the mold? - What happens to solid waste generated during casting? - Check the presence of iron oxides in wastewater stream. - Check noise intensity. - Is cooling water recycled?

Shearing

- What types of metal working fluids are in use (oil-water emulsions or synthetic emulsions)?
- Check the use of acids and alkalis in this stage.
- Notice the scales, metal chips, solvent still bottom wastes and sludge. What is the disposal method of this solid waste
- Is the scrap metal reintroduced into the process as a feedstock or disposed of?
- Measure noise.

Forming Operations

- Are there any solvents applied to metal and machinery that results in air emissions?
- Check the solid wastes such as metals and solvent residues generated during this stage.
- Track the scrap metal and the metal working fluids since they may be regulated as hazardous wastes.
- Check lube oil replacement schedule for machinery.
- Check the disposal of spent lube oil.
- Check for noise.

Machining

- Check lube oil replacement schedule for machinery.
- Check the disposal of spent lube oil.
- What happens to solid wastes produced from drilling, sawing, grinding…etc.?
- Measure TSP (total suspended particles) in air.
- Measure noise; are there any procedures for hearing protection?

Surface Preparation

Degreasing	-	Check for the use of hazardous materials
	-	What is the type of degreasing technique applied (organic solvent-base or water-base)?
	-	If organic solvents are used check whether it is a halogen based solvent. Non-chlorinated solvents are preferred.
	-	If alkaline degreasing is used what is the alkalis used?
	-	If petroleum based (white spirit, thinner, mineral turpentine) is used check for fire protection plan because these materials are flammable
	-	Check the presence of VOC emissions during degreasing.
	-	Is there a ventilation system in place?
	-	Notice the amount of spilled chemicals such as solvents.
	-	Is the solvent- bearing wastes pretreated before disposal?
	-	Record the schedule of discharging degreasing baths.
	-	Check the effluent for oil and grease
	-	Check safety precaution for handling alkalis and hazardous materials
Pickling (acid cleaning)	-	Check for acid fumes in air
	-	Check for hazardous materials
	-	Check the safety precautions in handling acids
	-	Record the schedule of discharging pickling baths.
	-	Is the (acidic) wastewater combined with other metal finishing wastewater?
	-	Check the on-site treatment of aqueous wastes acid cleaning.
	-	What happens to solid wastes produced?
Surface Finishing		
Anodizing	-	List the chemicals used in the process
	-	Are there any mists or gas bubbles emitted from heated fluids?
	-	Is the wastewater treated on- site to recycle the metal? If not check for heavy metals in the wastewater?
	-	What happens to the produced sludge from conventional treatment process? Is it sent for metal reclamation or disposed off-site?
	-	Record the schedule of discharging anodizing baths.

Chemical conversion coating	- Make a list of the type of metal salts, acid or base solution used, so that you can check their presence in the effluent. - What type of chemical conversion coating is applied (chromating, phosphating, metal coloring, passivating) ? - Are there any emissions of metal-ion-bearing mists and acid mists? - Do the pollutants (metal salts, acid and base solutions) associated with these processes enter the waste stream? - What happens to the produced sludge from conventional treatment process? Is it sent for metal reclamation or disposed off-site? - Check the presence of heavy metals in wastewater stream. - Record the schedule of discharging coating baths.
Electroplating	- List the chemicals used in the process - Is cyanide used? If yes, what are the procedures for handling this toxic materials and wastes containing cyanides? - Are there any emissions of metal-ion-bearing mists and acid mists? - Check for fume suppressants to electroplating baths. - What happens to the solid phase sludge produced from chromium wastewater treatment unit? - Record the schedule of discharging electroplating baths.
Electroless plating	- List the chemicals used in the process - What is the metal deposited onto the object. - Check the presence of heavy or toxic metals in wastewater stream. - What is the pretreatment process applied to spent plating solution and rinse water? - Check for dealing with sludge resulting from wastewater pretreatment. - If cyanide is used, check its presence in the effluent and the handling procedures - Record the schedule of discharging electroless plating baths.

