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Natural Resources, Science and Technology Division

Mission Report
to
The Kingdom of Saudi Arabia

ENVIRONMENTAL MANAGEMENT IN THE INDUSTRIAL CITIES OF SAUDI ARABIA

(Phase I : Riyadh Industrial Cities 12-23 December 1992)
(Phase II: Jeddah and Dammam Industrial Cities 10-20 April 1993)

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The views expressed in this report are those of the author and do not necessarily reflect those of the United Nations Economic and Social Commission for Western Asia.

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EXECUTIVE SUMMARY

In response to a request from the Government of the Kingdom of Saudi Arabia (Ministry of Industry and Electricity) a mission was undertaken during 12 - 23 December 1992, and 10-20 April 1993 to **assess environmental management in the Saudi Industrial Cities SICs and to examine alternatives for waste minimization, material reclamation and handling of hazardous wastes in selected pollution-generating industries.**

The following industrial sectors have been examined during the mission **(a) Dairy; (b) Paint formulation; (c) Printing; (d) Metal finishing; (e) Leather tanning; (f) Fabricated metals; (g) Bus assembly; (h) Water proofing materials; (i) Plastics; (j) Industrial gases; (k) Foundries; (l) edible oil; (m) Yeast; (n) Match; (o) Carpets, (p) Surfactants, and miscellaneous chemical industries** .

While production plants in SICs employ measures for pollution control with various degrees of effectiveness, there are **viable opportunities for waste minimization and pollution prevention through application of simple and cost-effective cleaner technology in most of these plants.** The proposed technology modifications have been based on a balanced equilibrium between the needs of environmental protection and the impact on production costs.

SICs comprise industries for conversion of primary materials into secondary products. The main hazardous wastes arisings are spent lubricating wastes, and hide cuttings contaminated with chromium. Liquid wastes are discharged without pretreatment in most instances, either to the municipal sewerage system or to a centralized treatment plants.

The practice of recycling the treated water for landscaping and downgraded process uses should be extended to all industrial facilities whenever feasible. **Upgrading operational and monitoring practices of the centralized wastewater treatment plants may enable** appreciable water quality **improvement** and hence **expand water reuse in industrial processes; recommendations in this regard are presented in the report.**

Focusing on the issue of environmental management in SICs, the report emphasized the need to internalize the cost of pollution-externalities; **a range of economic measures are proposed to ensure compliance with environmental regulations.**

Proceeding to the issue of training the report highlighted the need for the use of practical techniques to reach the SICs managers, and workers through show-how tours and group discussions. The report then discussed the importance of **establishing an environment information system to enable exchange of information on material exchange, pollution prevention technology, regulations and other relevant subjects.**

To enable execution of a reactive strategy for environmental management in SICs, the report proposed establishing an environment unit within the administrative structure of The Industrial Cities Department of The Ministry of Industry and Electricity ICD/MIE. The units mandate is to monitor and control environmental quality in SICs within the context of an integrated industrial environmental management scheme. Details of the scheme are presented in Annex I.

In the final part of the report, options for waste minimization in the individual industrial sectors have been presented with special reference to practical approaches for segregation of polluted and toxic effluents, process modifications, product substitution and reclamation of potentially marketable materials. Employing these prudent measures is expected to increase productivity and profitability of SICs industries, and ensure their environmental compatibility.

1. INTRODUCTION

Integration of environmental concerns in industrial development is promoted by the Government of Saudi Arabia; with emphasis on proper industrial location, environmental impact assessment, selecting appropriate technology, and encouraging reclamation and recycling of wastes.

Within this context, the SICs were established to promote private investment in industry; this allows project owners to acquire land lots within the SICs at nominal rental fees and permits production facilities to benefit from the efficient infrastructure of services including transportation, communication, power, water and in some cases centralized treatment of wastewater.

In selecting new industries and manufacturing activities in the SICs the following environmental factors are considered:

* Adequacy of the production technologies and their potential environmental impacts.

* Opportunities for recycling of byproducts and means of handling hazardous wastes.

* Restricting use of potable water from municipal and underground supplies and promoting use of the recycled treated water in cooling, washing and processing operations, whenever feasible.

* Discharged effluents should not contain chemicals which may deleteriously affect the sewerage system or the quality of the recycled water.

While the above does not represent a comprehensive list of requirements for a new industrial project in SICs, it nevertheless demonstrates the emphasis placed on issues involved in appraising the environmental impacts of production activities within SICs.

The Ministry of Industry and Electricity MIE, is entrusted with development, management and maintenance of the government owned industrial cities. Each industrial city has an administrate body to supervise and monitor construction, operation, and service activities; these bodies are centrally coordinated by the Industrial Cities Department ICD of the MIE.

In assessing the environmental impacts of industrial pollution in SICs, it is important to recognize that this process is complex and cumulative. In such large industrial centres, it is irrelevant to consider the impact of an individual discharge on the environment as it should be assessed with other industrial discharges from the same location while considering the prevailing climate, wind velocity, and the capacity of the receiving environment to absorb or assimilate the pollutants.

The assessment should go beyond the mere effects on the environment to include other nuisances such as excessive noise, progressive absorption of free space, and chaotic traffic. In the SICs, additional "unique" conditions expose the community to more environmental dangers. These include vulnerability and depletion of groundwater resources, the greater complexity and potential hazards of some processes, particularly those emanating from the conversion and down stream industries which dominate in the SICs, and the tropical climate which intensifies pollution problems.

For these reasons, it is essential to view the process of industrial development in the SICs from the very outset as a multi-purpose undertaking which may not only change the physical and economic environment, but could also affect social well-being.

The Meteorological and Environmental Protection Administration MEPA has recognized the importance of environmental impact assessment EIA of the new development projects, and has recently proposed a new set of regulations to insure incorporation of EIA in the feasibility studies of projects with potential adverse environmental impacts. MIE and other concerned government institutions, are presently reviewing these regulations prior to their enactment.

Reprocessing and reutilization of industrial residues in SICs offer the potential of returning these secondary materials to beneficial uses rather than their discharge which causes detrimental effects on environmental amenities. Successful residue utilization involves (a) rendering recovered products suitable for beneficial use; (b) promoting marketability to ensure profitable operation; (c) employing appropriate reprocessing technology; and (d) creating an overall enterprise that is socially acceptable and economically feasible.

The attitude of SICs entrepreneurs, which favours the use of virgin materials, is a consequence of economic and technical policies based on abundance of energy and generous subsidies provided to production inputs. If effective utilization of residues is to occur, these policies should be reconsidered to encourage the generating industry or a specialized secondary industry to reprocess these residues.

Despite the concerted efforts of ICD/MIE, management of residues in SICs production facilities is still tackled in a piecemeal manner, and is rarely considered within the context of a comprehensive resources conservation scheme; constraints which hamper effective reuse of residues include: (a) lack of economic incentives; (b) scarcity of managerial and technical skills needed for implementing reutilization schemes; (c) shortage of capital for investment in material reprocessing; (d) unreliable information concerning marketability of the processed residues, and (e) unfavourable consumer attitude.

Effective waste reutilization in SICs may benefit from regionalization, where industrial byproducts from separate but compatible sources can be brought to a centralized facility for treatment. Demonstrations and pilot-scale studies must be promoted by MIE as an effective means for introducing new methods and technologies for residue recovery and utilization.

In conclusion, more efforts are needed to promote waste recycling in SICs; this can only be achieved if residues are considered as **complementary resources rather than as undesirable** materials.

2. TERMS OF REFERENCE

Upon the request of the Ministry of Industry and Electricity of the Kingdom of Saudi Arabia, the advisory service of the ESCWA Regional Adviser in Environment was provided during the period 12-23 December 1992 and 10-20 April 1993.

The **overall objectives of the mission** encompass:

- Reviewing production processes, sources of wastes and practices of pollution control in the SICs.

- Identifying options for waste minimization and residue reclamation and reuse in the surveyed industrial cities.

- Proposing management alternatives for implementing, financing and administering pollution prevention programmes to meet environmental standards and the needs of SICs.

The **specific activities of the mission** include:

- Assessment of industrial environmental management practices in Riyadh Industrial Cities RICs (phase I), and in Jeddah Industrial City JIC and Dammam Industrial Cities DICs (phase II)

- Evaluate operational practices of the centralized waste treatment facilities in the SICs.

- Propose an outline for an integrated environmental monitoring scheme to be implemented by the ICD/MIE.

3. SAUDI INDUSTRIAL CITIES SICs

The Government of the Kingdom recognizes industrial development as an essential base for further progress and economic development of the country. To pursue this objective, MIE has already developed 12 industrial cities in the Kingdom (Riyadh (2), Jeddah (4), Dammam (2), Al-Qssim (1) and Al-Hesa (2)); plans are underway for development of additional 13 cities in various regions of the Kingdom. The facilities provided in the SICs include water, sewerage, power, and road networks; and a central workshop to render maintenance and engineering services. Other public utilities such as clinic, restaurant, police and fire stations, and banks are also available. Where centralized wastewater treatment is provided, a network of the recycled water give an easy access for all plants to use the treated water for landscaping and as processes water whenever feasible.

Riyadh Second Industrial City RIC II, is one of the largest SICs, and is located south-east of the Riyadh city, about 18 km from the city centre. RIC II has been developed in two phases during the period 1978 - 1988, and presently occupies about 12 million m2, with further expansion to be completed during the 4th 5-year plan covering an additional 4 so km.

The site is well planned with convenient access to Riyadh and other major cities. Landscaping is visible everywhere; its presence enhances the surrounding environment in ROE II and lessen to some extent air emission problems.

About 400 establishments are presently housed in RIC II, most of which produce minor amounts of residues (food processing 24, carpets and garments 9, wooden furniture 14, board and paper packaging 11, metal construction industries 71, mechanical industries 35, advertising 6, tile products 18). However, other manufacturing establishments generate variable loads of wastewater pollution and/or solid hazardous residues (tanneries 3, water proofing materials 1, chemicals formulation and processing 14, printing 11, plastic processing 28, metal plating 12, dairy 6). A total of 24 production plants in RIC II were visited during the mission.

Riyadh First Industrial City RIC I is a compact complex (45000 m2) with about 60 operating establishments (food processing, metal construction industries, specialty paper, galvanization and metal plating, foundries, plastics, furniture, household appliances, air conditioning equipment and mechanical industries). RIC I is situated 2.5 km to the east of the city center bordered to the east by the railway station and to the west be mixed developments including car repair shops and small commercial establishments.

Six industrial facilities in RIC I were visited (paint formulation, foundry, water proofing materials, pesticide formulation, trails assembly, and plastics) . By and large, the processing operations and the working environment seem satisfactory. Water is provided through the municipal network and all industrial plants are connected to the city sewerage system. Wastewater is discharged without pretreatment, however, the sewerage authority periodically checks effluents to insure conformity with discharge regulations sewers.

Jeddah Industrial City JIC is among the oldest and largest SICs. JIC was established in the early seventies and occupies about 14 Million square meters in five phases of development. JIC is located about 8 Km from Jeddah City centre; manufacturing plants already in operation are 250 , another 170 are in various stages of development. Development of green-belt and landscaping is restricted due to lack of suitable irrigation water from the central wastewater treatment plant.

Solid and hazardous waste management is handled by the concerned industries or private contractors. Since no hazardous waste site has been designated in Jeddah area, all waste arisings from JIC is presently disposed of in the municipal landfill. Information concerning the quantity and nature of the generated solid wastes is extremely lacking in JIC.

Environmental conditions are, by and large, acceptable . Management of the JIC exercises effective powers to keep the premises in tidy conditions. The city is well planned with adequate services and access. However, due to the rising demand for locating new industrial facilities in JIC, some incompatible industries are located in adjacent sites which induces operational problems to sensitive industries such as food and chemical processing. The visited industries in JIC include edible oil refining, paints formulation,
perfumes and cosmetics, yeast, confectioneries, insulating and waterproofing materials, tanning, carpets, specialty oils, and match production.

Dammam First Industrial City DIC I, is located on Dammam-Khobar Highway and occupies 2.7 million m2 in three phases of development. DIC I has 290 operating establishments in chemical, aluminum, printing, mechanical, food processing, construction, plastics, paint formulations and miscellaneous industries.

DIC I has no central WWTP; industries which conform to the requirements of Dammam municipal WWTP are permitted to discharge into the public sewerage system. Plants which generate heavily polluted or toxic wastes are requested to handle their effluents through specialized waste management firms (Zegwwaard , Kannoz) or by owned wastewater tankers. Solid and hazardous wastes are disposed of in designated landfill sites or in the waste disposal facility of Jubail Industrial Complex. Plants visited during this mission include fiberglass insulation, chemical inhibitors, building chemicals, specialty chemicals, dairy, X-ray film packaging, paint formulations, and aluminum products.

Dammam Second Industrial City DIC II, is located on Dammam-Riyadh Highway, about 30 Km from Dammam city centre. DIC II has 83 operational facilities in food, paints, detergents, tissue paper, solvents, chemicals, furniture, plastics and metal manufacturing.

DIC II has a centralized WWTP which appears to function satisfactorily.

Management of DIC II observes strict environmental guidelines and cooperates with industrial concerns in implementing landscaping and green-belt projects .

3.1 MANAGEMENT OF HAZARDOUS WASTES IN SICs

Non-hazardous solid wastes are collected from the industrial sites or designated transit stations within SICs for disposal in the municipal sanitary landfills. The generators or their contract haulers are responsible for transportation of hazardous liquids, sludges and metal residues to the site of hazardous waste disposal in the municipal landfill. In order to reduce transportation costs, individual companies provide enough storage capacity within their premises to fill large trucks. No centralized hazardous waste treatment or on-site pretreatment of hazardous waste is provided by SICs.

Hazardous materials are disposed of without taking the necessary precautions required for handling toxic wastes. In most cases, a restricted storage area is provided in the plants for transit collection and storage of hazardous residues. Large amounts of potentially recyclable materials are currently being landfilled or stockpiled.

Visits to the manufacturing facilities in SICs revealed several sources of potentially hazardous materials that are inadequately disposed of at present. These sources include:

* Off-specification products;
* Products whose date for appropriate use has expired
* Materials spilled, lost or having undergone other mishap including any materials, equipment etc. contaminated as a result of the mishap;
* Materials contaminated or soiled as a result of planned actions (e.g. residues from cleaning operations, packing materials, containers);
* Unusable parts, (e.g. exhausted catalyst);
* Substances which no longer perform satisfactorily (e.g. contaminated acids, contaminated solvents);
* Residues of industrial processes, (e.g., still bottoms);
* Residues from pollution abatement processes, (e.g., scrubber sludges, baghouse dusts, spent filters);
* Machining/finishing residues, (e.g., lathe turnings, mill scales); and
* Residues from raw materials processing.

The following disposed of wastes from SICs may contain hazardous constituents in the form of liquid, sludge or solid materials

* Residue from substances employed as solvents;
* Halogenated organic substances not employed as solvents;
* Tempering salts containing cyanide;
* Mineral oils and oily substances,(e.g., cutting sludges);
* Oil/water, hydrocarbon/water mixtures, emulsions;

* Substances containing PCBs and/or PCTs,(e.g., dielectrics);
* Inks, dyes, pigments, paints, lacquers, varnish;
* Resins, latex, plasticizers, glues/adhesives;
* Pytotechnics and other explosive materials;
* Non-halogenated organic substances not employed as solvents;
* Inorganic substances without metals;
* Ashes and/or cinders;
* Non-cyanidic tempering salts;
* Metallic dust, powder;
* Spent catalyst materials;
* Liquids or sludges containing metals;
* Residue from cleaning of tanks and/or equipment; and
* Contaminated containers (e.g., packaging, gas cylinders, etc.).

