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ENVIRONMENTAL AUDITS OF INDUSTRIAL PLANTS IN SRI LANKA

Prepared for

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International Resources Group, Ltd.
Sri Lanka

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ENVIRONMENTAL AUDITS OF INDUSTRIAL PLANTS IN SRI LANKA

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PART I PILOT STUDY: ENVIRONMENTAL AUDITS OF SIX INDUSTRIAL PLANTS

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INTRODUCTION AND BACKGROUND

Under the five-year Natural Resources and Environmental Policy Project of USAID and the Government of Sri Lanka, the International Resources Group is carrying out a program of environmental assessments, or audits, including a training program for consultants and industry in Sri Lanka. IRG engaged its subcontractor Malcolm Pirnie, Inc. to assist with this project. The Malcolm Pirnie consultants assigned to this project were Mr. James C. Stouch, P.E. and Mr. Peter F. Schmidt from their York, Pennsylvania office.

The objectives for the project are to:

- Establish and pilot an approach to environmental audits and assessments which is appropriate for industry in Sri Lanka. The approach should account for: the minimal, albeit evolving body of environmental regulations; scale and scope of industrial operations; the concern of industry for equal enforcement of regulations among competitors; and the balance which must be struck between economic development, industrialization, and environmental management.

- Expose a variety of industrial operations to the environmental assessment process, including what to expect in the way of information requirements, the significance and rationale behind issues of environmental concern, and the benefits of recommendations and alternatives identified as a result of the assessments.

- Provide hands-on training for Sri Lankan consultants who could form the nucleus of environmental assessment capability in the country.

- Cooperate with representatives of the Technology Initiative for the Private Sector (TIPS) program in Sri Lanka by sharing information regarding assessment results. The industries may then qualify for TIPS program assistance with financing and/or technical support to implement assessment recommendations. Additionally the TIPs and other similar programs can be used to develop a framework and nurture the market for environmental assessments in Sri Lanka.

- Maintain the confidentiality of all information and findings with each of the volunteer industries in the project.

The initial phases of the project were conducted over the course of approximately five weeks during March and April 1993 culminating with submittal of draft reports to the industries. It began with a review of the assessment process and development of a tailored Environmental Assessment Checklist for Sri Lanka. The seven in-country consultants were assigned to teams with each consultant taking a "team leader" role responsible for one assessment. Assessments were conducted at the following six plants:

- Parquet (Ceylon) Ltd. - wood flooring manufacturer

- Rio Industries (Pvt.) Ltd. - steel furniture manufacturer

- Sascon Knitting Co. (Pvt.) Ltd. - knitting , dying, and garment manufacturing

- Mason's Mixture Limited - resin, paint, coating, adhesive manufacturer
- Siriyangie D.C. Mill - manufacturer of desiccated coconut, charcoal, fatty acids and oils
- Singalanka Standard Chemicals Ltd. - sulfuric acid and aluminum sulfate manufacturing

Each plant was visited and a limited site assessment was performed. Using the information gathered and observations made a report was generated describing the site conditions and opportunities available to reduce the generation of pollution.

The remainder of this report consists of a description of environmental assessments, the pilot environmental assessment protocol used, accomplishments, conclusions, and recommendations.

ASSESSMENT PROTOCOL ADOPTED

Sri Lankan environmental regulations are in their infancy. Lacking a regulatory basis for the assessment protocol, the Malcolm Pirnie consultants developed a broad pilot protocol to help individual industrial plants identify potential opportunities to correct environmentally unsound practices. Particular emphasis was placed on identifying cost effective waste minimization or pollution prevention opportunities. The rationale for this approach was that without a regulatory incentive, an economic incentive would be the next best motivator for an industry to conduct an assessment and act on the findings.

It should be noted that even with the promise of a free assessment and a focus on identifying potential cost saving projects only seven of the 30 industries approached were willing to participate in the assessment program. Thus, feedback from these pilot assessment industries is critical in terms of future improvements with respect to the audit protocol and assumptions.

Appendix I contains a copy of the checklist developed to guide the site assessment under the pilot program. The checklist was developed in a group format - led by the Malcolm Pirnie consultants - so that the rational behind each category in the checklist could be transferred to the Sri Lankan consultants.