Painting	-	List the type of pigment used in paint (organic or inorganic) - Check the presence of VOC emissions during painting? - Check ventilation - If spray painting is used • Is there a water curtain for minimizing air emissions? • Are the workers using protective measures? • Record the amount of contaminated effluent from water curtains - Check the sources of solid and liquid phase wastes from: • Equipment washing and drying, • Excess paints discarded after expiration of the paint shelf life, • Paint application devices. - Estimate the contribution of cleaning solvents, dry powder paint and still bottom wastes to solid and liquid wastes.
Polishing	-	Measure TSP (total suspended particles) in air. - Measure noise intensity.
Galvanizing	-	List the chemicals used in the process - Is the applied technique hot or cold? If hot, check temperature and humidity of the workplace. - Are there any emissions of chloride mist, dust, metal and acid fumes? - What happens to the produced sludge from metal finishing? - Check the presence of heavy or toxic metals in wastewater stream.- - Is the rinse water pretreated before joining the main wastewater stream? - Record the schedule of discharging galvanizing baths
Service Units		
Water treatment units	-	If chemicals and coagulants are used, such as lime, alum and ferric sulfate, inorganic sludge will be generated. Check the amount and method of disposal. - In case of ion-exchange units and reverse osmosis the effluent wastewater will be high in dissolved solids.

Boilers	- Check the height of the chimney in relation to surrounding buildings. - Perform flue gas analysis if mazot is used as fuel or if suspicious about results of analysis presented by facility management in the opening meeting. - Check for fuel storage regulations and spill prevention. - Check noise.
Cooling towers	- The amount of blowdown from the cooling towers is about 10-15% of the make-up water and is low in BOD and high in TDS.
Garage, and Workshops	- Check for noise and take measurements if necessary. - Check solid waste handling and disposal practices. - Check for spent lube oil disposal method. Ask for receipt if resold.
Storage facilities	- Check storage of hazardous materials and fuel as per Law 4. - Check spills prevention and containment measures for storage of liquids.
WWTP	- Check for sludge accumulation and disposal. - Analyze the treated wastewater.
Effluent analysis	
Receiving body	- The nature of the receiving body determines the applicable laws. - Check if effluent discharge is to public sewer, canals and Nile branches, agricultural drains, sea or main River Nile. - Accordingly, define applicable laws, relevant parameters and their limits.
Sampling	- A sample must be taken from each final disposal point. Each sample will be analyzed independently. - According to legal procedures in Egypt, the effluent sample is spilt and one of them is sealed and kept untouched.

9.3 Ending the Field Visit

When violations are detected a legal report is prepared stating information pertaining to sampling location and time. Violations of work environment regulations should also state location and time of measurements. Other visual violations such as solid waste accumulation, hazardous material and waste handling and storage, and material spills should be photographed and documented. The facility management should sign the inspection report, but it is not necessary.

A closing meeting with the facility management can be held to discuss findings and violations.

Note to inspector: • *The less certain the team leader is about a specific violation the more reason not to discuss it at the closing meeting.*

10. Conclusion of the Field Inspection

The activities performed during the site inspection are essential for preparation of the inspection report, for assessing the seriousness of the violations, for pursuing a criminal or civil suit against the facility, for presenting the legal case and making it stand in court without being contested, and for further follow-up of the compliance status of the facility.

10.1 Preparing the Inspection Report

An example of an inspection report is included in Annex (K) of the General Inspection Manual (EPAP, 2002). The inspection report presents the findings, conclusions, recommendations and supporting information in an organized manner. It provides the inspectorate management with the basis for proposing enforcement measures and follow-up activities.

10.2 Supporting the Enforcement Case

Many issues may be raised and disputed in typical enforcement actions. Enforcement officials should always be prepared to:

- Prove that a violation has occurred. The inspector must provide information that can be used as evidence in a court of law.
- Establish that the procedures were fairly followed.
- Demonstrate the environmental and health effect of the violating parameter.

10.3 Following-Up Compliance Status of Violating Facility

After performing the comprehensive inspection and detecting the violations the inspectorate management should:

- Decide on the sanctions and send the legal report to the judicial authority.
- Plan routine follow-up inspections. This type of inspection focuses on the violating source and its related pollution abatement measure. Self-monitoring results are reviewed during the visit.
- Follow-up the enforcement case (legal department)

List of References

List of References

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

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

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

HYPERLINK http://eippcb.jrc.es/pages/FActivities.htm

http://eippcb.jrc.es/pages/FActivities.htm

(Column ”Documents available” and Ferrous metals processes by clicking BREF)

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

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

[6] EPA Office of Compliance Sector Notebook Project, Profile of the Fabricated Metal Products Industry,

HYPERLINK http://www.epa.gov/oeca/sector; US Environmental Protection Agency,1995.