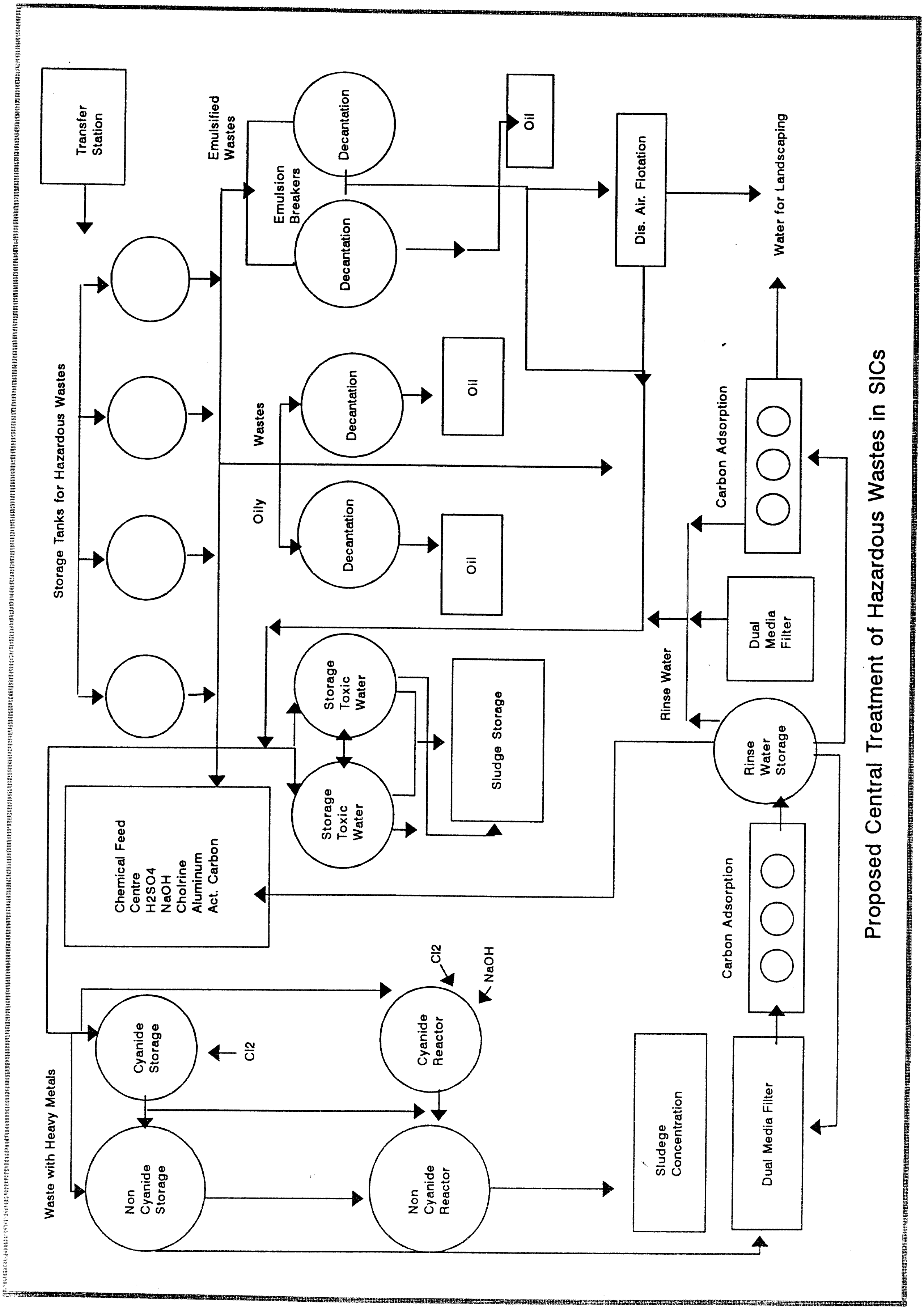
The following are identified as potential operations for resource recovery, recycling, reclamation of direct reuse of industrial wastes (secondary materials) in SICs. Some of these operations may not be economical when handled by the individual generators. However, their treatment in centralized facilities may prove profitable

* Use as a fuel or other means to generate energy;
* Solvent reclamation/regeneration;
* Recycling/reclamation of organic substances which are not used as solvents;
* Recycling/reclamation of metals and metal compounds;
* Recycling/reclamation of other inorganic materials;
* Regeneration of acids or bases;
* Recovery of components from catalysts; and
* Oil re-refining or other reuses of oil

In view of the present unacceptable practices for handling of hazardous wastes in the SICs, MIE should adopt a system for proper management of these wastes. A sechmatic of a centralized treatment system for hazardous wastes is shown in Figure 1; additional treaments may be added according to the special needs of each industrial city.

The broad objectives of the system may include:

* Encouraging reuse; recycle-resource recovery whenever technically and economically feasible.
* Emphasizing waste-exchange to enable effective waste reuse.
* Discouraging incineration of waste to alleviate air pollution problems in the SICs and the surrounding areas.
* Promoting private investment in waste reclamation.



Proposed Central Treatment of Hazardous Wastes in SICs

3.2 CENTRALIZED TREATMENT OF INDUSTRIAL WASTEWATER IN SICs

The wastewater treatment Plant WWTP in RIC II is designed to treat an average flow of 14,000 cubic meter per day CMD. However, actual treatment capacity ranges from 7,000 - 10000 CMD. About 250 plants have been connected to the RIC II sewerage network so far; continued connection of the remaining industrial plants and the expected operation of additional water consuming industries in the third expansion phase of ROE II will increase wastewater flow close to the designed capacity by the end of 1994 .

In the WWTP the combined industrial effluent passes through 2 sets of grit chambers for removal of coarse constituents, then to parshal flume for flow measuring. The first stage of treatment consists of equalization and aeration in a primary lagoon (effective volume 57700 CMD) with a detention time of 6-8 days. This followed by a second aeration-stage in the final lagoon for about 6 days. According to plant records , the average values of influent suspended solids SS, biochemical oxygen demand BOD, and chemical oxygen demand COD are 320, 290, and 685 mg/l , respectively.

The double-stage aerated lagooning results in the following average removals , SS 76 percent, BOD 80 percent, and COD 68 percent. Lagooning is followed by treatment in solid contact clarifiers (2 sets, DT 3.8 hrs) and the clarified water passes to a chlorine contact chamber where post chlorination takes place (8 mg/l , contact time 60 min.). The collected sludges are treated in aerobic digesters (2 sets, DT 16 days) and the digested sludges are further dried in sludge lagoons (4 sets, each has an effective volume of 2900 CMD.

The WWTP/RIC II, has a well-equipped wastewater monitoring laboratory with adequate facilities for measuring chemical and bacteriological parameters. In addition, the laboratory has an advanced atomic absorption spectrophotometer for measuring the following metals: Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Copper, Cobalt, Iron, Lead, Lithium, Manganese, Mercury, Nickel, and Zinc. The WWTP and its laboratory are presently operated and maintained by a private company (Saudi Tumpane Co.).

The WWTP at DIC II treats 8000-10000 m3/d industrial wastewaters. Treatment consists of screening, flow measuring, grit chamber, followed by equalization and aeration for about 8 days detention time in an aerated lagoon. Average influent characteristics are COD 750 mg/l, BOD 400 mg/l, TDS 300 mg/l and SS 200 mg/l. Biological treatment is achieved in successive stages of facultative lagooning and maturation (each with a detention time of 4.5 days). The average characteristics of the effluent is COD 25 mg/l and BOD 15 mg/l. The treated effluent is subjected to post-chlorination before final disposal. Part of this water is being utilized for landscaping projects; however, non is being reused for industrial purposes in DIC II.

The WWTP at JIC has a design capacity of 22000 m3/d. However, severe operational and maintenance problems limit the treatment capacity to 5000 m3/d.

Treatment involves screening, grit removal, equalization/aeration and aerated lagooning. An anaerobic digestion unit is provided, however it is inoperable at present due to faulty operation of the treatment system and the subsequent lack of biological sludge.

The effluent quality from the plant is unfit for irrigation and industrial uses due to its heavy content of dissolved and suspended impurities. At present, this polluted effluent is rerouted for further treatment in Jeddah municipal WWTP before final disposal.

The Saudi Tumpane Company ,which operates the WWTPs at RIC II and DIC II, has been recently assigned the responsibility of operating WWTP/JIC. The company is presently implementing a major corrective plan to improve operation and monitoring practices of WWTP/JIC.

The following are some common observations concerning **improper practices** at WWTPs of SICs; they are not meant to undermine efforts of the plant personnel, but rather to strengthen and improve the existing operation and monitoring activities :

* Failure to maintain automatic samplers and reliance on grab samples collected once a day for monitoring treatment performance (influent pumping station, lagoon A, lagoon B, reused water and sludge). This limited analytical programme, can not detect events of massive discharge of pollutants (accidental or illegal discharge of toxic constituents), periodicity of peak loads, and process malfunctions caused by equipment and faulty feed stocks .

* Sample's integrity is affected by improper sampling and external contamination which subsequently gives false results for some parameters such as BOD, bacteria counts and nutrients.

* No quality control and quality assurance QC/QA programme is presently followed in the laboratory , which shed some doubts on the accuracy and precision of the reported data. An inter-laboratory control procedure should be executed by the laboratory manager to insure the quality of data generated and to provide an in- house evaluation of the analysis performance capability. External checks must be performed in cooperation with outside laboratories (King Saud University, Research institution,. etc.) for periodic check of the data reliability and analytical performance.

* The existing scheme for monitoring industry compliance with MIE effluent guidelines, is poorly planned and implemented. Improper sampling and analysis by inexperienced technicians may lead to questionable results. Monitoring industrial effluents provide scanty data on the conventional pollutants from some industries but virtually

nothing is known about the presence of toxic and hazardous pollutants from ROE II industrial facilities. (Refer to Annex I for a proposed integrated environmental monitoring scheme).

* Monitoring plant effluents consist of measuring a unified set of parameters (BOD, COD, pH, SS, NH3, PO4, conductivity and residual chlorine ??). Analytical programme should be defined in accordance with the nature of specific industrial activities, in conformity with the objective of monitoring , particularly with regard to release of hazardous constituents such as chromium and toxic organic matters. Effluent's monitoring does not mean collecting data for the sake of filling forms. Rather it should be viewed as an essential tool to control industrial processes, provide warning of abnormal events or illegal discharge practices, and continuously assess the quality of influents to WWTP. (See Annex II for the suggested parameters to be monitored for the individual industries).

* As normal operation of WWTP, involves possible fouling of equipment and variations in influent's characteristics, periodic monitoring (at least every 3 hours during the day shift) can reveal equipment fillers or presence of slugs of toxic or undesirable constituents in the combined influent. The inoperable on-line instruments (pH, temp, DO, and conductivity) and the automatic sampling devices must be replaced or maintained. Continuous monitoring is ideal for prompt response to rectify offsets due to variations in influent loading and/or characteristics. Laboratory analysis of grab samples should be replaced by composite sampling for parameters that are not amenable to continuous monitoring (BOD, COD, SS. etc).

* <u>Analysis, of total organic carbon (TOC)</u> should be added to the existing analytical scheme. TOC is useful as "overall indicator" of the organic loading of industrial effluents from the manufacturing plants, and as reliable sensor for the adequacy of the WWTP performance.

* <u>Gas chromatography (GC) is recommended</u> to monitor toxic constituents in <u>the recycled treated water</u> . As various solvents and auxiliary chemicals are used in almost all industries in SICs, it is expected that their residues may accumulate in the treated water. The following chemicals may be incorporated in the new GC analytical scheme (ethylene oxide, propylene oxide, ethyl benzene, toluene, hexane, benzene, and methylene chloride).

* <u>Flow measurement</u> of polluted liquid discharges from water-intensive production facilities and the recycled water for industrial and landscaping purposes should be employed wherever feasible. Measuring effluents' flow is essential to convert concentration of pollutants into loadings. The present system of <u>emphasizing waste</u>

concentration rather than loading is deceiving, as it overlooks important sources of pollution. Flow sensors may be used to measure wastewater flow from major industries (tanneries, food processing, metal fabrication ..etc). These measuring devices operate by means of sensors which sit on the bottom of a sewer pipe. The sensor measures the level and the velocity in the pipe; the volumetric flow-rate is then calculated based on the average velocity and the flow area. Such measurements are highly reliable. In almost all instances, industrial facilities were not able to give even a rough estimate of their average consumption of the recycled water (treated wastewater). As this water is offered free of charge, both the management of WWTPs and industry indicated no interest in installing metering facilities. Installation of water meters or other simple means of flow measuring is recommended to improve accounting for the produced water, to assess the magnitude of leakage in the water distribution system, and to encourage rational use of the recycled water by the benefiting industries.

* Stack monitoring is recommended for some air polluting industries (water proofing materials and plastics). Vinyl chloride monomer VCM is used in the production of PVC in at least one industrial plant. VCM is extremely hazardous and a confirmed carcinogen. On-line VCM GC analyzer should be installed on the relevant stacks or potential emission sources. Monitoring Volatile Organic Compounds VOCs is also recommended by on-line stack instruments at sources of emissions from the manufacturing of water proofing materials.

* Area air monitoring should be also provided for early leak detection, as well as assessing ambient air quality in the SICs. Fixed or mobile air monitoring stations where appropriate, may be used to measure levels of the relevant parameters such as particulate matters,CO, Nox, Sox, Ozone.. etc.

4. PROPOSED MEASURES TO STRENGTHEN ENVIRONMENTAL MANAGEMENT IN SICs.

4.1 IMPOSING ECONOMIC SANCTIONS TO ENCOURAGE POLLUTION CONTROL

Institution of a system of charges to be levied on polluters in SICs may provide vital financial source to supplement those of the IED/MIE budget allocated for pollution control. These funds would enable investing in pollution control facilities, where no other source of finance currently exists. However, levying charges should not imply the right to pollute, since emission standards would remain enforceable; the charges should merely provide "supportive mechanism" to ensure compliance with the standards. The financial resources generated through the charges will also enable strict enforcement of emission standards, and additional financing of the centralized treatment facilities in SICs.

The application of the "polluters pay principle-3P's" is not widely accepted by industry in Saudi Arabia at present. However the 3Ps implies that costs for the prevention or control of pollution caused by industry must be paid by the individual concerns responsible for the emission of pollutants. Putting 3P's in practice involves imposition of pollution charges which represent payment by industry for use of the assimilative capacity of the environment, or to benefit from the WWTP services. The proposed economic sanctions , and regulatory instruments such as standards limiting maximum emissions can complement each other for effective control of pollution emanating from SICs.

A pollution charge should be based on effluent flow and concentration of pollutants (waste load). Methods of cost allocation and recovery subject to institution in SICs include:

* **Users charge**: This system is based on the use of , or benefit from the WWTP where various industrial wastes are combined and treated together. The unit-user charge is expressed as cost/unit waste. The total charge for a given contributor is the sum of the unit user charges multiplied by their corresponding loads. This system is appropriate for industries connected to WWTP within the SICs (RIC II, DIC II, and JIC).

Surcharge costs are typically calculated according to the following formula:
Cost = Q [C1 + C2 (BOD - X 1) + C3 (SS- X2) + C4 (N- X3) + C 5 TX].
Where: Q = Annual average flow.
C1 = Unit cost of flow to treatment works.
C2, C3, C4 = Treatment cost of BOD, suspended solids (SS) and nitrogen (N), respectively.
X1, X2, X3 = Non-chargeable BOD, SS, N, respectively.
C5,TX = Concentration and cost of treatment of toxic constituents such as cyanide, phenol,.. etc.

* **Negotiated contracts:** In cases where there are several small industrial contributors to the municipal system as in ROE I, the sewerage authority can negotiate individual contracts taking into account the special nature of each effluent. Contracts are also useful in planning of a new industry, as it may be charged the capital costs for that portion of the design capacity allocated to its use.

* **Property taxes:** Though this system of taxation is convenient and commonly applied for other purposes, it may be inefficient and inequitable for paying pollution charges at SICs. The system encourages excessive generation of waste loads, as there is no incentive for industry to reduce pollution. Inequities would occur as non-polluters are forced to bear a share of the total cost which should be paid by the polluting industries only.

4.2 PROVISION OF ENVIRONMENT INFORMATION SERVICES FOR SICs

SICs manufacturers may encounter difficulties when seeking solutions to their technical and environmental problems; access to pertinent information is either limited or unavailable. For example, international institutions or government agencies may have special technical arrangements to help entrepreneurs to solve their pollution problems; commercial banks may have low-term loans available for pollution control projects; others may be in bad need for byproducts or even the process wastes from a particular industry. These few examples illustrate the considerable scope and importance of providing information services to inform SICs of these viable opportunities.