Another consideration in the adoption of the pilot protocol was that each of the pilot industries was either involved or desired to be involved with the TIPS program. The TIPS program provides support to companies seeking to upgrade their capabilities to be able to compete more effectively in the international market place. This market focus gave further incentive to the industries engaged in this assessment to resolve potential environmental impairments by improving their production processes.

The last major considerations in the pilot protocol development was that the assessment needed to be carried out in a compressed time frame (less than 4 weeks), and for many of the assessment team it was their first exposure to industrial environmental

assessments. Thus, the pilot assessment focused on identifying opportunities for subsequent in depth evaluations.

PILOT ENVIRONMENTAL ASSESSMENT FINDINGS

The Central Environmental Authority has not yet fully exercised its enforcement responsibilities granted under the National Environmental Act of 1980, as amended in 1988. Because of limited enforcement of environmental regulations, the lack of meaningful penalties for violations, the minimal requirements to remediate environmental problems, lax worker health safety laws and practices, and the low cost of worker compensation, there is currently very little incentive for industries to operate in an environmentally responsible manner in Sri Lanka. Moreover, because of limited liability exposure of Sri Lankan industries, if an environmental assessment program is to succeed it must tap alternative market forces to encourage environmentally responsible industrial operations.

Along with NAREPP/IRG staff, the Malcolm Pirnie consultants held a series of meetings were held with the Chamber of Industry (COI), TIPS and the Metropolitan Environmental Improvement Programma (MEIP). The purpose of these meetings was to elicit feedback from the interested and affected parties in Sri Lanka who are likely to be involved in environmental assessments. The following points were raised:

- Many industries have limited confidence in the majority of Sri Lankan engineering firms. This lack of confidence seems to center around two issues. One issue was the industry's desire for confidentiality; companies feared that secrets would be transmitted to competitors as the consultants worked with other companies. The second issue concerned the ability of the engineering firms to design and implement recommendations that were feasible and cost effective.

- According to the COI, its members are interested in ways to make their operations more efficient. COI is trying to develop resources for its member companies to identify individuals involved in applied science and make available case studies of successful improvements.

- Industries would like affordable technical outreach programs and access to appropriate information.

- Everybody is waiting for a push while still unsure of what, or how hard, the push needs to be.

The findings that resulted from the pilot assessments of the six industries suggest specific training and experiential needs:

- Often the assessment checklist was followed blindly. This often resulted in collecting information that was not needed for the particular assessment.

- Access to information needed to explore various potential opportunities was hampered by the lack of knowledge of the country's information resources.

- Report writing was difficult. Difficulties ranged from word processing proficiency to technical writing skills and abilities to distinguish high priority from low priority recommendations.

- More emphasis and guidance needs to be provided to the in-country consultants to focus on achievable low technology options before exploring higher cost and more complex opportunities.

- For most of the industries assessed pollution/waste problems could be solved with increased emphasis on sound industrial engineering practices.

Two significant public policy/investment issues were idenfied:

- Proper disposal of wastes is a common problem. No practical options now exist for the safe disposal of hazardous wastes and other industrial residual wastes.

- Worker health and safety is a major problem at all facilities assessed. Very little information seems to be available to the workers and industry owners on managing these human risks.

At the same time, an important institutional opportunity was identified:

- The Ceylon Institute for Scientific & Industrial Research (CISIR) was well respected by the industry.

ENVIRONMENTAL ASSESSMENT RECOMMENDATIONS

Sri Lanka currently lacks the regulatory impetus for conducting environmental assessments. However, other incentives are apparent that, properly managed, may encourage this practice. Incentives could be found in:

- Donor program pre-requisites
- Process improvements
- Community relations

Additionally, the environmental assessment can be used as a forum for introducing the concept of "benchmarking" between different industries. Benchmarking identifies the best practices of each industry so that other industries can modify these practices to meet their own conditions. Benchmarking can be carried out without giving up trade secrets or market advantages since it generally identifies procedures and practices that are applicable to a range of industries.