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

[8] Total particulate concentration, ambiant air analysis & noise level at Ghabour plant, Development research and technological planning center, Cairo University, internal report, April 1998.

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

[10] Parcom reco-mmendation 92/4. Paris Commission. On the reduction of emissionsfrom the electroplating industry. Date of adoption: 1992, Paris.

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

[12] Pollution Prevention and Abatement Handbook. World Bank Group. Electroplating. July 1998.

Annex (1)

Inspection Checklist for Fabricated Metals Facility

Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency
Basic Data Sheet

Date of visit:……………………………………. Visit number:………………………….

Facility name:……………………………………

Commercial name:……………………………………………………………………….

Licensed Activity:……………………………….. Days off:………………………

Legal status:…………………………………………………………………………….

Address of facility

Area of facility:………………………………… Governorate:………………………….

City:…………………………………………… Zone:……………………………….

Phone no. :………………………………… Fax no.:……………………………….

……………………………….. ………………………………….

Year of operation :……………………………….. Postal code:……………………………

The Facility Representative:……………………………………………………………..

Environmental management representative:…………………………………………………….

Chairman/Owner:………………………………………………………………………………

Address of Administration
e-mail:……………………………………………..

Phone no. :………………………………… Fax no.:……………………………….

……………………………….. ………………………………….

The industrial sector:……………………………………………………

No. of male employees: …………………… No. of female employees:…………………

Do they work in production …………………………….

Total no. of employees: ………………………….

Number of shifts/day:…………………shifts/day

Duration of shift:……………………….hrs/shift

Environmental register:………………………….. Hazardous waste register:…………….

EIA:…………………………………………….. Self monitoring:……………………….

Nature of Surrounding Environment

Industrial ❑ Coastal ❑ Coastal/ Residential ❑

Industrial/ Residential ❑ Residential ❑ Agricultural ❑

Agricultural/ Industrial ❑ Agricultural/ Residential ❑ Desert ❑

<u>Power Consumption</u>

Electricity ❑ Fuel ❑

Electric power: ……………...kWh/(day-month-year)

Type of fuel	Fuel consumption	
Mazot	……………………….	Ton/(day-month-year)
Solar	……………………….	Ton/(day-month-year)
Natural gas	……………………….	Ton/(day-month-year)
Butagas	……………………….	Ton/(day-month-year)
Other ….	……………………….	Ton/(day-month-year)

The GPS (Global Positioning System) reading for Gaseous Emissions

1- LAT(Latitude):..……. LONG(Longitude):…….
2- LAT(Latitude):……… LONG(Longitude):…….
3- LAT(Latitude):……… LONG(Longitude):…….

Production

Product	Quantity/ (day-month-year)
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………

Water Supply

Artesian well ❑ Municipal water ❑ Treated water ❑ Nile water ❑

Canal water ❑ Other………….. ❑

Water Consumption

Amount of water consumed in operation (day-month-year):

Process ……..m^3/ Boilers…………………..m^3/

Domestic usage………....m^3/ Cooling………………....m^3/

Other…….. …………….m^3 /

Total amount of water consumed (day-month-year)……… …………..m^3/

Type of waste water:
Industrial ❑ Domestic ❑ Mixed ❑

Wastewater Treatment:
Treated ❑ Untreated ❑

Type of Treatment:
Septic tanks ❑ pH adjustment ❑ Biological treatment ❑
Chemical treatment ❑ Tertiary treatment ❑

Amount of treated water/ (day-month-year)……………..m^3 /
Amount of waste water/(day-month-year)……………………….m^3 /

Final wastewater receiving body:
Nile ❑ Lakes (fresh water) ❑ Drain ❑
Groundwater ❑ Public sewer system ❑ Canals❑
Agricultural Land ❑ Desert Land ❑ Other……………………….❑

The Global Positioning System(GPS) reading for final disposal
1-LAT(Latitude):……. LONG(Longitude):…….
2-LAT(Latitude):……. LONG(Longitude):…….