In view of the above, establishing an information centre in ICD/MIE is necessary to collect and disseminate information of interest to entrepreneurs of SICs. The type of information must include, among other things, environmental regulations concerning manufacturing; alterative technologies for pollution control; sources of financial aid; environmental training for small-scale industries; potentials for material exchange. The information may be disseminated through newsletters,or IED/MIE extension officers in the field.

In addition, the continuous tightening of pollution control regulations and the rising prices of raw materials in the Kingdom may prove attractive to the profit-oriented small entrepreneurs to look for markets for the valuable components of their wastes. Waste generators and potential users may be linked through an information clearing-house which receives offers of, and requests for, waste materials. These are published and circulated among member industries and their trade associations. Such clearing-houses, which may be preferably located at the administrative offices of SICs, can operate with minimum staff and office space; the information system may include standardized formats for waste characterization and suggestions on reuse of various wastes.

4.3 TRAINING SICs PERSONNEL IN INDUSTRIAL ENVIRONMENTAL MANAGEMENT

To some managers of the SICs, the environment is conceived as a convenient receptacle for waste and as a nuisance when its deterioration leads to imposing costly cleanup actions.

A fundamental change in this attitude is necessary to eliminate occupational risks to workers and to minimize the negative impacts on the surrounding environment. This can be achieved when those responsible for the day-to-day running of SICs industries, are reached and convinced of the economic and environmental benefits of waste minimization and the opportunities for savings through material recovery and recycling of water and energy.

Because workers are more occupied with production problems rather than environmental concerns, their training should follow unconventional routes. Obviously, rigorous instructions in the classical training format is doomed to fail in this particular situation. An alternate, is to expose the prospective trainees to real case studies and demonstrations, and no where is that better than in the industrial locations themselves.

In-situ training is recommended in this case. This may cover various aspects such as identification of pollution sources, process changes to reduce discharge, methods of material recovery, precautions for handling toxic chemicals, spill containment, in-house storage of hazardous residues, and simple on-site pretreatment of wastewater.

In addition to in-situ training of workers, the managers of SICs should learn of options for clean technology employed in similar installations throughout the Kingdom. This "show-how" approach is extremely useful, particularly when such technologies can be adopted at a reasonable cost.

Informal meetings and group discussions organized by an environmental trainer on site, also enable workers to keep abreast of practical ideas and successful methods to control pollution. Sharing knowledge and experience in this manner should be advocated as a preliminary stage to bring environmental issues to workers attention, through exposure to disciplines and opinions of others.

While the development of in-house manpower is essential for the success of industrial environmental management, equally important is the development of expertise for planning, monitoring and enforcement within the administrative mechanism of IED/MIE . Special attention should be given to training of IED personnel to become aware of the environmental impact of manufacturing operations, and to use the knowledge and experience gained to curb industrial pollution through the institution of appropriate regulations and administrative instructions .

Because of the undesirable impacts of pollution and the need to mitigate their effects, it is proposed that MIE should arrange in cooperation with the Saudi Chamber of Commerce and Industry and its branches in Riyadh, Jeddah and Dammam for intensive training programmes (one-day seminars for managers and one-week mobile workshops for SICs personnel) to promote sound operational practices and appropriate waste control techniques in SICs industries. International experts may participate in such training activities; arrangements could be secured through ESCWA, UNDP, UNIDO and WHO.

4.4 ESTABLISHMENT OF AN INTEGRATED INDUSTRIAL ENVIRONMENTAL MANAGEMENT SCHEME IEMS

The complexity and importance of environmental management in SICs requires formulation and execution of a reactive strategy which entails the establishment of an Environmental Management Unit EMU within the administrative system of ICD/MIE. The unit's mandate is to monitor and control environmental quality in SICs accordingly to the objectives and criteria set by national laws and MIE directives.

The scope of activities and performance level of EMU depend on available resources which may involve expanding the existing capabilities (i.e. wastewater monitoring laboratories) and hiring full-time environmental specialist to manage the proposed EMU.

It is noteworthy to emphasize that, EMU is not intended to replace or assume functions assigned to other institutions (MEPA, health authorities, ... etc.) but should work closely with them to fill existing gaps; it would undertake tasks of environmental management in SICs currently overlooked and to provide backup for effective implementation of IEMS. A brief outline of the scope and duties of the proposed EMU is presented in Annex I.

5. WASTE MINIMIZATION IN SICs: EXPERIENCE AND PROSPECTS

Many of the SICs pollution problems are not amenable to the traditional approach of end- of-pipe treatment. Pollution prevention through waste reduction, elimination, or recycling of pollutant discharges to the air, water or land holds the promise to future gains in environmental protection and offer tangible and intangible benefits . These benefits include:

* Reduction of health and ecological risks; avoiding the shift of pollutants among environmental media and reducing risk of exposure;

* Economic benefits; reducing waste management costs, increasing operational efficiency, and sale of reprocessed materials .

Alternatives for management of industrial wastes at SICs include process modifications, improving operating conditions, design changes, by-product recovery, on-site treatment, centralized treatment, combined treatment with municipal wastewater, and reuse of the treated effluents. This options are illustrated in Figure 2.

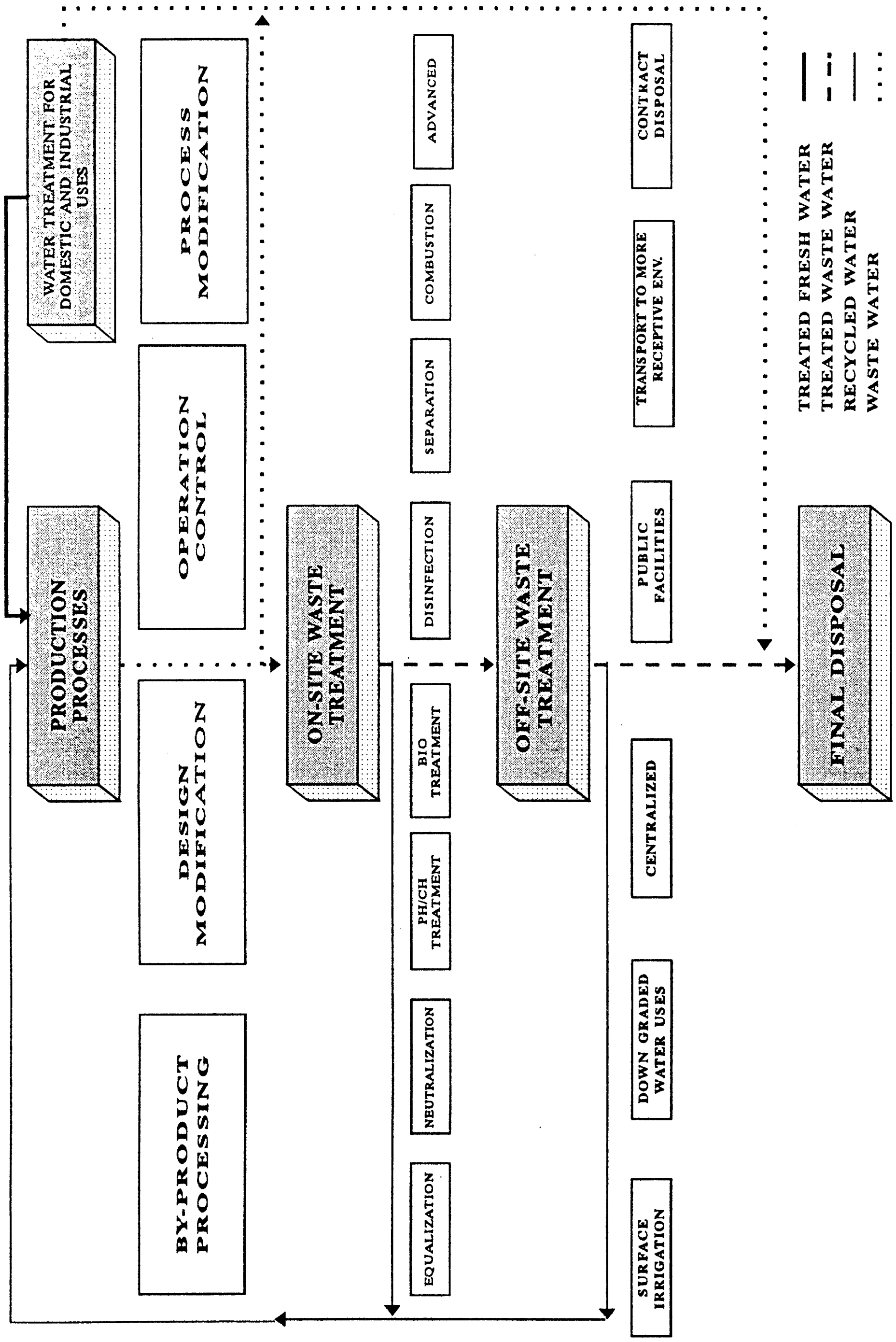
To survey wastes and processes in SICs and to enable proper identification of pollution prevention measures , brief visits were undertaken to selected industries known to be generators of conventional wastes and/or hazardous residues.

It should be recognized that the arbitrary selection of the visited plants may result in missing of some important polluting industries or overstating the importance of less significant ones. However, investigation of the potentially pollution generating industries in RIEs indicated possible application of generic pollution prevention measures in many industries. These measures include:

* Control of VOCs with potential recovery of volatile solvents from chemical formulations, plastic molding, printing, furniture, and metal industries.

* Oil-Water separation ; it was surprising to note that most plants are not provided with oil traps. In some cases oil form a considerable portion of the discharged effluents (food, oil, metal finishing etc.). Emulsion breaking by physical/chemical means may be needed in some cases. Activities such as cutting and cooling fluids in metal working and making should be carefully controlled to reduce oil wastage.

* Testing Reaction Baths; simple and quick tests should be employed to determine when a process bath, reaction mixture, or rinse water has reached its exhaustion point. At present, discharges or disposal of baths are done on an arbitrary routine schedule that may produce larger volumes of waste of incompletely exhausted baths. Automatic



OPTIONS FOR MANAGEMENT OF INDUSTRIAL WASTES IN SAUDI INDUSTRIAL CITIES sensors may by of great benefit in monitoring the service life of the reaction baths; simple analytical techniques are also available to monitor chemicals' reactivity and to indicate when replacement is needed based on proper judgment.

* Small scale recovery of acids, alkalies and solvents, while practical elsewhere, find limited use in SICs. Encouraging operation of such facilities and evaluating the hardware and economics of such recovery systems may require technical assistance .

* Scrap metals: A number of industries, including the finishing of castings, machinery fabrication, and auto finishing, generate scrap metals as cuttings and turnings, grinding dusts, damaged parts, etc. These materials, often contaminated with cutting fluids, are usually discarded as solid waste or at best, are sold to scrap dealers for reprocessing. Improved casting, forging, and machining processes and equipment would simultaneously reduce the waste loads produced and the amount of raw material used to fabricate the product. Such changes in production practices in SICs are usually brought about for reasons other than environmental concern, such as significant economic factors or regulatory pressures (e.g. worker safety); where significant capital investment is involved, these changes are very slow.

Visits undertaken to various manufacturing plants during this mission revealed enormous opportunities for waste minimization and pollution prevention through introduction of simple and cost-effective cleaner technology measures. The approach followed in the visits was reviewing both the production processes and sources of wastes, followed by discussions of the potential process modifications with industry personnel. The following is a brief description of the production processes and **preliminary suggestions** to improve productivity, reduce waste generation and to enhance practices of material reclamation and recycling.

5.1 DAIRY INDUSTRIES

Three plants were visited in this mission (two at RIC II and one at DIC I).

I. Process Description

The plants use dried milk for fluid milk reconstitution, and production of yogurt, sour cream (labana), ice cream, canned juices and drinks.

The visited plants are medium-scale facilities which use pretreated water (deionized, carbon filtered and UV sterilized). The imported juice concentrates and dried milks are diluted with water, and packaged using automatic filling machines. The Al Rabic plant uses an advanced UHT for milk production. Housekeeping practices in the RIB II dairies are conforming to the hygienic standards of dairy processing.

The cleaning system in the visited dairy plants, represents the major source of effluent discharge. The pollution load depends on (a) the amount of milk solids discharged into the drain through rinsing operations, (b) the concentration of cleansing detergents in the final effluent and (c) the amount of milk solids and juice residues discharged into the drain as a result of the cleaning operation itself. Cleaning operations commonly involve four steps: pre-rinse, cleaning, post-rinse and sanitation. All wastewater effluents are presently discharged into the sewer network without pretreatment. Circulation cleaning is replacing the hand-cleaning operations in most processes, primarily because of its efficiency and concomitant improvement in product quality.

II. Options for Waste Minimization

* Potentially recoverable milk solids may be discharged into the drain through accidental spills or faulty operations. Accounting system based on fat/solids input-output presently followed in RIB II dairies are frequently inaccurate because of inherent errors in sampling, analysis, measurement of products and package filling. The installation of <u>water meters</u> and a waste monitoring system are recommended to ensure effective operation and to minimize processing losses.

* Effective control of water use in dairy processing in RIB II plants can be achieved through:

  - Installation of automatic shut-off valves on all water hoses so that they cannot run when not in use.

  - All hand-operated valves, especially multi-post valves, must be marked, to identify open, closed and directed flow positions to minimize personnel operational errors.

  - Installation of suitable liquid level controls with automatic pump stops where overflow is likely to occur (filler bowls, process vats, silo tanks, etc.).

- All Clean-In-Place (CIP) lines should be rigidly supported to eliminate leakage of fittings caused by line vibrations.

- All piping around storage tanks and process areas where pipelines are taken for cleaning should be identified to eliminate misassembly and damage to parts and subsequent leakage of the processed liquids.

- Drip shields should be installed on filling equipment to collect the product during filling machine jams.

* Filling machines for fluid products should be equipped with a product-capture system to collect products at the time of change-over from one product to another. An air-actuated by-pass valve interlocked with a low level sensor could be installed on the filler product recovery system or on a container collecting the product from drip shields. When the product in the filter bowl reaches the minimal low level, the product by-pass system would open for draining followed by a series of short flushing rinses. At present, the remaining product is flushed directly to the drain when changing to another product which generates excessive organic pollution in the effluent.

* Small parts such as filler parts, homogenizer parts and separation parts from machines needing hand-cleaning should be cleaned in a specially-designed cleaned-out-of-place (COP) circulation tank equipped with a pump and thermostatically-controlled heating system.

* The use of CIP air-actuated sanitary valves in place of plug valves is recommended as they shut down in case of actuator failure, reduce leaks in piping systems, and do not require removal for cleaning. CIP systems should be used whenever possible. They should be automated to eliminate human error, to control the use of cleaning compounds and waters, and to improve cleaning efficiencies.

* The floors of the processing area <u>should be smooth</u> to allow inclination toward the drains. Faulty slopping in the floor areas causes accumulation of cleaning water on the floors and prevents their continuous drainage.

* <u>No in-house waste monitoring is presently implemented</u> in the visited plants. A time-activated wastewater sampler may be installed on the discharge line of the combined effluent from each plant. For plant-control purposes these interval samples can provide a visual daily picture of the wastes even without testing for free fats, product

residues, and turbidity. Analysis of pH, oil, BOD and suspended solids in the plant effluent should be incorporated in the routine in-house scheme of the quality control laboratory.

5.2. PAINT FORMULATION INDUSTRY

There are several paint formulation plants in SICs. The Saudi Paint Co. (RIB II) and the Arabian Danish Paint Co. (RIB I) and Sigma Paints DIC I) were visited during this mission. Obtaining, process-related pollution prevention information from the visited plants was difficult because of the competitiveness and the confidential nature of the industry.

I. Process Description

The production of solvent-based paints consists of mixing resins (Alkyd, Acrylic, and vinyl), dry pigments, and extenders (Ca CO_3, Talc or China clay, and Titanium oxide) in a high-speed mixing tank fed from a grinding mill to ensure homogeneity of the paint base. Next, solvents are added (naphtha, xylene, toluene, butanol or other thinning solvents). During agitation resins are gradually added. Upon reaching proper consistency samples are tested for viscosity, specific gravity, flow and drying time in accordance with the required specifications. The paint is then screened to remove any undispersed constituents and directly poured from bottom hopper into paint cans and moved to storage.

Preparation of water-based paints involves mixing water with glycol and hydroxymethyl cellulose. To this mixture, dry pigments and fillers are added followed by the addition of plasticizers, preservatives, anti-foaming agents and polyvinyl acetate emulsion. The consistency is adjusted by adding additional water and fillers. The rest of the processing is similar to that of the solvent-based paints.

The manufacture of printing inks at the Arabian Danish Paint Co., consists of milling the pigment with the resin and dispersing in the solvent medium. Solvents used to clean the reaction vessels (tubs) between batches are reused for the initial washdown of successive batches. Solvent distillation is also practiced at the plant.

Mixing tanks are provided with a central dust suction system connected to baghouse filter for separation of fine particulate matter. The processing areas are provided with adequate ventilation; for the removal of VOC during manual transfer from containers to mixing tanks.

Minor spills from damaged paper bags of the powdered raw materials are found in some instances, and spills of pigments and residues of the manual filling exist in the processing area, but properly contained.

The following process wastes were identified in the visited plants.

Waste	Sources	Composition
Empty Containers	Unloading raw materials Plastic containers (resins)	Paper bags (fillers)
Fine dusts	Unloading and mixing	Pigments and fillers
Volatile organics	Emission from open process	Solvents
Spills	Filling and accidental discharge	Paint
Waste Water	Spent water from tank cleaning	Paint, water
Waste Solvents	Equipment cleaning using solvents	Paint, solvent
Sludges	Screening sludges and residue of solvent recovery	Paint, solvent, Residues

II. Options for Waste Minimization

* Cleaning of mixing tanks represents the major source of liquid wastes associated with paint manufacturing. The visited plants have no floor drains, which dictates the use of dry clean-up (sweeping). The following are suggested measures to reduce the frequency of tank-cleaning and to minimize the use of liquids in washing.

- Use of rubber wipers to scrape the sides of mixing tanks to remove paint clinging to the walls of the mixer prior to washing.

- Use of high-pressure spray heads in place of regular hoses presently in use, for cleaning water-based tanks. Recycling of cleaning-solvent-based tanks in the plant is presently practiced, this reduces the overall volume of cleaning solvents.

- Use of Teflon lining for mixing tanks may reduce paint adhesion. Reduced clinging minimizes both the frequency and amount of liquids used for cleaning.

- Proper scheduling of paint production for longer cycles from light to dark colours to avoid the need for frequent cleaning. However, long-term scheduling may be difficult at present due to spontaneous changes in production schedules to meet immediate market demands.

* Automation of raw materials addition (metering of liquids and weighed dosages of solids), and automatic pouring of paints could result in significant reduction of air emissions (volatile solvents and fine particulate matter) generated during unloading and mixing of raw materials and may reduce accidental discharges in manual filling. Automation of processing equipment should be integrated in paint formulation processes.

* Volatile organics are emitted in detectable amounts from the open mixing tanks. Processing areas should be provided by conservation vents, carbon absorbers or vapour compressors. Employment of one or more of these emission control methods can result in cost-saving by reducing evaporation losses and improving the working environment.

* Centralized air filtration system minimizes workers' exposure to localized dusting. However, the collected dusts are unrecyclable. Installing a separate <u>dedicated</u> baghouse filter for each production line may enable recycling of the collected dusts. However, retrofitting to segregate dust emissions in the existing plants may be costly.

* Spills inadvertently occur at various places in the paint formulations plants. These spills are presently scooped up to the fullest extent possible. The scooped water-solvent-based materials are redistilled in the solvent recovery still. The use of chemicals (adsorbents) as a replacement for manual scooping should be discouraged as it limits recycling of the spilled materials. Scooping should be carried out immediately to prevent drying and sticking of the paints.

* Recycling of ink is recommended. At present, printers frequently mix leftover with virgin ink which may create problems in printing due to accumulation of solvents and fibers. Waste ink could be collected from printing shops and reprocessed in central facility at the ink plant through filtration and reformulation. The reformulated ink is comparable to lower quality new inks.

Solid wastes are presently codisposed of in the sanitary landfill. This practice should be banned. The hazardous portion of the waste (chemical sludges, rejected paints, packages of toxic chemicals, etc.) should be separated from non-hazardous wastes and stored in on-site restricted area, pending the establishment of new a facility for permanent disposal of hazardous wastes in Riyadh.

5.3. THE COMMERCIAL PRINTING AND PUBLISHING INDUSTRIES

I. Process Description

The printing and publishing industries in SICs include establishments engaged in printing by one or more of the common process such as lithography, gravure or screen and the supporting services such as book binding, engraving, photoengraving and electrotyping. Lithographic printing used in most printing shops consists of making a negative receptive to an oil-based ink in certain fields , while water is used to prevent adhesion to the plate in other areas.

Lithography in the visited plants (Safier Press and All-Obaikan Printers) uses Solvents and Volatile oils that cause VOCs emissions. Pigments used for coloured inks may contain heavy metals, however, most plants have already switched to organic dyes.

Flexography is used for printing packages such as plastic wrappers, corrugated boxes, milk cartons and paper bags. The printing mixture consists of dissolved and dispersed pigments in a solvent. Screening is used for specialized printing on fabrics, in larger printing plants in SICs.

Waste paper comes from rejected print , scraps and overruns. Most trash paper is presently pressed and shipped abroad for reprocessing. Considering the large quantities of trash paper generated in the printing and allied industries in SICs, it is recommended to <u>assess the economic feasibility of establishing a specialized paper reprocessing plants in SICs</u>.

Scraps photographic materials and aluminum plates are presently sold for metal recovery. Spent photo-processing chemicals and plate-making wastes are drummed for disposal . However, illegal dumping in the sewer system is practiced in smaller printing shops.

II. Options for Waste Minimization

- Some of the visited printing establishments have switched to special detergents instead of Isopropyl Alcohol to reduce VOC's emissions from the fountain solutions. However, VOC emissions were deleted where sheets or non-heat set webs inks are used, such emissions can be controlled by installing cooler/condenser systems. Most plants use rags matted with solvents for cleaning operations. The dirty rags contain solvent, waste ink, oil and other contaminants and should be classified as hazardous waste.

- Small ink containers (1 gal.) commonly used at SICs are scraped and discarded with residual quantities of ink. Arrangements can be made, particularly with local ink manufacturers for purchasing ink in recyclable bulk containers which can be used for refilling to eliminate the need for discarding smaller containers.

* Use of electronic pre-press systems for type setting and copy preparation should be encouraged to optimize use of chemicals, films and paper.

* Vesicular films are gradually replacing silver as photographic material in larger printing shops in RIB II. These films produce a non-hazardous waste and their use should be extended to smaller printing shops.

* Metal etching should be substituted by presentisized lithographic or photo-polymer to eliminate hazards associated with cyanide etchings.

* Dangerous chemicals such as benzene, carbon tetrachloride and methanol should be replaced whenever feasible with glycol ether which has lesser toxicity.

5.4. LEATHER TANNING

I. Process Description

RICs II has 3 tanneries; two plants were visited during this mission (Safy For Leather Tanning and Al-Ahli Leather Factory). Another small-scale tannery was visited at JIC (Modern Tanning).

The hides received from local slaughter houses are either cured or green salted. Salting the hides is necessary to reduce the moisture content by diffusion and osmosis and to stop biological deterioration of the keratin and hide constituents.

Processing Starts with cutting hides in half along the backbone (halving or siding). Trimmings are collected and disposed of in the sanitary landfill. Hides are then soaked in water containing a surfactant and lime to allow rehydration. Dirt, salt, blood and non-fibrous proteins are removed in this process. The soak water is heavily polluted and usually drained after soaking to the common sewer system of the plant.

Fleshing involves removal of the attached adipose fatty tissue and meat residues which have been left from the slaughtering process. The fleshing are caught in a trap and the water drained and discharged to the plant sewer system. The fleshing are collected and disposed of in the landfill.

Unhairing is chemically achieved by loosening and dissolving the hair by sodium sulphide or sodium sulphydrate. The hides are conditioned in lime water to dissolve the unwanted residual proteins. Both hair burning and reliming are among the principal sources contributing excessive pollution loads in the final effluent.

Tanhouse processes starts with bating in rotary drums using pancreatic enzyme and solution of ammonium salts. The process results in deliming the skin, reducing swelling, peptizing the fibers and removal of any protein degradation products. In pickling, salt is added to protect the hides from acid hydrolysis. Sulphuric acid is then added to prepare for the following tanning process (in some cases formic or lactic acids are used for acidification).

Chrome tanning followed at SICs tanneries. Sodium formate and chrome tan is added to the pickle solution and the process is performed in rotary drums. At the end of the tanning process, alkali solution is added slowly to increase the Ph of the tan liquor for chrome fixation.
The tanning process contributes substantially to the waste load and represents the major source of heavy metals in the tanning waste.

The traditional hair-save methods of leather production presently used at Al Ahli plant has been replaced by a "straight-through" process at **Safy plant.** In the new process soaking, unhairing, bating, pickling and tanning is accomplished within a single processing unit. Besides eliminating numerous hide handling steps, this modified process results in significant reduction in the beamhouse-tanyard effluent volume.

One-bath chrome tanning is practiced at Al Ahli plant. In this process, hydrated chromic sulphate complexes react with the biologically-occurring, fibrous protein substrate, collagen, to form leather. Means of driving this chrome fixation - reaction to practical completion is the offering of an excess of chromate (III) sulphate. The excess chrome is discharged to plant sewers when tanning is complete. Following the discharge of these spent tanning liquors, relatively large volumes of wash waters are used to remove surface impurities and to extract unwanted salts and oils and greases from the tanned hides. As much as 2 kg of chromium may be discharged in one cubic meter of waste.

II. **Options for Waste Minimization**

* To reduce chromium pollution, Safy plant is already employing high-exhaustion BAYCHROMC process which uses organically masked chrome tanning materials at temperature of 35-40 ^{Oc}. at the end of tonnage and with short floats. The process reduces chromium consumption to 68 percent of the conventional chrome tonnage. This process is recommended in other tanneries, particularly as it does not require major changes of the production process.

* The tanning effluent represent a major source of pollution in RIB II. The untreated effluents (except Safy Wastewater) are presently discharged to the RIB II sewer system laden with high organic and inorganic, dissolved and suspended solids and containing potentially toxic metal residues. Objectionable odours from the decomposition

of protein solid waste, hydrogen sulphide, ammonia and VOC are common in RIB II tanneries.

* Pretreatment of wastewater is presently practiced at Safy plant . this involves screening, equalization, flocculation and clarification. While this pretreatment removes most suspended solids, dissolved organics (Oxygen demanding constituents) are not satisfactorily removed in the existing system. In view of their extremely high pollution loads all RIB II, tanneries should install on-site wastewater pretreatment facilities consisting of Physicochemical (primary) followed by biological (secondary) treatment to reduce the excessive pollution load discharged to the sewer system.

* RICs tanneries should install spent chrome recovery system which consists of concentration of chrome in relatively dilute process wastes to yield a sufficiently chrome-rich byproduct which can be recycled, while substantially reducing effluent levels. The most effective means of achieving this chromium separation/concentration is by precipitation with alkali followed by sludge thickening and filtration .

* One of the most important factors in the design of an efficient treatment system for chrome recovery is the correct choice of alkali for precipitation. While all available alkalies (soda ash, aqueous ammonia, hydrated lime and caustic soda) demonstrate chromium hydroxide precipitation capability, hydrated lime has been accepted for tannery wastewater treatment. Chromium hydroxide has a relatively low particle density and it is highly hydrated in an aqueous system. Only hydrated lime-chromium hydroxide precipitate responds favourably to the addition of coagulants and/or flocculants to yield large, dense, rapidly settling floc particles. The lime-precipitated sludge can be readily filtered to yield a high-chromium filter cake suitable for landfill or subsequent acidification and reuse.

* SICs tanneries which presently employ environmentally objectionable practices, should be expected to tighten-up their operations to prevent wasting resources, chemicals and water and to avoid these becoming sources of pollution; introduction of modern production control system similar to that used at Safy plant should be encouraged.

* Tannery residues can be a useful source of chemicals and protein. For instance it is possible to recover chromium from chrome leather shavings and waste by enzymatic hydrolysis. Leather-board can be produced from vegetable tanned shaving and trimmings. It is also possible to use chrome tanned waste, although the quality of the leather-board is not as high.

* Untanned trimmings represent a source of gelatin, and untanned fleshing a source of glue, both are presently produced from expensive virgin materials. Tallow and grease can be obtained from fleshing by rendering. The possibility of producing protein suitable for animal and fish feeds from trimmings should be also investigated. They can be used alone or in combination with soya and/or synthetic amino acids to supplement the deficiencies in collagen. It is believed that such uses are not religiously objectionable.

* Collagen dispersions can be coagulated with natural and synthetic rubber lattices to give low density rubber shoe soling material. Collagen can be incorporated in coating materials, in pharmaceutical applications, as an absorbent material for filtering sulphur dioxide and other air pollutants. Protein hydrolysate can be applied in the manufacture of cosmetics. They can also revert to the leather industry, being incorporated at the pertaining processing stage.

5.5. METAL FINISHING INDUSTRIES

I. Process Description

Metal finishing constitutes an essential operation in many SICs industries such as manufacture of household appliances, metal furniture, metal and gold industries, and lighting poles.

The following plants were visited during this mission galvanization (National Company for Galvanizing Galvanco, and Omega for lighting poles), golden jewelry (Saudi Gold Co.) and metal furniture (Saudi Kuwaiti Company for Industrial Chrome Metallic and Medical Furniture) .

Metal finishing involves stripping, removal of undesirable oxides, and cleaning. In plating, the metal to be plated serves as the anode. The total liquid wastes are not voluminous, but are **extremely dangerous because of their toxic content.** The most important toxic contaminants are acids and metals, such as chromium, zinc, copper nickel, tin, and cyanide. Alkaline cleaners, grease, and oil are also found in the wastes.

There are two main sources of waste from plating operations, each one is distinctive in its volume and chemical nature: (i) batch solutions; and (ii) rinse waters, including both non-overflowing reclaimable rinses and continuous overflow rinses. Various stripping and cleaning operations may precede the plating processes in RIEs plants .

A typical example of electroplating occurs at the Saudi Kuwaiti plant where the profiles are loaded on travelling racks in a way which allows full exposure of the surface to liquids in the treatment baths and enables removal of the dragout before transfer to the rinsing tanks.

Pretreatment involves soaking the profiles in a decreasing bath which contains a weak alkaline surfactant to remove oily impurities from the surfaces of the articles. Air agitation is provided in this bath to enable effective degreasing. The degreased profiles are transferred to a rinsing process in separate tanks arranged in series.

The profiles are then immersed in Nickel sulphate tank for 7 minutes to form a plating base, followed by rinsing in 3 consecutive washing tanks. Electroplating takes place in the dichromate solution for 3 minutes followed by 3-stage rinsing and final drying.

Galvanization for lighting poles and other profiles at RIEs involves degreasing, rinsing, pickling in HCL solution for 10 minutes at 150 °C , flaking in NH_4Cl $Zn\ Cl_2$ solution followed by hot dip galvanizing in mother zinc bath. All spent plating chemicals are presently collected on-site for eventual dumping in the landfill site; smaller quantities of spent chemicals are often dumped in the sewer system. Dross from zinc galvanization is presently collected and sold for rerefining. Wastewaters generated from rinsing, floor washing and cleaning of tanks also find its way in most instances to the RIB II sanitary network.

II. Options for Waste Minimization

Inexpensive changes in processing and waste control methods can greatly reduce the amount of wastewater and hazardous waste generated in electroplating. Those techniques enable plating shops to avoid much of the waste treatment costs. Moreover, these techniques can actually pay for themselves in a very short period of time because they save large quantities of water and process chemicals.