Engineering Drawings for the Facility
Gaseous emissions map Yes ❑ No ❑

Sewer map: Domestic ❑
Industrial ❑
Mixed ❑
Factory Layout ❑
Production process flow diagram ❑

Raw material consumption

No.	Trade name	Scientific name	CAS no.	UN no.	Physical state	Type of container	Amount	Classification	
								Hazardous	Non-Hazardous

Inspection Team Member:

Team member	Position

Date: Inspector signature:

Annex (1- B)

Inspection Checklist for Production Lines and Service Units

Annex (F-2)
Inspection checklists for hazardous materials and wastes for a facility

1. Hazardous materials (to be filled in case the facility uses hazardous materials) (1)

Fill the following table according to the codes below

Hazardous material	Amount	Field of utilization	Storage method(2)	Method of disposal of the containers	Conformity of containers to specifications(3)	Presence of MSDS(4)

(1) To be filled from the list of used raw material and chemicals according to the hazardous material list issued by the Ministry of Industry, checking the presence of a valid license for handling

(2) According to law 4/1994, does the storage area have:
S_1: alarm, precaution and fire fighting system?
S_2: first aid procedures?

(3) Check containers' compliance with law4/1994:
C_1: sealed and don't cause any threats while handling
C_2: unaffected with along storing period
C_3: labeled with hazard and toxicity signs
C_4: labeled in Arabic (production, origin, utilization instruction)
C_5: labeled with its content, the effective substance and its concentration

(4) Material safety data sheet

2. Hazardous wastes (to be filled in case the facility generates hazardous wastes)[(1)]

Fill the following table according to the codes below										
Hazardous waste	Source	Amount generated/ year	Storing method			On-site treatment and disposal			Transportation method	Presence of documents indicating off-site disposal[(6)]
			Method of storage inside the facility	Compliance of containers' specifications and labels with law 4/1994[(2)]	Compliance of storage areas with law 4/1994[(3)]	Treatment[(4)]	Final disposal[(5)]	Compliance of treatment and disposal with law 4/1994		

[(1)] Hazardous wastes can be identified according to law 4/1994 and by using the hazardous wastes list of the Ministerial decree no.65 for 2002 as refrence

Is there a hazardous wastes register? Yes ❑ No ❑

[(2)]Does the facility take into consideration that the storage containers should be:
C_1: with sealed covers to protect the container from rain water and dust and to prevent any wastes leakage during storage and/or transportation
C_2: constructed or lined by impermeable material which doesn't react with the contained material
C_3: of suitable capacity C_4: labeled

[(3] Specification of storage area: determining specified locations for storage of hazardous wastes where safety conditions are set up to prevent the occurrence of any harm to the public or to those persons exposed to the wastes

[(4)] Which of the following methods are used by the facility for the treatment of hazardous wastes?
N_1: biodegradation N_2: incineration N_3: physical or chemical treatment

[(5)] Which of the following methods are used by the facility for the hazardous wastes final disposal?
F_1: land filling in specially engineered landfill F_3: other (specify)……………….

[(6)] Contracts with wastes' contractors and receipts.

Annex (1- C)

Inspection Checklist for
Production Lines and Service Units

Checklist for Metal Shaping Operation (Casting)

1. General- Casting	
1.1 The housekeeping status Floor condition Penetrating odor Piling of solid waste	 -- -- --
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Ambient Air-Casting	
2.1 what is the fuel used in the furnace In case of using Mazout as fuel, is the surrounding are a residential area?	-- Yes ❑ No ❑
2.2 What is the height of the stack	--
***Note**: the height of the stack should be 2.5 the height of surrounding buildings*	
2.3 Are there analysis for the flue gases from the stack Are they recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑
***Note :** If no_Perform your own measurements*	
3. Status of the Working Environment -Casting	
3.1 Check for the ventilation system	--
3.2 What are the protective measures available to the workers?	--- --
3.3 Is there noise produced during charging the furnace	Yes ❑ No ❑
3.4 what is the duration of noise exposure by the workers	--
3.5 Are there any noise measurements? Are they included in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑
3.6 Do you feel heat stress beside the furnace? Are there any measurements? Are they recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑ Yes ❑ No ❑
3.7 Check for the presence of VOC emissions during casting Are there any measurements for these emissions?	-- Yes ❑ No ❑
***Note :** If suspicious, make you own measurements*	
4. Status of Effluents (wastewater)- Casting	
4.1 Record the cooling water flow rate	--
4.2 Check the presence of iron oxides in wastewater streams	--
4.3 Check the presence of oil in spent cooling water effluent	--

Checklist for Surface Preparation Operation (Degreasing)