The following are recommended measures for waste minimization:

* Accumulation of contaminants in the rinsing tanks comes from the dragout of chemicals when the profiles are transferred from the treatment baths to the rinse tanks. Appreciable variations in the volume of dragouts were observed during the plant visits and are attributed to variable speed of withdrawal and variations in concentration and temperature of the bath. Minimizing the dragout may result in substantial reduction of wastewater and improved use of chemicals. The following suggestions may be considered:

  - Increasing the rate of drainage by mechanical vibration or air stream stripping, in plants where such practices are not employed .

  - Sufficient but optimum dripping time should be allowed. Performing **a chemical analysis of total carry-over** can determine the optimum dripping time. Effective process control may replace present arbitrary judgement of the dragout periods, practiced in most plants.

* Rinse water minimization is important to reduce the quantity of wastewater. However, care must be taken in cascade rinsing to ensure control of carry-over of contaminants. Uncontrolled build-up of contaminants may impair the profiles or lead to frequent rejection of the treatment baths.

* Chemical analysis should corroborate the visual inspection of rinse water. Continuous monitoring can be achieved by installation of conductivity meters to measure the rate of build-up of dissolved contaminants; hence enables dumping frequencies to be determined on the basis of actual testing.

* Rinsing is employed in multi-stage rinsing tanks which are totally separated. An alternative which could be investigated without major process changes is the application of the ECO-Rinse system . In this system the first rinse tank after each treatment acts as a static rinse tank in which the dragin/dragout takes place. Dragout is reduced by 50 percent as the same quantity of liquid is transferred to the treatment bath (by the untreated profiles) as to the subsequent rinse tank by the treated profiles. Recovery of chemicals can be optimized while reducing contamination of the preceding baths. Counter-current rinsing should be applied in the second rinsing tank which follows each treatment stage.

* Electroplating involves use of expensive chemicals which represent a source of hazardous pollution. These liquid wastes may be recovered; evaporation achieves recovery by distilling the effluent until it reaches the allowable concentration for reuse . The process offers favorable return on investment and eliminates a hazardous source of pollution. Double-effect evaporation is recommended. In this system, about 50 percent of the spent effluent is concentrated in the first effect using steam. The vapours from the separator of the first effect enters the second-effect reboiler and condenses to provide the energy required to reach final concentration of the plating solution. Distillate can be recycled to the rinsing tanks.

* Drain boards are not used in most plating plants. These may be installed to collect treatment solutions that drip off the travelling rack and the profiles after they are pulled out of the treatment tanks. These solutions if collected and drained back into the treatment tanks can reduce the rate of build-up of contaminants in the rinse tanks. Since dragout is reduced, make-up chemical consumption is also reduced.

* Pure metals can be recovered from dilute static rinses by an electolytic cell system "Chemelec". The metal is recovered directly to the plating bath as dissolving anodes. The cell is used to maintain an electroplating drag-out tank at a low concentration , so that metal losses into the drain are reduced by a factor of about 100.

* Blue passivation in the Galvanic industry uses trivalent chromium instead of hexavalent chromium to allow for reuse of chemical bath, less aggressive rinsewaters and lower operating costs. The conventional technology for the chromating of zinc coatings utilizes hexavalent chromium and mineral acid, which reacts with the metal. The recommended modification utilizes Cr III and H2O2 which dissolves little zinc and the bath can be replenished with concentrate and reused.

5.6. THE COMPOSITE PLASTICS AND FIBER GLASS-REINFORCED INDUSTRIES

I. Process Description

SICs host numerous plants specialized in manufacturing of plastics and fiber glass products. Both thermoplastic and thermosetting resins are used to manufacture FRP/C plastic products at SICs. Thermoplastics processing offers faster molding cycles, lower emissions, ease of recycling and lower labour intensity. Processing involves the combination of polymerizing resin and reinforcing material. FRP/C are manufactured by either mold-based processes or fiber glass coating-based processes.

Production of PVC pipes involves automatic mixing of PVC powder with stabilizers, fillers and colouring pigments. Conversion to plastic pipes by thermal extrusion occurs at 200-210 °C, the hot pipes are continuously passed through a vacuum chamber where water spraying is applied for cooling in a closed cycle. The hot water is continuously withdrawn for recooling and recycling to the vacuum chamber. The pipes are socketed in the final manufacturing stage .

Wasted PVC from extrusion, purging , floor sweepings in the mixing areas, and finishing residues are reclaimed, ground and recycled for reprocessing in pipes for less critical applications. Polyethylene tubes are manufactured in same plants from a ready-mix powder by extrusion.

A wide range of injection and blow molding products are also produced at RIB II from polypropylene, polyester, polycarbonate and polyurethane. Specially shaped acrylic panels and FRP/C sanitary ware are also produced at SICs.

Liquid hazardous wastes in plastics processing include spent cleaning solvents, scrap solvated resin left over in mix tanks, and diluted and partially cured resins.
Solid wastes mostly include gelcoat and resin overspray material that may reach the floors, expired raw materials thickened beyond usefulness, empty resin and solvent drums and clean-up rags.

From the standpoint of waste control and occupational exposure, two solid wastes are most significant. These are (a) the gelcoat and resin overspray and (b) the resin and gelcoat waste that has thickened. The gelcoat overspray, accumulates as a paint-like coating wherever it settles and dries. Approximately 85 percent of the resin spray goes onto the mold and 15 percent may end up as waste. Fabricators in RIEs use spread paper, usually treated with a fire-retardant, on the floor to catch the overspray. Dried overspray is fully cured and non-hazardous, so periodically the paper is collected and sent to a landfill.

Organic vapours consisting of VOC are emitted from fresh resin surfaces during the fabrication process and from the use of solvents (usually acetone) for cleanup of tools, molds and spraying equipment. Organic vapour emissions from fiberglass fabrication processes occur when the polymerizing agents and solvents contained in the liquid resin mix evaporate into the air during resin application and curing.

II. Options for Waste Minimization

* Acetone and methyl ethyl ketone (MEK) are used for equipment cleaning. The solvent is normally reused until the accumulated resin prevents effective cleaning. Proper scheduling of production runs may reduce the need for cleaning equipment between batches.

* Solvents presently used in most plastic and FRP/C plants in SICs may be substituted by less toxic and less volatile solvents that are biodegradable, water-soluble and recoverable. Dibasic ester (DBE) based organic solvents are gradually replacing volatile solvents such as acetone, thus reducing VOCs emissions and increasing the potential for reuse.

* Plants producing moderate quantities of contaminated solvents (about 50 gal/d) are presently disposing of spent solvents with other hazardous wastes in an improper way. Batch-type distillation units are recommended for on-site solvent recovery for those generators. The unit typically consists of collection tank, a heated boiling chamber, a condenser and a clean solvent collection container, all housed via single compact cabinet.

* The existence of over many production facilities (plastics, printing, paint formulation, chemicals .. etc) in SICs offers a unique opportunity to collect and recycle solvents in centralized facilities. Most of these plants generate spent solvents in the range of 5-50 gallons/day. Centralized solvent recycling is well-suited to such small quantity generators in RIB II, who may not generate sufficient volumes of waste solvent to justify on-site recycling. Centralized solvent recycling also offers the advantages of economy of scale, convenience of off-site treatment and improved recovery.

* Emulsifiers may also replace solvents in many cleaning operations.

The emulsifier is an alkaline mixture of surfactants, wetting agents and other preparatory ingredients which can be safely disposed in the sewer as they are biodegradable and non-flammable. Replacing solvents by emulsifiers is recommended for hand and tool cleaning which usually represents the largest consumption of acetone.

* Significant waste reduction can be achieved in FRP/C spraying processes (also applies to spray painting in bus assembly and spray coating of cast iron profiles). Waste often accumulates around the bottom of sprayed objects because the tip of the spray gun is directed down toward the bottom of the object, rather than horizontally. Likewise, in vertical spraying, the spray dissipates as a fine mist away from the object. Appropriate spray orientation may result in elimination of overspraying. Airless systems (electrostatic atomization) or air-assisted systems (air stream which forms an envelope that forces the sprayed liquid to follow a controllable, less dispersed pattern) may also replace high-pressure spraying in many industrial applications in SICs.

* Overburning of PVC during extrusion may occur in case of operation malfunctions and startups. In such cases, considerable toxic PVC fumes emit from the extruders. Workers in this sensitive area must be equipped with **activated-carbon respirators** for protection in case of fume releases, and overhead suction hoods must be installed to enable quick removal of fumes from the extrusion area.

5.7. THE FABRICATED METALS PRODUCTS INDUSTRY

I. Process Description

Metal fabrication processes represent an integral part of many industrial activities in SICs. Metal construction plants, mechanical equipment plants , household appliances and metal furniture plants , all involve metal fabrication, and as such generate various hazardous waste streams, including oily wastes from machining operation, metal-bearing streams from surface treatment operations, and solvent, alkaline and acidic solutions from metal cleaning and stripping processes.

Machining involves drilling, milling, reaming, threading, polishing, cutting and shaping. Metal working fluids include water, emulsions of oils and mineral oils. Spent metal working fluids are at present either discharged to the sewer system or collected and disposed of in the landfill.

Contamination of water miscible metal working fluids by "tramp" lubricating and hydraulic oils constitutes a major problem in the RIEs metal fabricating industries. The tramp oils interfere with the cooling effects of the fluids, impair its filterability and promote bacterial growth.

Metal fabrication plants at RIEs regularly employ cleaning to avoid the generation of rejects during subsequent use or processing steps by removing contamination from the surface of the parts being cleaned. Removal of soils can be achieved by way of detergency, solvency, chemical reaction, or mechanical action. Each of these actions, or a combination of actions, can be employed in a cleaning operation. Organic solvents, the most widely used class of cleaners, are used primarily for removing organic or oil-based contaminants.

Aqueous cleaners contain acids, alkalies or chelating agents. Acid cleaners such as sulphuric, nitric, and hydrochloric acids are commonly used to remove oxidation scale and rust from metal surfaces. Alkaline cleaners are solutions of inorganic salts often used in heated soaked tanks to remove heavy oily soils and some solid soils. Caustic solution is often employed as a paint stripping agent. For both acid and alkaline aqueous cleaners, rinse water plays an important part in the cleaning operation.

Paint application is practiced in the fabricated metal plants, mostly by using surface coating. Several coating techniques including roller coating, flow coating, dipping and spraying are practiced in SICs depending on the size, shape and quantity of items to be painted. The wastes from both cleaning and painting operations are usually drummed for disposal in the landfill, although in some instances, they are discharged illegally to the sewer system.

II. Options for Waste Minimization

* Contamination of metal working fluids by tramp oil can be reduced through periodic gasket and seal replacement. The fluids serviceability can be extended by on-site filtration, clarification and centrifugation. Periodic addition of specialized biocides to the fluid can also extend its life by combating microbe growth.

* It was noticed, in some instances, that articles were cleaned and stored for extended periods before coating. Parts should not be cleaned and then warehoused for long periods before subsequent coating. During storage, the parts become contaminated by air-borne oils or by handling. These contaminants interfere with ultimate finish quality and increase the rate of rejects.

* Appropriate cleaning involves the shortest cleaning sequences, employing the least toxic cleaning medium, generating the least amount of wastes, and still providing the necessary minimum level of cleaning to the part at minimum cost. Any proposed changes to the cleaning process requires careful evaluation of potential effects of the cleaner on the substrate that might affect the integrity of downstream processes (anodizing, plating, painting, etc.). A case in point is the use of terpenes derived from citrus plants and pine trees. These are safe substances, widely used in various industrial applications. The

terpene cleaners are available commercially as water solutions with surfactants, emulsifiers, rust inhibitors, and other additives. Terpenes tested very favorably as substitutes for halogenated solvents for removal of heavy greases, oily deposits, and carbonized oils. Terpenes are also tested as alternatives to chlorofluorocarbons in parts cleaning.

* Since many spray systems at SICs are manually operated, the operator has a major influence on the amount of waste produced. When air pressures are set too high, the paint has a tendency to bounce off the surface and increase overspray. Another factor affecting overspray is the practice of arching the spray gun instead of keeping it perpendicular to the surface. When the gun is arched 45 degrees away from the surface at the end of each stroke, overspray can be great and an uneven coat of paint can result. Manual spraying therefore should be eliminated altogether whenever feasible.

* Preventive maintenance also plays a critical role in reducing the amount of overspray, stripping waste, and equipment cleaning waste produced. Whenever a bad finish is produced, the paint is normally stripped off and the entire paint application procedure is begun again. By maintaining all application equipment in good working order, the likelihood of producing a bad finish is lessened. Spray guns should be cleaned after use or whenever there will be an appreciable interval between use. For hand-held units, a solvent rinse with occasional blow-back (accomplished by covering the fluid tip and operating the trigger, this blows the paint back to its container) is adequate.

* Solvent-based systems for paint application often pose potential health hazards, due to the emission of toxic solvents and the disposal of a large amount of waste paint sludge. To minimize the quantity and toxicity of waste paint requiring disposal, it is recommended to switch to water-based paints, whenever practicable to eliminate the hazardous components of the paint and also to allow for maximum re-use of paint overspray, thus increasing the efficiency of the paint application process.

* It is recommended to switch to water-based paints in place of the volatile solvent paints whenever feasible. One feature which makes water-based coatings attractive is that no major equipment changes are necessary to apply water-based coatings with solvent-based coating equipment. Another advantage lies in the ease of recovering paint overspray. Overspray from a water-based coating can be collected or captured with water in the spray booth. The solution can subsequently be concentrated and reused as paint again.

5.8 BUS AND TRAILER FRAME INDUSTRIES

I. Process Description

The establishments in this industrial category are mostly engaged in assembly and furnishing of buses and trailers and body painting. Two plants were visited during the mission (Al-Jomaih Bus plant in RIC II and The Saudi Bus Co. in RIC I). Most of the wastes generated by these plants are associated with the painting operation including toxic and ignitible thinners, paint and primer wastes, oil-contaminated rags, sanding dusts and non-hazardous furnishing wastes. Body work involves extensive welding, cutting and forging operations. It was noticed that, torching flames in particular, produce considerable air emissions.

Painting is often performed inside a spray booth and all exhaust passed through dry filters (though inadequate and overloaded in most instances). Existing dirty filters may be hazardous due to solvent loading from wet painting. The use of dry filters is limited to capturing particulate matter with limited removal of VOC. Excess paint, sludges and thinner mixtures are poured in large drums for on-site storage. The waste drums are periodically removed by a hauler for disposal in the landfill area. Discarded paint cans and oily rags are disposed of in on-site dumpsters while liquid wastes such as thinners and vehicle washing waste-waters are discharged into the sewer system. Spelled oily fluids and paint residues are commonly allowed to drain onto the floor which are then either absorbed with drying agent or rinsed down drains during routine washdowns.

II. Options for Waste Minimization

* Paint application wastes include leftover paints, dirty thinner from cleaning of spray guns and paint cups, VOCs, and pigments, and dirty spray booth filters. Ways to reduce these wastes include rigid inventory control; better housekeeping practices; mixing paint according to need; better operator training; proper cleaning methods; and recycling solvents on and off site.

* The potential for accidental spills and leaks is highest at the point of transfer of thinners from bulk drum storage to process equipment. Spigots or pumps should always be used to transfer waste materials to storage containers. Direct pouring from drums to smaller container should be banned. Evaporation can be controlled through the use of tight-fitting lids, spigots and other appurtenances. The reduction of evaporation will increase the amount of available material and result in lower solvent purchase cost.

* To reduce VOCs emissions, it is necessary to reduce the amount of paint sprayed for a given job. The standard method of applying paint is the air spray gun. Typical transfer efficiency is on the order of 20 to 40 percent. Many of the newer spray application systems have transfer efficiencies greater than 65 percent. Since with lower

efficiency, more paint is wasted, higher efficiency systems should be used in RIEs plants.

* Operators should be trained not to arc the spray gun and blow paint into the air. The practice of maintaining a fixed distance from the painted surface while triggering the gun should be encouraged. Air pressure (often set too high) should be well regulated. When the pressure is set too high, most of the paint bounces off the object and forms a fog. The proper adjustment of air pressure can increase transfer efficiency by 30 to 60 percent.

5.9. WATER PROOFING MATERIALS INDUSTRIES

I. Process Description

The Arabian Water Proofing Industries located in RIC II,JIC and DIC I are specialized in production of Bituminous water proofing materials. Bitumen which is produced at a nearby refinery as a bottom product of petroleum oil distillation (sof./pent. grade 60/70), is subjected to oxidation at 200 °C to produce oxidized bitumen (foundation asphalt 85/25 and roofing asphalt 115/15). Specialty products such as primer (bitumen and solvents), fiberated and non-fiberated emulsions and aluminum paint (Bitumen, solvent and aluminum powder) are also produced at the plant.

Production of water proofing membranes constitutes coating a carrier (polyester, woven glass fiber, jute or paper) with oxidized bitumen or modified bitumen with rubber of plastic followed by a thin cover coat of polyethylene on which granular plastic, sand or aluminum may be added to form the surface layer of the membrane products.

The main environmental problem of this industry is emission of air pollutants which represents a nuisance to the neighboring industries and residential areas. Waste oil is used for burning in the Bitumen oxidation furnaces. **Hazardous air pollutants HAPs from this process may include dioxin, polycyclic organic matter, trichloroethylene and polychlornated biphenyls.** A large proportion of the emissions occur as organic vapours. However, organic particulate emissions also emanate from the oxidation process.

In the membrane production area, considerable HAPs are released from the coating and surface granulating processes. The existing emission control equipment (wet scrubbing of oxidation vent gases and central suction system in the membrane production department) are ineffective. Extensive emission of HAPs from this plant represents a serious occupational hazard to the workers in the production areas and may cause acute environmental and health impacts in the surrounding areas.

II. Options for Waste Minimization

* The plant management of RIC II plant is presently studying offers for installing thermal incinerator to control HAPs from the bitumen oxidation process. Compared to other techniques, thermal incineration is appropriate for this source of emission as it is much less dependent on HAPs characteristics and emission stream characteristics. Destruction efficiencies up to 99 percent are achievable with thermal incineration. However, it should be noted that while the process can accommodate minor fluctuations in flow, thermal incinerators are not well suited to streams with highly variable flow because the reduced residence time and poor mixing during increased flow conditions decreases the completeness of combustion. It should be noted that, the performance of a thermal incinerator is largely dependent on the combustion chamber temperature. It is, therefore, recommended that continuous monitoring of this parameter be employed if thermal incineration is used for control of HAPs in this plant.

* The use of catalytic incinerators may be also investigated . They are similar to thermal incinerators in design and operation except that they employ a catalyst to enhance the reaction rate. Since the catalyst allows the reaction to take place at lower temperatures, significant fuel savings may be possible with catalytic incineration.

* Emission streams with high HAPs concentrations from bitumen oxidation should not be treated by catalytic incineration without pretreatment since such streams may cause the catalyst bed to overheat and lose its activity. Also, fluctuations in the HAPS content of the emission stream should be kept to a minimum to prevent damage to the catalyst. Destruction efficiencies of 95 percent of HAPs can typically be achieved with catalytic incineration. Higher destruction efficiencies (98 to 99 percent) are also achievable, but require larger catalyst volumes and/or higher temperatures.

* The existing wet scrubbing (condensers) system may be kept as preliminary air pollution control device for removing HAPs from emission stream prior to treatment in the thermal incinerator. In these cases, removal efficiencies obtained by condensers can range from 50 to 60 percent. The removal efficiency of a condenser is highly dependent on the emission stream characteristics including the nature of the HAPs in question (vapour pressure-temperature relationship) and HAPs concentration, and the type of coolant used. Since water is used as a coolant, the saturation conditions represent high outlet concentrations. Therefore, it is not possible for condensation with water only (existing system)to achieve the low outlet concentrations that would be required in HAPs control at this plant.

* Vapour emissions from process fugitive sources particularly during membrane coating and drying, can be controlled at points of generation by add-on absorption device in conjunction with the existing hooding, enclosures or closed vent systems. Since operators have to access the

equipment and the coated felt from feeding to discharge, existing hoods and partial enclosures can not be avoided as primary devices for collection of vapours. In the proposed absorption system the exhaust gases passes from the collection hoods to a series of carbon beds which capture HAPs. To desorb the HAPs the beds are backflushed with steam or hot air. The effectiveness of the system depends not on the amount of adsorption of a new bed but on the loading which the bed can achieve in regular cyclical operation. The amount of organics recovered depends on the HAPs and type of carbon, but generally the removal efficiency is in the range 95-99 percent.

5.10. INDUSTRIAL GASES

Acetylene is produced at Industrial Gases Plants in RIC II and in JIC by chemical reaction between calcium carbide and water. The calcium carbide is fed into the water to form acetylene gas, and calcium hydroxide or lime slurry which is discharged as waste from the generator at a rate of 10 CMD. The collected lime slurry is stored in a tank and trucked daily for off-site disposal .

The generator is designed to generate acetylene at pressures not exceeding 15 PSI. Acetylene that has passed through the first stage of the compressor is not normally allowed to accumulate in large volumes. Charging acetylene which has passed the first stage of the compressor is always confined to small volumes within piping and specially constructed containers. Acetylene cylinders are so constructed that when charged can be safely stored at pressures above 15 PSI. Recycled water is used for cooling cylinders during charging. The plant visit did not disclose any unique environmental problems or significant opportunities for waste minimization.

5.11. FOUNDRIES

Two foundries were visited during this mission; the modern factory for Casting in RIC II and Al-Dakheel Foundry in RIC I. Both plants rely on scrap for gray-iron production. Melting occurs in direct flame fuel fired furnaces that emit considerable smoke which is collected by hoods discharging to gravity stacks.

The molten metal is transported to the pouring area in a transfer ladle, where it is poured into the pouring ladle. The poured molds are then allowed to cool for a period of time, and the solidified castings are removed from the mold, rough cleaned of mold material, and allowed to cool until the cast metal is cold enough to handle. During this time the metal emits a light smoke, and the smoke is removed by exhausting. The pouring stations in the visited foundries are not provided with hoods and the fumes are dispersed in the production areas.

After the casting is removed from the mold, a cooling conveyor carrying hot castings is provided to expose them to outside conditions until they are ready for the cleaning room.

The sand handling system that returns, conditions, and supplies the basic ingredient in the sand mold has many points where dust is generated. Hoppers below the shake-outs, discharge to a system of conveyors, elevators, chutes, screens, coolers, bins, mixers, and the like. From the first place the poured mold is broken , and at every subsequent point where work is done to remove the solidified casting from the mold, exhaust ventilation must be provided. The route that the hot, heat-fractured sand follows on its return trip to the mixer (where it is again conditioned for molding) must be ventilated at each point where the sand is disturbed. Some of the points, such as the shake-out, plows, and mixer, need special hooding to accommodate workmen required on the process. Other points, such as transfer points where the sand falls from one conveyor to another, can be enclosed as much as possible.

When the castings have cooled enough to be handled , the spruces and cores are removed. This is done by knocking them off by workmen using handtools. The station where knocking is done are not exhausted to protect the workmen and remove the dust. The refuse generated at this operation is removed by conveyor, either to a sprue mill where the metal is prepared for remelting or to a point where the waste material is deposited. The sprue mill and the conveyors carrying the dust waste material are not provided with dust exhaust. It is therefore recommended to install air cleaning device such as a medium-efficiency wet scrubber or a fabric arrester.

Following the knockout, the casting are cleaned. Depending on the type and the size of casting involved, this is done by grinding, abrasive blasting, tumble mills, chipping, sawing, cutting, powder washing, etc. All these operations create dusty conditions; an efficient exhaust ventilation system should be installed to reduce air emissions.

Extractor fans may be used for collection of fugitive dust. The dust can be recovered by water scrubber while the collected sludge is returned to the mixer to make new mould.

5.12 EDIBLE OIL REFINING

I. Process Description

The visited Plant in JIC is specialized in refining of palm, sunflower, and corn oil. The production capacity is 65000 t/y refined oils. Processes involve neutralization to remove natural acidity and continuous bleaching with fuller's earth at 160 C.

The bleached oil is then passed to a heat exchanger in a counter-current flow with the superheated oil from the deodourization process. This results in substantial energy conservation as the bleached oil is preheated before entering the deodorizers while the deodourized oil is subjected to precooling before filling;

similar energy conservation is achieved in other processes. In addition to conserving energy, this system minimizes the need for water cooling and steam heating in oil refining.

The bleached oil is subjected to deodourization in the final treatment stage to remove objectionable volatile matter. Vacuum is achieved by multi-stage steam ejectors which utilize water in successive stages to maintain vacuum in the deodorizers. The refined oil is cooled and packaged using fully-automated filling system.

II. Options for Waste Minimization

* The condensates from the steam jet ejectors contain substantial amounts of volatile substances; this polluted effluent is subjected to Dissolved Air Flotation where finely-dispersed air bubbles cause agglomeration of the dispersed oil. The treated oil is recycled in a closed water cooling system.

* Solid wastes, mainly composed of spent bleaching clay (about 170 t/y) is presently dumped in the municipal landfill. Despite the non-hazardous nature of this waste, it is advisable to assess the possibility of its regeneration by caustic treatment and reactivation by calcination at elevated temperatures. The reactivated clay can be reused in various bleaching and adsorption processes in the industrial cities.

* Water meters should be installed for major processes to provide water-use data and to detect excessive use incidences. All cleaning-water hoses should be equipped with automatic shut-off valves and high pressure sprays to conserve water used for housekeeping operations.

* Monitoring instruments should be installed at major wastewater outfalls. A time-activated sampler may be useful in visual monitoring of excessive oil and turbidity.

* Addition of extra drip-shields on oil-filling equipment may be help in containing oil in case of filling-machine jams. The existing bottom drip saver is not adequate for collection of tangential splashes which drip from the glass shield in case of operational failures.

5.13 YEAST PRODUCTION

The only plant for production of yeast is located in JIC. Imported molasses from Egypt and Italy are fermented using Saccharomyces Cerisiae. At the end of the propagation process yeast cells are separated from the mash and filter-pressed to obtain the yeast blocks. The rated capacity of the plant is 2000 t/y dry basis yeast.

The wastewater generated from the plant is ladened with organic matter, acids and mineral salts. On-site biological wastewater treatment using a new anaerobic treatment process has a rapid hydraulic throughput, high loading capability, low sludge production, and stable operation. The system appears to operate satisfactorily; however, no wastewater analyses were available to check operational performance.

The high nutritive value of the waste yeast from the fermentation process (Carbohydrates 43 % and Protein 47%) makes it suitable source for many products. The proposed recovery system involves sieving, degassing, evaporation, distillation, and drying. The recovered materials include concentrated proteins, carbohydrates, vitamins and ethyl alcohol. These products can be profitably marketed for various commercial uses.

5.14. MATCH MANUFACTURING

Matches are produced at a plant located in JIC using the continuous machines of the cut, set and dip type. The splints are passed through a bath of weak solution of monmammonium phosphate to prevent after glowing of the used splints. The treated splints are then forced through holes in plates which are arranged on an endless chain whose motion carries the splints through successive dipping and filling operations. The dip consists of potassium chlorate as an oxidizing agent, sulphur and rosin as oxidizable material. Glue is used in the dip mixture as an oxidizable blending material and ground glass is added as filler.

After dipping and air drying, the matches are punched out into a vibrating trough. Match boxes prepared at the plant are opened and matches are inserted through automatic filling machines.

Match manufacturing generates minor amounts of wastewater from equipment cleaning as most processes are dry in nature. Most rejects are reprocessed or contained in a proper manner. Housekeeping practices are acceptable.

5.15. MANUFACTURING OF TISSUE PAPER

Tissue paper is produced from the imported "Jumbo rolls" at a plant located in DIC II. The manufacturing process involves mixing of the pulp with addition of starch and antifoaming agents; refining and preparation of tissue paper by continuous process on a Yanki paper machine. The refined slurry is fed at constant rate to an endless wire screen to reduce the water content. The formed paper layer moves on a felt blanket through a series of pressing rolls and then through the drying section of the machine to adjust the final moisture content to about 10%.

The plant produces 60000 t/y tissue paper and consumes about 1000 m3/d process water. Water is withdrawn from on-site well and subjected to reverse osmosis treatment to remove salinity and to render it suitable for the requirements of tissue paper manufacturing. Wastewater generated from processing operations is presently discharged to the central sewerage system without on-site pretreatment.

The white water from the paper machine is recycled for dilution of stocks. The use of save-all clarified water for felt showers is being investigated to insure its suitability for extended applications. Inclined screen savealls are not recommended as they do not remove suspended matter effectively. The clear liquid may be only used for stock dilution. Rotary or drum savealls are more effective than the ordinary screen type and the clear water from these savealls can be used for paper-machine showers.

It should be noted that, prolonged water reuse may result in build-up of suspended solids that can lead to plugging and reduction in life of wires and shower nozzles. The dissolved solids may lead to corrosion and scaling of equipment, and accumulation of colour and odour. Therefore, a through investigation is warranted to optimize the operating conditions of the saveall system at the plant.

5.16. PRODUCTION OF DETERGENTS

Modern Industries Plant in DIC II produces variety of household detergents and shampoos. Molten sulphur is oxidized to sulphur trioxide SO3, in successive reaction towers. Linear alkyl benzene reacts with the formed gas to form Alkyl benzene sulphonate ABS which constitutes the basic ingredient in all-purpose household detergents.

Additives are mixed with ABS in for formulation of detergents . These include, Sodium triphosphate (disperser), Sodium Sulphate (reduces interfacial tension), Carboxy Methyl Cellulose (reduces redeposition), Sodium Silicate (corrosion inhibitor), and fatty acids(foam stabilizer). Brighteners, perfumes and antioxidants are also added to detergent formulations.

Because of the hazardous nature of SO3, the process is essentially leak free. Continuous operation of the sulphonation reactor reduces generation of pollutants to a great extent. A considerable amount of water is used for cooling the sulphonation reactor; however, recycling minimizes water consumption in this process. Wastewater from neutralization comes from leaks with occasional contribution from wash-outs. Product changes and build-up of deposit require periodic shut-downs for cleaning. Major sources of wastewater are wash-outs of equipment and effluents of gas scrubbing. Wastewater is discharged to the sewerage system without pretreatment.

The plant is implementing sound environmental practices which involve monitoring of emissions, incorporating measures for waste minimization, and implementing field studies for assessment of products life-cycles.

5.17. PRODUCTION OF ORGANIC CHEMICALS

The Dhahran Chemical Industries in DIC II produces pure acrylic for paints, styrene acrylic for exterior coatings and PVC formulations, terpolymer for emulsion paints, homopolymers for adhesives, and copolymers for fabric finishing in the textile industries.

Wastes arisings constitute spills, off-specification products, and tank residues. Practical and simple changes in formulation and packaging areas can reduce waste generation. The proposed measures depend on a change in workers attitude toward environmental and occupational requirements rather than on employing process modifications. Spills inadvertently occur during processing; scooping should be carried out immediately to prevent drying and sticking of polymers. Improved cleaning of processing tanks can be achieved by using rubber wipers to scrape residues clinging to the walls of the mixers. On-the-job training is recommended to improve production practices and environmental awareness.

Nalco Saudi Company at DIC I produces oxygen scavenging chemicals, ion-exchange resins, corrosion inhibitors and water clarification chemicals. The rate of production is 3000t/y. The company is using returnable containers scheme which eliminates drum disposal problems, reduces accidental spills, enables continuous chemical feed, and alleviates disposal problems of residual chemicals. Such innovative approach should be followed, whenever feasible, in all chemical handling systems in SICs.

5.18. PRODUCTION OF DUCTILE IRON PIPES

The Saudi Arabian Ductile Iron Plant is located in DIC II. The plant produces 50000 t/y DI pipes; the gray iron is melted and magnesium is added to produce DI. The molten Di is automatically fed via a tilted trough into a cylindrical metal mould, rotating at high speed. The molten iron is distributed over the wall of the mold and solidifies . Once removed from the moulds, the pipes are annealed at a controlled temperature to reduce the hardness and increase the elongation. Finishing of the DI pipes consists of external coating with metallic zinc and internal lining with cement mortar.

The plant has an advanced (RO) water treatment plant which produces 1000 m3/d deionized water for various processing and cooling operations. The plant employs recent advances in production technology and applies intensive water recycling in cooling operations. Coating and lining of the DI pipes is performed automatically which cuts waste generation drastically. Ultrafiltration of the spent fluids which are used for cold machining is recommended. The spent fluids may be pretreated through a magnetic filter; ultrafiltration ensures removal of pollutants with larger molecules than the active fluids.