1. General- Degreasing	
1.1 The housekeeping status Floor condition Leaking steam	 -- --
1.2 Make sure that the operation line is operated	--
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Effluents - Degreasing	
2.1 Record the schedule of discharging the degreasing baths	--
2.2 check the presence of oil and greases in the effluent streams	--
2.3 check the discharging point of the unit	--
3. Status of the Work Environment- Degreasing	
3.1 Check the presence of VOC emissions during degreasing?	--
3.2 check for the presence of efficient ventilation system	--
3.3 Are there personal protective equipment available in the unit?	Yes ❑ No ❑
4. Status of chemicals and hazardous materials-Degreasing	
4.1 What is the amount of spilled chemicals such as solvents	--
4.2 Are the solvent-bearing wastes pre-treated before disposal	Yes ❑ No ❑
4.3 Check for hazardous materials handling and storage are they comlying with the law 4/1994?	-- Yes ❑ No ❑
4.4 What is the type of degreasing technique applied (organic solvent-base or water-base)	--
4.5 If organic solvents are used check whether it is a halogen based solvent. Non – chlorinated solvents are preferred	--
4.6 If alkaline degreasing is used what is the alkalis used	--
4.7 If petroleum base (white spirit, thinner, mineral turpentine) is used check for fire protection plan because these materials are flammable	--
4.8 Check safety precaution for handling alkalis and hazardous materials	--

Checklist for Surface Preparation Operation (Pickling)

1. General- Pickling (acid cleaning)	
1.1The housekeeping status Floor condition Penerating odor	 --- ---
1.2 Make sure that the operation is operated	---
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Effluents- Pickling (acid cleaning)	
2.1 Is the (acidic) wastewater combined with other metal finishing wastewater	---
2.2 Record the schedule of discharging the pickling baths	---
2.3 check the discharging point of the unit	---
3. Status of Work Environment (acid cleaning)	
3.1 check the presence of efficient ventilation system	---
3.2 Are there personal protective equipment available in the unit?	Yes ❑ No ❑
3.3 Check the presence of acid vapors	
3.4 Are there measurments for the acid vapors Are they recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑
4. Status of Solid Waste- Pickling (acid cleaning)	
3.1 What happens to solid waste produced from this operation	--- ---
3.2 Check the presence of the indicative documents	--- ---
5. Status of Chemicals and Hazardous Materials- Pickling (acid cleaning)	
5.1 Enclose a list of the hazardous materials used	---
5.2 check the emergency procedures of the hazardous materials	--- ---

Checklist for Surface Finishing Operation (Anodizing)

1. General- Anodizing	
1.1 The housekeeping status Floor condition Leaking steam Penetrating odor	 -- -- --
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of Work Environment- Anodizing	
2.1 check for the presence of efficient ventilation system	-- --
2.2 Are there personal protective equipment available in the unit?	Yes ❑ No ❑
2.3 Do you notice vapors or gaseous emissions?	Yes ❑ No ❑
2.4 Are there any measurements for these emissions and the heat stress? Are these measurements recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑
3. Status of Effluents- Anodizing	
3.1 Is the wastewater treated on-site to recycle the metal? If not check for heavy metals in the wastewater	Yes ❑ No ❑ --
3.2 Record the schedule of discharging the anodizing baths	-- --
3.3 check the discharging point of the unit	--
4. Status of solid waste -Anodizing	
4.1 What happens to the produced sludge from conventional treatment process? Is it sent for metal reclamation or disposed off-site?	-- -- Yes ❑ No ❑
4.2 Check the presence of the indicative documents	-- --
5. Status of Hazardous Materials -Anodizing	
5.1 Enclose a list of the hazardous materials used	--
5.2 check the handling and storage of hazardous materials in the facility Are they compiling with the conditions of the law 4/1994 5.3 check for the emergency procedures of the hazardous materials	-- -- Yes ❑ No ❑ --- ---

Checklist for Surface Finishing Operation (Chemical Conversion Coating)

1. General- Chemical Conversion Coating	
1.1The housekeeping status Floor condition Penetrating odor	 --- ---
1.2 Check that the unit is in operation	---
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Effluents- Chemical Conversion Coating	
2.1 Make a list of the type of metal, salts, acid or base solution used, so that you can check their presence in the effluent	--- --- ---
2.2 Check for the presence of heavy metals in wastewater streams	---
2.3 Record the schedule of discharging the coating baths	---
2.4 check the discharging point of the unit	---
3. Status of Work Environment- Chemical Conversion Coating	
3.1 check for the presence of efficient ventilation system	--- ---
3.2 Are there personal protective equipment available in the unit?	Yes ❑ No ❑
3.3 Do you notice any vapors or gaseous emissions?	Yes ❑ No ❑
3.4 Are there any measurements for these emissions and the heat stress? Are these measurements recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑
4.Status of Solid Waste- Chemical Conversion Coating	
4.1 What happens to the produced sludge from conventional treatment process? Is it sent for metal reclamation or disposed off-site?	--- --- ---
4.2 Check the presence of the indicative documents	--- ---
5. Status of the Hazardous Materials - Chemical Conversion Coating	
5.1 What type of chemical conversion coating is applied (Chromating, phosphating, metal coloring and passivation)	---
5.2 List the chemicals used in the process	---
5.2 check the handling and storage of hazardous materials in the facility Are they compiling with the conditions of the law 4/1994	--- --- Yes ❑ No ❑
5.3 check for the emergency procedures of the hazardous materials	--- ---

Checklist for Surface Finishing Operation (Electroplating)

1. General- Electroplating	
1.1The housekeeping status Floor condition	--
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Effluent- Electroplating	
2.1 Record the schedule of discharging the electroplating baths	--
2.2 check the discharging point of the unit	--
3. Status of Work Environment- Electroplating	
3.1 check for the presence of efficient ventilation system	-- --
3.2 Are there personal protective equipment available in the unit?	Yes ❑ No ❑
3.3 Are there any emissions of metal-ion bearing mists and acid mists?	--
3.4 Check for fume suppressants to electroplating baths	--
3.4 Are there any measurements for gaseous emissions in the work environment? Are these measurements recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑
4. Status of Solid Waste- Electroplating	
4.1 What happens to the sludge produced from wastewater treatment unit ?	--
4.2 Check the presence of the indicative documents	-- --
5. Status of Hazardous Materials- Electroplating	
5.1 List the chemicals used in the process	--
5.2 Is cyanide used? If yes what are the procedures for handling the toxic materials and wastes that contain cyanide	Yes ❑ No ❑ -- --
5.2 check the handling and storage procedures of hazardous materials in the facility Are they compiling with the conditions of the law 4/1994	-- -- Yes ❑ No ❑

Checklist for Surface Finishing Operation (Electroless Plating)

1. General- Electroless Plating	
1.1The housekeeping status Floor condition	--
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
1.4 What is the metal deposited onto the object?	--
2. Status of Work Environment- Electroless Plating	
3.1 check for the presence of efficient ventilation system	-- --
3.2 Are there personal protective equipment available in the unit?	Yes ❑ No ❑
3.3 Do you notice any emissions from plating bath? Are there any measurements for gaseous emissions in the work environment? Are these measurements recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑ Yes ❑ No ❑
3. Status of Effluents - Electroless Plating	
3.1 What is the pretreatment process applied for the spent plating solutions and rinse water?	-- --
3.2 Record the schedule for floor washing	
3.3 Record the schedule of discharging the plating baths	--
3.4 check the discharging point of the unit	--
4. Status of Solid Wastes - Electroless Plating	
4.1 Check the methods of disposal of sludge generated from wastewater treatment	-- --
4.2 Check the presence of the indicative documents	-- --
5. Status of Hazardous Waste- Electroless Plating	
5.1 List the chemicals used in the process	--
5.2 If cyanide is used check its presence in effluent and handling procedures	-- --
5.3Check the presence of heavy or toxic metals in wastewater streams	-- --
5.4 check for the emergency procedures of the hazardous materials	-- --
5.5 Check the handling and storage procedures of hazardous materials in the facility	-- --
Are they compiling with the conditions of the law 4/1994	Yes ❑ No ❑

Checklist for Surface Finishing Operation (Painting)

1. General- Painting	
1.1The housekeeping status Floor condition	 --
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
1.2 List the type of pigments used in paints (organic or inorganic)	--
2. Status of Work Environment - Painting	
2.1 Check the presence of VOC emissions during painting?	--
2.2 check for the presence of efficient ventilation system	-- --
2.3 If spray painting is used. Are the workers using personal protective equipment ?	Yes ❑ No ❑
3. Status of Effluents-Painting	
3.1 If spray painting is used. Is there a water curtain	Yes ❑ No ❑
3.2 Record the amount of contaminated effluent from water curtains	-- --
3.3 check the discharging point of the unit	--
3.4 what is the disposal method of the spent solvents	-- --
4. Status of Solid Waste- Painting	
4.1 what are the disposal methods of: - Expired paints - Empty containers - Paints bearing solid wastes	 -- -- --
4.2 Check the presence of the indicative documents	-- --