5.29. ALUMINUM PRODUCTS

I. Process Description

The Aluminum Products Company produces 160000 t/y Aluminum profiles; the plant is located in DIC I. Aluminum billets are preheated and fed into cylindrical chamber of the extrusion press to form profiles according to the shape of the die orifice. The profiles are then cooled, aged, pre-treated and subjected to surface treatment. This involves anodizing, chemical dying , and electrostatic colouring.

Pre-treatment involves degreasing, rinsing, etching in concentrated caustic bath, desmuting in dilute sulphuric acid bath followed by rinsing. The profiles are then subjected to passivation in a hexachromate bath followed by rinsing and drying.

Anodizing the profiles is accomplished in concentrated acidic Sulphuric acid bath where Aluminum strips attached to the sides of the bath acts as cathodes while the profiles act as anodes. The acid used in the anodizing bath is periodically treated in an ion-exchanger to remove impurities accumulated during processing and reused in a closed cycle.

Electro-colouring is performed in sequential pattern. The bronze colour is developed by immersion in stannous sulphate bath which contains a commercial pigment. An alternating current is used for metal deposition on the profiles. Finishing of the articles consists of rinsing, chemical fixation, and sealing in hot water.

Wastewater generated from rinsing, wasting of treatment liquors, floor washing, and equipment cleaning are neutralized and settled in an on-site facility and transferred by tankers for off-site disposal at a rate of 700 m3/d. Alkaline effluents from degreasing ,etching and rinsing are segregated from the desmuting and passivation effluents . These acidic wastes are adjusted to pH 2-3 and its dichromate content is reduced to chromate by sodium metabisulphite. The reduced chromate is mixed with the alkaline effluent which causes precipitation of chromium hydroxide at pH 8-9. The treated effluent is trucked for disposal in the Jubail Hazardous Waste Facility.

II. Options for Waste Minimization

* Dilution rapidly reduces the quality of the passivation solution, which necessitates periodic replacement of expensive chemicals. To overcome this problem, it is proposed to subject the dilute solution to filtration and concentration in rinse film evaporator. The condensed water vapours can be recycled in the rinsing tanks, while the concentrated chromate solution can be returned to the passivation process.

* Impurities entering the passivation bath can be reduced through allowing sufficient retention in the rinses and extending drainage time prior to passivation, and by installing dripping plates on the reaction tank to minimize dragout of the chromate solution.

* Static rinsing could be replaced by counter-current rinsing or ECO-rinsing. This can reduce dragin/dragout and improve utilization of chemicals.

* Chemical analysis should replace visual inspection of processing bathes. Installing conductivity meters is essential to monitor the rate of build-up of dissolved solids (contaminants) which enables accurate determination of liquors' replacement frequencies.

6. CONCLUSIONS AND RECOMMENDATIONS

While recognizing that industrialization is vital for sustainable development in Saudi Arabia, more emphasis should be **placed on cleaner technology, conservation of resources and abatement of pollution at source.** The following actions deserve consideration by the Ministry of Industry and Electricity:

* Generous incentives are offered to encourage private investment in SICs. Such incentives have yet to incorporate protection measures to control industrial emissions within the context of the national strategy to conserve environmental amenities. Creation of an environmental management unit within the institutional framework of ICD/MIE will provide a mechanism for addressing pollution problems and environmental concerns in SICs (Section 4.4).

* There is a need to influence the options for new industrial activities in SICs, and to make use of proper experience and judgment for identify likely problems and proper mitigation measures for pollution control, particularly in hazard generating industries. The environmental impact assessment regulations, recently proposed by MEPA, may produce such a prospect for proper environmental planning during the extension of existing SICs and the development of new ones in the Kingdom.

* Wastes are produced by almost all SICs production facilities, but some are most likely to produce hazardous constituents requiring special treatment. Wastes from tanning, metal plating and finishing, printing, paint formulations, water proofing materials and plastic molding requires particular attention for proper containment of their hazardous wastes. A cradle-to-grave policy should be adopted for proper management of hazardous wastes in SICs (Section 3.1); the proposed MEPA regulations for hazardous waste control is a step forward in this direction.
  Inadequate network of facilities and supporting infrastructure for hazardous waste handling exist in some industrial sites. Alternatives for waste management include incineration, detoxication, and landfill containment. Incineration is not recommended to avoid air pollution problems. Detoxication is practiced on a limited scale in some industrial establishments; however, the process generates large quantities of hazardous sludges , which complicates transfer and disposal problems. Landfilling appears indispensable for an integrated hazardous waste management scheme in SICs , but disposal sites have to be properly designed, operated, and monitored.

* MIE should review existing economic incentives to SICs investors, to ensure their compatibility with the goals of conservation of resources and prevention of pollution; incentives that conflict with these goals should be removed. A priority action for MIE, is to adopt and implement the polluter pays principle, which reflects the price of environmental damage arising from

pollution in the production costs (Section 4.1). A proper guidelines for environmental audit of the existing SICs should be developed and implemented by MIE in cooperation with MEPA to ensure the sustainability of industrial development in the Kingdom.

* A system for information services operated by ICD/MIE may act as a delivery mechanism for information concerning legislation, emission standards, cleaner technology, waste minimization and other relevant issues influencing decisions regarding industrial environmental management (Section 4.2).

  A waste exchange system in SICs should be established based on uniform classification of wastes. The system could operate through a clearing house to link potentially interested users with generators of wastes. The information might include characterization, amounts and suggested reuses of wastes.

* The level of awareness for pollution prevention among SICs personnel has to be strengthened. Development of human resources for effective pollution control in SICs should receive priority. On-the-job workshops for the workers, and group seminars for industrial managers, ICD/MIE staff and regulatory personnel are bound to strengthen environmental awareness, enhance responsiveness to pollution control initiatives and create specialized cadre for environmental management in SICs (Section 4.3).

* Pollution control legislation should consider cost of practicable waste treatment technology, and the relation between emission loads and the assimilative capacity of the environment. Legislation should be drawn up and enforced in such a away that if violations occur, effective sanctions can be imposed.

* There is a need to link enforcement with evolving environmental jurisdiction through implementing an integrated monitoring scheme which involves liquid and gaseous emissions, solids and hazardous wastes, noise and the work environment. The institution of effective monitoring programme in support o environmental enforcement will reflect the MIE interest in maintaining a clean environment in SICs for the benefit of workers and the surrounding communities (Section 4.4).

* Despite the increased interest in cleaner technology, its wide-scale application in SICs has yet to benefit from the new and proven technologies introduced in similar industrial activities in the industrialized countries. This is attributed to inadequacy of information on new waste minimization technologies, management resistance to employ what they view as cumbersome changes and lack of policy measures conducive to investment in such technologies.

* Employing innovative cleaner technologies and utilization of low-waste production systems should be regarded as an essential prerequisite to approving new industries in SICs. Such technologies can be easily adopted during installation of new factories or when a plant is retooling and replacing worn out equipment. Retrofitting existing plants may be expensive, but inevitable if these plants are to be brought in compliance with the limitations on industrial pollution in the Kingdom.
  Pollution control efforts at the end of the manufacturing processes should be continued, however, prevention technology must be adopted to the best technical capability.

* The common assumption that waste generation is limited to the manufacturing processes only, is invalid. Waste minimization should involve all stages of material handling, from unloading of raw materials, transfer, processing and storage of finished products. The five categories of waste minimization identified in this report include, process changes, operational changes, chemical substitutions, and product reformulations. These options should be given careful consideration for improved environmental management in the SICs manufacturing establishments.

* Several changes in the present operating and house keeping practices are proposed to minimize waste generation in dairy processing, paint formulation, printing, tanning, metal finishing, plastics and fiber-glass, fabricated metals, bus assembly, water proofing materials and foundries.
  The goal is to limit unnecessary waste generation at minimum cost. Applying waste segregation, improving materials handling, leak detection, and preventive maintenance are examples of easily applicable operating practices. Others include scheduling of batch operations to limit the frequency of equipment cleaning, reduction of paint overspraying, recovery of solvents and toxic metals, reclamation of waste papers and tanning residues. Specific actions were also recommended to conserve wastes in food processing, improve reactions in chemical industries, replace toxic compounds with less hazardous materials and on-site treatment of volatile emissions and polluted effluents (See 5.1 to 5.11).

ANNEX I

A PROPOSAL FOR ESTABLISHING AN ENVIRONMENTAL MANAGEMENT UNIT IN ICD/MIE

Strengthening environmental management functions of ICD/MIE, requires establishing a new unit to carry out these functions. The unit should be charged with managing pollution problems within SICs and coordinating environmental protection activities with other concerned government institutions.

EMU must use all practicable means consistent with the national and MIE environmental polices to strengthen pollution control programmes and optimize the use of resources within SICs . The proposed duties of EMU embrace inter alia:

* Review and appraisal of the various programmes and activities of industrial plants and enterprises in the SICs for the purpose of determining the extent to which such programmes and activities are contributing to the achievement of the goals of environmental protection and to make necessary recommendations to the concerned industries in that regard;

* Coordinate with MEPA the development and implementation of a collective programme for off-site treatment of hazardous wastes , and supervise operation of the centralized WWTPs , with emphasis on enforcing measures to reflect costs associated with pollutants discharge so that they will be taken into account in the waste disposal decisions of the polluters (see section 4.1);

* Implement programmes for manpower development and on-the-job training for pollution control and waste minimization;

* Enforce regulations for control of industrial emissions;

* Development and implementation of a comprehensive pollution monitoring programme according to the following outlines:

A. Discharge of Industrial Wastewater

The proposed scheme for issuing permits comprises three essential steps. Namely, preliminary review, issuance of clearance certificate and discharge permit:

(i) Preliminary review: Prior to construction of new facilities or expansion of existing ones in SICs, industries will be required to submit a detailed report which would include the following information: description of the process ; raw materials and auxiliaries used, especially hazardous and priority pollutants; water balance with schematic for points of use; recycle and discharge ; characteristics and loads of pollutants generated in the raw effluents; descriptions of wastewater treatment facilities and the anticipated loads of pollutants discharge with the treated waste; layout of the plant and the waste treatment facility; and the anticipated date of operation. The report should be submitted to EMU 4 months prior to starting construction. (See Annex II).

(ii) Clearance certificate: Upon review of the report, EMU will advise the applicant of one of the following decisions: (a) clearance for starting construction; (b) provisional acceptability pending meeting additional requirements; or (c) refusal to grant clearance based on the submitted information. The receipt of the clearance certificate does not absolve the industry of its responsibility to complete procedures required by other government agencies.

Steps (i) and (ii) are presently imposed with some variations as prerequisites for approval of new projects in SICs. MEPA (No Objection Certificate) is also requested before issuing the final project approval by MIE.

(iii) Discharge permit: The discharge permit will include a description of effluent sources approved for discharge, pollutant parameters and their analysis frequency, applicable discharge standards, method of reporting spills, periodic reporting requirements and the expiration date of the discharge permit.

(iv) Monitoring violations: If priority parameters exceed those specified by MIE or MEPA guidelines by 10 to 30 per cent, this should be regarded as a "temporary event". This may be caused by industrial leaks, spills, or short-term non-point discharge. Identifying causes of temporary violations is difficult due to the transient nature of the source. Temporary violations should not be used as a regulatory tool as they provide only circumstantial evidence of pollution; yet they are valuable for assessing chronic problems of a transitory nature such as deliberate dumping of prohibited wastes and as a cross-check on incidents of major industrial leaks. A chronic violation, on the other hand, is defined as a case of more than 30 per cent in excess of the limits of the regulated pollutants for 3 or more consecutive checks. This can be traced through periodic and annual reports to determine if a violation in certain plant represents a temporary or a chronic event.

B. Monitoring Air Emissions

Activities of air monitoring may include:

(i) Monitoring ambient air quality through data collected from the fixed stations network to establish air pollution index (API), to predict long-term trends and to correlate ambient concentrations with local meteorological data;

(ii) Mobile monitoring, needed for hot spots (high-impact areas) identified through complaints and not covered by the stationary network, to measure the impact of specific industrial plants;

(iii) Existing polluting industries are required to submit an overall assessment of their gaseous pollutants, and their proposed plan for abating air emissions. Actual or estimated API values above set criteria by MEPA or MIE will provide guidance for acceptance of proposed additional activities in SICs;

(vi) New industries should submit **prior to construction** a review report covering the following: identification of emission sources (raw materials, fuel, products); characteristics and loads of fugitive emissions; location of stacks associated with point sources, type of control equipment and efficiency at full and normal loads; in-house monitoring programme; and expected dates of completing construction and reaching normal operation.

C. Solid and Hazardous Waste Monitoring

The plan involves monitoring compliance with guidelines (recently proposed by MEPA) for collection, transport, reuse or disposal of refuse and industrial residues. Implementation of the plan consists of the following:

(i) Implementing regulations for management of solid wastes and codes of practices for collection and transportation activities undertaken by the private contractors and the documentation data of the sanitation authorities (collection schedule, vehicles for pickups, vehicle maintenance, amount of trucked refuse, etc.);

(ii) New and existing industrial facilities should submit a statement to EMU concerning the generated residues which are temporarily contained or disposed of with domestic refuse, and estimates of construction and demolition debris and their disposal method;

(iii) Monitoring of hazardous residues generated from SICs industries will be undertaken by EMU in coordination with MEPA. Generators shall submit information concerning: chemical composition and characteristics of the residues (ignitability, corrosivity, toxicity, radioactivity, mutagenicity or infectiousness): quantities generated; storage location (climatic data, topographic and soil characteristics, hydrological data including anticipated impacts on water resources); storage procedure (dikes, transfer areas, surface impoundments and tanks); industrial operations must formulate and implement contingency plans for emergencies and major spills which specify a course of action in the event of accidental release of hazardous materials, equipment and material used to combat release, staff training and notification procedures;

(iv) As most of the hazardous wastes generated within SICs are disposed of off-site, MEPA in the recently proposed regulations for management of hazardous waste (currently under review by MIE) will institute a manifest system to track handling, transporting and disposing of hazardous waste. The manifest will accompany a bulk shipment or individual batches and record the following information: The generators' name and address; description of waste; handling precautions and hazardous properties; quantity of transferred material; designated disposal facility. Following the signing of the manifest by the operator of the disposal facility, it should be returned EMU. Implementation of the new regulations in coordination with MEPA will eliminate most of the short comings of the present system for management of hazardous wastes in SICs.

D. Monitoring Noise and Occupational Exposure

The occupational health centre which operates under the supervision of the Ministry of Health MOH, provides medical services for workers in RIB II in case of injuries but does not provide regular services for monitoring working conditions or hazards which affect occupational health.

It is therefore, suggested, to integrate the functions of monitoring the work environment in the EMU activities; this task should be undertaken in cooperation with MOH with full participation of the existing centre in the new scheme.

The monitoring plan sets forth the procedures for acquisitions, reporting and interpretation of noise and occupational exposure data.

(i) Noise monitoring at emission sources (locations of industrial, and construction activities) and receptor areas. Noise should be monitored at appropriate times such as periods of relaxation versus times of high-noise levels during rush-hours.

(ii) Occupational exposures include a host of sources: physical (noise, vibration, excessive temperatures, ionizing radiation); biological (insects, moulds, fungi, bacteria); biochemical (monitoring, repetitive motion, fatigue); and chemical inhalation or skin absorption (mists, vapours, gases, dusts, fumes). The monitoring plan may encompass: (a) evaluation of sources of hazards and measurement of exposure level; (b) setting controls to reduces exposure.

ANNEX II

PROPOSED INDUSTRIAL WASTEWATER DISCHARGE PERMIT APPLICATION

I. APPLICANT AND FACILITY DESCRIPTION

1. Name of Facility

   ....

2. Mailing Address

   ....
   ....

3. Chief Executive Officer

   Name ....

   Title ....

4. Authorized individual to contact in case of emergency (i.e., spill, fire, process upset, etc.) or for information in this application.

   Name ....
   Title ....
   Facility Phone Number ....