Checklist for Surface Finishing Operation (Polishing)

1. General- Polishing	
1.1The housekeeping status Floor condition	--
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of Work Environment - Polishing	
2.1 Are there measurement for TSP and noise Are they recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑
***Note** :If no Perform your own measurment* *If Yes: Check the exposure time for noise*	
2.2 check for the presence of efficient ventilation system	--- --
2.3 Are the workers using personal protective equipment?	Yes ❑ No ❑
3. Status of Effluents-Painting	
3.1 Record the schedule of washing the floor?	--- ---
3.2 check the discharging point of the unit	--
3.3 Check the presence of grid to screen the metal generated from the polishing	-- ---

Checklist for Surface Finishing Operation (Galvanizing)

1. General- Galvanizing	
1.1The housekeeping status Floor condition	 --
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Effluents- Galvanizing	
2.1 Check the presence of heavy or toxic metals in wastewater streams (by analysis)	--
2.2 Is the rinse water pretreated before joining the main wastewater streams	--
2.3 Record the schedule of discharging the galvanizing baths	--
2.4 check the discharging point of the unit	--
3 Status of Work Environment- Galvanizing	
3.1 Check for temperature and humidity	--
3.2 Are there any emissions of chloride mist, dust, metal and acid fumes Are there any measurements for gaseous emissions in the work environment? Are these measurements recorded in the environmental register?	Yes ❑ No ❑ Yes ❑ No ❑ Yes ❑ No ❑
3.3 Check for the presence of efficient ventilation system	--- --
3.4 Are the workers using personal protective equipment ?	Yes ❑ No ❑
4. Status of Solid Waste- Galvanizing	
4.1 What happens to the produced sludge from metal finishing ?	--
4.2 Check the presence of the indicative documents	-- ---
5. Status of Hazardous Materials- Galvanizing	
5.1 List the chemicals used in the process	--
5.4 check for the emergency procedures of the hazardous materials	-- ---
5.5 Check the handling and storage procedures of hazardous materials in the facility Are they compiling with the conditions of the law 4/1994	--- --- Yes ❑ No ❑

5. Status of solid waste-Casting	
5.1 What happens to the sludge generated from casting operation?	--- --- ---
5.2 What is the method of disposal of solid wastes generated from the scrap sorting?	--- --- ---
5.3 Check the presence of the indicative documents	--- --

Checklist for Metal Shaping Operation (Shearing)

1. General- Shearing	
1.1The housekeeping status Floor condition Piling of solid wastes	 -- --
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Work Environment-Shearing	
2.1 Check for the ventilation system	--
2.2 What are the protective measures available to the workers?	-- --
2.3 Does the facility have noise produced from this operation If Yes Check the exposure duration Is it recorded in the environmental register	Yes ❑ No ❑ --- Yes ❑ No ❑
***Note**: If suspicious perform your own measurements*	
3. Status of Effluents (waste water)- Shearing	
3.1 what are the type of operating fluids(oil emulsions, water, synthesis emulsions or oil derivatives) 3.2 check for the disposal methods for the used operating fluids 3.3 Check the presence of the indicative documents	--- --- -- -- --- --
4. Status of Solid Waste- Shearing	
4.1 What is the disposal method for these solid waste (the scales, metal chips, solvent still bottom wastes and sludge)	-- -- --
4.2 Is there scrap metal reintroduced into the process as a feed stock or disposed of	--
4.3 Check the presence of the indicative documents	--

Checklist for Metal Shaping Operation (Forming)