II. PLANT OPERATIONS

1. Provide a detailed description of manufacturing processes, facilities or service activities provided on the premises, specifically those processes which involve process wastewater or hazardous materials. Use additional sheets in necessary.

   ....
   ....
   ....
   ....

2. Principal raw materials used.

   ....
   ....
   ....

3. Chemicals and compounds used (Refer to Table I):

   ....
   ....
   ....

4. Solvents used:

   ....
   ....

5. Describe storage practices for the chemicals and solvents listed above:

   ....
   ....

6. List all products manufactured or services provided by your facility along with the corresponding SIC (Standard Industrial Code) number.

PRODUCT OR SERVICE	**SIC CODE**
....	....
....	....
....	....

III. WATER USAGE AND DISCHARGE INFORMATION

1. List intake water sources and volumes:

Source	Volume M3/d	(Check one) Estimated/Measured
Municipal Water System	....	........./.......
Private Well	....	........./.......
Industrial Water	....	........./.......
Purchased Water	....	........./.......

2. List average volume of discharge or water:

Source	Volume M3/d	(Check one) Estimated/Measured
City Sewer System	....	......../........
Waste Hauler	....	......../........
Evaporation	....	......../........
Contained in Product	....	......../........
Other (Specify)	....	......../........

3. Describe how each process and contact cooling waste stream is generated (use additional sheets if necessary)

....
....
....
....

4. Is the discharge to the sewer:

Continuous ....
Batch ....
If batch discharge, give the frequency of occurrence:
....
What is the average volume in M3 of each batch?
....
What is the maximum volume in M3 of each batch?
....
What is the number of batches each?
Day......... Week........... Month..........
Quarter........

IMPORTANT:

Provide a schematic of the plant flow showing process, sanitary, cooling streams, etc., and their point of entry into the sewer system. Indicate on the schematic location of pretreatment facility.

IV. Pretreatment

1. Describe any wastewater treatment equipment or processes in use:

   ....
   ....

2. Describe any additional pretreatment facilities and/or processes under consideration. Include a specific time schedule for completion:

   ....
   ....

3. Do you dispose of any chemicals, solvents, sludges, or hazardous materials as a result of your production processes?

   ( ) yes ( ) no

   If so, provide a description of each material, giving the composition,; annual quantity, and means of disposal.

   ....
   ....
   ....
   ....

4. If a private hauler is used to haul sludges/residuals, provide name and MEPA Identification Number.

   ....
   ....

5. Where is the ultimate disposal site for sludges/residuals?

   ....
   ....

6. Do you have copies of manifests for waste hauled off site?

   ( ) yes ( ) no

7. Do you have a spill prevention, containment and control plan (SPCC) for your facility?

   ( ) yes ( ) no

8. Do you have a solvent management plan for your facility?

   ( ) yes ( ) no

9. Do you have a certified operator for your pretreatment facility?

   ( ) yes ( ) no

   If yes:

   Name..
   Address...
   Certification Number..............................

PRIORITY POLLUTANTS

Priority pollutant	Type of chemical substance
Acenaphthene	Aromatic
Acenaphthylene	Aromatic
Acrolein	Organic
Acrylonitrile	Organic
Aldrin	Pesticide
Anthracene	Aromatic
Antimony	Metal
Arsenic	Metal
Asbestos	Mineral
Beryllium	Metal
Benzene	Aromatic
Benzidine	Substitute aromatic
Benzo[a]anthracene	Aromatic
3,4-Benzofluoranthane	Aromatic
Benzo[k]fluoranthane	Aromatic
Benzo[ghi]perylene	Aromatic
Benzo[e]pyrene	Aromatic
e-BHC-α	Pesticide
b-BHC-β	Pesticide
r-BHC (lindane)-γ	Pesticide
g-BHC-Δ	Pesticide
bis(2-chloroethoxy)methane	Chlorinated ether
bis(2-chloromethyl)ether	Chlorinated ether
bis(Chloromethyl)ether	Chlorinated ether
bis(2-Chloroisopropyl)ether	Chlorinated ether
bis(2-Ethylhexyl)phthalate	Phthalate ester
Bromoform	Chlorinated alkane
4-Bromophenyl phenyl ether	Chlorinated ether
Butyl benzyl phthalate	Phthalate ester
Cadmium	Metal
Carbon tetrachloride	Chlorinated alkane
Chlordane	Pesticide
Chlorobenzene	Chlorinated aromatic
Chlorodibromonethane	Chlorinated alkane
Chloroethane	Chlorinated alkane
2-Chloroethyl vinyl ether	Chlorinated ether
Chloroform	Chlorinated alkane
2-Chlorophenol	Phenol
4-Chlorophenyl phenyl ether	Chlorinated esther
2-Chlorophythalene	Chlorinated aromatic
Chromium	Metal
Chrysene	Aromatic
Copper	Metal
Cyanide	Miscellaneous
4,4-DDD	Pesticide
4,4-DDE	Pesticide
4,4-DDT	Pesticide
Dibenzo[a,h]anthracene	Chlorinated aromatic
1,3-Dichlorobenzene	Chlorinated aromatic
1,4-Dichlorobenzene	Chlorinated aromatic
3,3-Dichlorobenzidene	Substituted aromatic
Dichlorbromothane	Chlorinated alkane
Dichlorodifluromethane	Chlorinated alkane
1,1-Dichloroethane	Chlorinated alkane
1,2-Dichloroethane	Chlorinated alkane
1,1-Dichloroethylene	Chlorinated alkane
2,4-Dichloro phenol	Phenol
1,2-Dichloropropane	Chlorinated alkane
1,2-Dichloropropylene	Chlorinated alkane
Dieldrin	Pesticide
Diethyl phthalate	Phthalate ester
2,4-Dimethyl phenol	Phenol
Dimethyl phthalate	Phthalate ester
Di-n-Butyl phthalate	Phthalate ester
4,6-Dinitro-o-cresol	Phenol
2,4-Dinitrophenol	Phenol
2,4-Dinitrotoluene	Substituted aromatic
2.6 Dinitrotoluene	Substituted aromatic

Priority pollutant	Type of chemical substance
Heptachlor epoxide	Pesticide
Hexachlorobenzene	Chlorinated aromatic
Hexachlorobutadiene	Chlorinated alkane
Hexachlorocyclopentadiene	Chlorinated alkane
Hexachloroethane	Chlorinated alkane
Indeno[1,2,3-c,d]pyrene	Aromatic
Isophorone	Organic
Lead	Metal
Mercury	Metal
Methyl bromide	Chlorinated alkane
Methyl chloride	Chlorinated alkane
Methylene chloride	Chlorinated alkane
Nickel	Metal
Nitrobenzene	Substituted aromatic
2-Nitrophenol	Phenol
4-Nitrophenol	Phenol
n-Nitrosodimethylamine	Organic
n-Nitrosodi-N-propylamine	Organic
n-Nitrosodiphenylamine	Organic
Para-chlor-meta-cresol	Phenol
PCB-1016	Chlorinated biphenol
PCB-1221	Chlorinated biphenol
PCB-1232	Chlorinated biphenol
PCB-1242	Chlorinated biphenol
PCB-1248	Chlorinated biphenol
PCB-1254	Chlorinated biphenol
PCB-1260	Chlorinated biphenol
Pentachlorophenol	Phenol
Phenanthane	Aromatic
Phenol	Phenol
Pyrene	Aromatic
Selenium	Metal
Silver	Metal
2,3,7,8-Tetrachlorodibenzo-p-dioxin	Chlorinated organic
1,1,2,2-Tetrachloroethane	Chlorinated alkane
Tetrachloroethylene	Chlorinated alkane
Thallium	Metal
Toluene	Aromatic
1,2-trans-Dichloraoethylene	Chlorinated alkane
1,2,4-Trichlorobenzene	Chlorinated aromatic
1,1-Trichloroethane	Chlorinated alkane
1,1,2-Trichloroethane	Chlorinated alkane
Trichloroethylene	Chlorinated alkane
Trichlorofluoromethane	Chlorinated alkane
2,4,6-Trichlorophenol	Phenol
Vinyl chloride	Chlorinated phenol
Di-N-Octyl phthalate	Phthalate ester
1,2-Diphenyl hydrazine	Substituted aromatic
A-Endosulfan-α	Pesticide
B-Endosulfan-β	Pesticide
Endosulfan sulfate	Pesticide
Endrin	Pesticide
Endrin aldehyde	Pesticide
Ethylbenzene	Aromatic
Fluoranthene	Aromatic
Fluorene	Aromatic
Haphthalene	Aromatic
Heptachlor	Pesticide

Conventional Water Quality Parameters Pertaining to Various Industries in SICs

Water Quality Parameters / Industry	BOD	TSS	Ph	Fecal Coliform	Oil & Grease	Temp.	COD	Color	Total P	Ammonia (as N)	Organic N	Nitrate	Flow	Phenols	Sulfide	TOC	Sett. Solids	Surfa-ctants
Dairy Products	•	•	•	•	•	•	•		•				•			•	•	•
Electroplating	•	•	•		•	•	•	•					•			•	•	
Plastics	•	•	•			•	•						•	•		•	•	
Soap & Detergents	•	•	•		•	•	•	•	•	•			•	•		•	•	•
Fertilizer Formulation	•	•	•			•	•		•	•	•	•	•			•	•	
Nonferrous Metals	•	•	•			•	•						•			•	•	
Leather Tanning	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•
Glass	•	•	•			•	•						•			•	•	
Paper Industry	•	•	•			•	•						•			•	•	
Paving & Roofing Materials	•	•	•		•	•	•	•					•			•	•	
Printing	•	•	•		•	•	•	•		•	•	•	•	•		•	•	
Bus Assembly	•	•	•			•							•			•	•	
Industrial Gases	•	•	•			•							•			•	•	
Pesticide Formulation	•	•	•			•	•			•	•	•	•	•		•	•	
Foundries	•	•	•			•	•						•			•	•	
Paint Formulation	•	•	•		•	•	•	•		•	•	•	•	•	•	•	•	

Heavy Metal Parameters Pertaining to Effluents from Various Industries in SICs

Water Quality Parameters / Industry	Total Cr	Cr VI	Copper	Nickel	Zinc	CN Total	Cd	Lead	Iron	Tin	Hg	Al	Arsenic	Barium
Dairy Products														
Electroplating	•	•	•	•	•	•	•	•	•		•		•	
Plastics			•						•					
Soap & Detergents														
Fertilizer Formulation														
Nonferrous Metals												•		
Leather Tanning	•	•												
Glass										•				•
Paper Industry														
Paving & Roofing Materials														
Printing	•	•	•		•	•		•						
Bus Assembly														
Industrial Gases														
Pesticide Formulation							•				•		•	
Foundries			•	•	•				•					
Paint Formulation	•	•									•			

ANNEX III
OFFICIALS MET

Ministry of Industry and Electricity

-	Eng Mobark Abdalla Al-Khfra	Deputy Minister of Industry and Electricity for Industrial Affairs.
-	Eng Abdalaziz Al-Twaigry	General Director, Technical Affairs Dept., MIE
-	Eng Solaiman Al-Solai	Deputy Director for Technical Affairs and Director of Industrial Cities Dept, MIE
-	Eng Ibrahim El-Huseni	Engineering and Projects Dept., MIE
-	Dr. Rajith Withana	(CTA/Senior Economist, UNIDO)
-	Dr. Ahmed Darwish	Chemical Ind. Expert, Saudi Consulting House

United Nations Development Programme

-	Mr. Hassan Issa	Resident Representative, UNDP
-	Mr. Sharouh Sharif	Deputy Res. Rep, UNDP
-	Mr. Jamil Sofi	Programme Officer, UNDP
-	Ms. Mona Hider	Programme Officer, UNDP
-	Ms. Mayan Kurdi	Programme Officer, UNDP

Riyadh Industrial Cities , RIC I & RIC II

-	Eng Khalid Al-rajeh	Manager, RIC II
-	Mr. Abduaziz Al-Faiz	Asst. Manager, Saudi Carpet Co.
-	Mr. Ibrahim El-Tahhous	General Manager, Al-Jomaih Bus Co.
-	Eng Rajab Al-Reyati	Prod. Eng., AlBilad Concrete Co.
-	Mr. Abdalla AlKhalifa	Service Manager, Al-Jomaih Lube Oil Co.
-	Mr. Jan Pedersen	Adm. Manager, Dane Food Co.
-	Mr. M. Tawakaina	General Manager, Modern Casting Co.
-	Mr. Samih Sakka	Prod. Manager, Saudi Bus Co.
-	Dr. Samy Mostafa	Technical Manager, SCIDCO
-	Mr. Nasser Al-Mofawez	General Manager, Arabian Danish Paint
-	Mr. Abdul Fatah Jabbado	Prod. Manager, SAPPCO
-	Mr. Ibrahim Hobeika	Executive Manager, Safy Tannery
-	Mr. Lutfi Yousef	R&D Manager, Arabian Detergents Co.
-	Mr. Mohamed ElBehairy	Prod. Manager, PLASCO
-	Dr. Ismail Fakhry	Executive Manager, Saudi Blantex
-	Mr. Khaled Al-Dakheel	General Manager, Dakheel Foundry
-	Mr. Abdul Razzak AlRakan	Asst. Manager, OMEGA Cables
-	Mr. Mohamed Sharbek	Manager, Riyadh Cables
-	Mr. Khaled Seafan	Plant Manager, Water Proofing Industries
-	Mr. Issam Feteha	Plant Manager, National Packing Co.
-	Mr. Abdallah Al-Obeikan	Manager, Obekan Packaging Co.
-	Mr. Gasser Al-Gasser	Managing Director, GALVANCO
-	Mr. Mohammed Nasif	Plant Manager, PAINTCO
-	Mr. Fayek Hassan	Prod. Manager, Al Rijhi Chemicals Co.

Jeddah Industrial City

- Eng Abudulazia Sherbeni	West Province Branch Director, MIE
- Mr. A. r. Bassam	Manager, Modern Tanning Industries
- Mr. R. M. Bhatti	Chief Chemist, Saudi Perfumes Co.
- Mr. Mohamed Ghandour	Saudi Lebanese Factories
- Mr. Anis Afiff	Manger, United Industries for Paints
- Mr. Fred Pine	Manager, Saudi Yeast Company
- Mr. Mohammad Al-Gami	Asst. Manager, Savola Edible Oils
- Mr. Chris Gally	Logistics Manager, Saudi Shell Lubricants
- Eng A. Sayd Maglad	Manager, Binzager Match Factory
- Mr. Ali Alshahari	General Manager, Bahlas National Carpets

Dammam First Industrial City

- Mr. Ibrahim Al-Thabit	Manager, DIC I
- Eng Mohammad Moyeed	Civil Engineer, DIC I
- Mr. Mutasim Khayri	General Manager, Perolite
- Mr. Gerbert Muhle	Manager, Arabian Fiberglass Industries
- Mr. Ahmed Naser	Manager, Building Chemical Industries
- Mr. Newton Calumpang	Plant Manager, Nalco Saudi Co.
- Mr. James Whally	Tech. Manager, SIGMA Paints
- Mr. Samul Varhese	Oper. Manager, Saudi Conduit Coating Co.
- Mr. Mahmoud Al-Gabary	Arabian Food and Dairy Co.
- Mr. Saleh Al-Ajairi	General Manager, National Film Co.
- Mr. Khalid Alfuhaid	Plant Manager, Aluminum Products Co.
- Mr. Dimitri Farmakalidis	Saudi Suspended Ceiling Co.

Dammam Second Industrial City

- Mr. Abdul latif Al-Saleh	Manager, DIC II
- Eng Jo Manjuran	Civil Engineer, DIC II
- Mr. Mohamed Kahil	Plant Manager, National Cleaning Products
- Dr. El-Sayed Abdulreheem	Research Manager, Saudi Paper Manuf. Co.
- Mr. Abdalla Salem	General Manager, Saudi Arabian Ductile Iron
- Mr. Anwar Asraf	Operations Manag.,Saudi Industrial Solvents
- Mr. Kamel Nagib	Manager, Modern Industries(P&G)
- Mr. Samir Subaihi	Manager, Dahran Chemical Industries
- Mr. Nader Nafady	Director, Bitumat Co.