1. General- Forming	
1.1The housekeeping status Floor condition Piling of solid waste	 --- ---
1.2 Check that the unit is in operation	---
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Work Environment-Forming	
2.1 Check for the ventilation system	---
2.2 Are there personal protective equipment available in the unit?	Yes ❑ No ❑
2.3 Does the facility have TSP (total suspended particles) measurements	Yes ❑ No ❑
***Note**: If suspicious perform your own measurements*	
2.4 Does the facility have noise produced from this operation If Yes Check the exposure duration Is it included in the environmental register	 Yes ❑ No ❑ -- Yes ❑ No ❑
***Note**: If suspicious perform your own measurements*	
3. Status of Effluents (waste water)- Forming	
3.1 check the disposal methods for the spent operating fluids	--- ---
3.2 Check the presence of the indicative documents	--- --
4. Status of Solid waste – Forming	
4.1 What happens to solid waste (metals and solvent residues) generated from this operation	---
4.2 Check the presence of the indicative documents	--- --
5. Status of Hazardous waste- Forming	
5.1 What happens to scrap metal and metal working fluids?	---
***Note**: enclose a list of the chemicals used to determine the hazardous materials*	
5.2 check the handling and storage of hazardous materials in the facility	-- --
5.3 Are they compiling with the conditions of the law 4/1994	Yes ❑ No ❑
5.4 check for the emergency procedures of the hazardous materials	-- ---

Checklist for Metal Shaping Operation (Machining)

1. General- Machining	
1.1The housekeeping status Floor condition Piling of solid waste	 -- --
1.2 Check that the unit is in operation	--
1.3 Type of operation	Batch ❑ Continuous ❑
2. Status of the Work Environment-Machining	
2.1 Does the facility have TSP (total suspended particles) measurements	Yes ❑ No ❑
Note*: If not perform your own measurements*	
2.2 Measure noise and check the exposure time	--
2.3 Does the facility have noise produced from this operation If Yes Check the exposure duration Is it included in the environmental register	Yes ❑ No ❑ -- Yes ❑ No ❑
3. Status of Effluents (waste water)- Machining	
3.1 check for the disposal methods for the spent oils	-- --
3.2 Check the presence of the indicative documents	-- --
4. Status of Solid Waste- Machining	
4.1 What happens to solid waste generated from drilling, sawing, grinding, …..etc	-- --
4.2 Check the presence of the indicative documents	-- --

Check list for Laboratories

1. General	
1.1 What is the amount of wastewater generated per day?	---
1.2 List the chemicals and materials used in the laboratories	--- --- ---
2. Status of the Work Environment	
2.1 Are there any odor/ gases/ noise in the work environment? 2.2 Check the exposure time	☐ Yes ☐ No ---
3. Handling of Hazardous Material	
3.1 Inspect storage of hazardous material. Is it in compliance with the requirements of law 4?	☐ Yes ☐ No
3.2 Are there any first aid measures in place?	☐ Yes ☐ No

Checklist for Wastewater Treatment

1. General	
1.1 What is the capacity of WWTP	--
1.2 Specify the units included in WWTP :	
Pumping station	☐ Found ☐ Not found
Equalization tank	☐ Found ☐ Not found
Aeration tank (ditch or channel)	☐ Found ☐ Not found
Final sedimentation tank	☐ Found ☐ Not found
Sludge thickening tank	☐ Found ☐ Not found
Sludge drying	☐ Found ☐ Not found
Others	--
1.3 List any chemical and their quantity used for wastewater treatment	-- -- -- -- --
2. Status of Effluent	
2.1 Are there analyses for the effluent If not Make your own	☐ Yes ☐ No
2.2 Are the results of the analysis included in the environmental register	☐ Yes ☐ No
3. Status of Solid Waste	
3.1 Determine the sludge disposal method *Note : It can be use in liquid or dry form, in agriculture*	--
3.2 If a third party is involved in disposal, get documents for proof	☐ Found ☐ Not found Comment -- -- --

Checklist for Garage

1. General	
1.2 Is there any detergent or solvent used for washing equipment parts, trucks, floor,….etc	☐ Yes ☐ No
1.3 What is the amount of oil and grease used per day?	---
1.4 What is the amount of spent lube oil generated per day?	---
1.5 How does the facility dispose of the spent oil?	---
2. Status of the Effluent	
2.1 What is the amount of wastewater generated?	---
2.2 Do you observe any oil / foams / solid matter in the inspection manhole?	☐ Yes ☐ No

Checklist for Workshops

1. Status for the Effluent	
1.1 What is the amount of wastewater generated?	---
1.2 What is your visual observation for the inspection manhole of the workshop?	---
2. Status of Solid Waste	
2.1 What is the amount of solid waste generated and its type?	---
2.2 How does the facility get rid of the solid waste generated?	---
3. Status of the Work Environment	
3.1 Are there any noise in work place	☐ Yes ☐ No
If yes	
3.2 Are there any measurements for noise	☐ Yes ☐ No
3.3 Check the exposure time	---
If not Perform measurements	