The following recommendations are offered to establish environmental assessments in Sri Lanka:

- Conduct a follow-up with the 6 pilot industries within 4 weeks of the report submission and again in 6 months in order to assess:

- the accuracy of the assessment reports in their portrayal of concerns, market constraints and operating practices;

- the validity of the report recommendations to the industry;

- how the industry uses or implements the recommendations;

- what the industry liked best about the assessment;

- what the industry would like to see changed or what additional tasks it would like added to improve the value of the report;

- whether the industry would be willing to pay for an environmental assessment in the future (and, if so, how much);

- what savings and other benefits the industry migh have accrued as a result of the assessment and subsequent investigations/projects.

- Take the lessons learned from this round of assessments and use them to develop a "draft" assessment manual and training program. The manual should contain:

  - factors to consider during assessment scope development;

  - a description of the various assessment steps/tasks including the objective for each step;

  - sample pre-assessment questionnaires;

  - a detailed site inspection form including annotated questions with the objective of each question and explanation of how the information would be used;

  - sample reports showing how the information gathered during the inspection was used in developing recommendations.

- Using the pilot assessments and literature from other countries, begin developing a repository or database, by industry segment, of Environmental Best Practices and Improvement Opportunities, aimed at small and medium sized industries.

- Conduct a second set of assessments in the 6 to 12 month time frame. Incorporate the lessons learned into the assessment protocol, and choose several similar plus several new industry segments. Similarities and differences to this project should be evaluated.

- Determine the value of the environmental assessment program. What is the extent of the demand for assessments created by this program? What are the expected results? How will the supply of talent meet this demand? Must training continue, and, if so, for how long?

- What will or should happen next in terms of industrial environmental management, given the uniqueness of each industry and the lack of regulatory impetus in Sri Lanka? What role will government have to play in the advancement of environmental management? Will complaints rise and increase political/economic costs of industrial pollution? Can this result be avoided by some immediate actions?

- Identify the roles of environmental assessments in the current and planned activities of the MEIP/World Bank and COI to support hazardous waste management and Safety, Health, and Environmental actions.

- Evaluate the benefits of including the CEA environmental officers in a future training component for environmental assessments.

ADDITIONAL RECOMMENDED NAREPP TASKS

- Industrial sludge is by far the most significant waste stream in Sri Lanka. It is important to quantify the magnitude, evaluate the constituent hazards, and identify management and reuse options for the sludge. Evaluation should be made of sludge management from textile dyeing factory wastewater treatment plants.

- The Board of Investment plays a critical role in avoiding/reducing industrial pollution problems. It will be important to evaluate its workload and information management systems, and its abilities to accommodate the Enterprise Zone and required outlying Section 17 plant inspections, and the licensing program.

Attached in Appendix I is the Assessment Questionnaire for the conduct of the environmental assessments/audits under the NAREPP/IRG pilot program.

Appendix II, also attached, contains the outline used for preparing environmental audit reports,

APPENDIX I

ASSESSMENT QUESTIONNAIRE

ENVIRONMENTAL AUDITS PROGRAM
SITE VISITS

DATE :

FACILITY NAME :

FACILITY LOCATION :

PHONE NO. FAX NO. :

FACILITY CONTACT/S : **Name** **Department** **Phone**

AUDIT TEAM : 1)

2)

3)

4)

5)

1.0 GENERAL INFORMATION

1) STD. IND. CLASSIFICATION (SIC) CODE NO:

2) PRIMARY FACILITY PRODUCT/PROCESS :

3) OBTAIN COPY OF PROCESS FLOW SHEET :

4) FACILITY SIZE

Land area :

% Developed :

5) NO. OF EMPLOYEES :

ORGANIZATION CHART : (please attach)

6) OPERATING SCHEDULE :

7) LOCATION PLAN :

8) PLANT LAYOUT :

9) SITE HISTORY :

10) FUTURE DEVELOPMENT CONSIDERATION:

11) DESCRIBE GEOLOGY/HYDROGEOLOGY/SOILS:

12) SURROUNDING LAND USE:

13) IS THERE KNOWN CONTAMINATION PROBLEMS ON SITE?: (explain)

13a) Off site? (explain)

14) ON-SITE OR NEARBY GROUND WATER WELLS?:

15) OTHER LOCAL OR REGIONAL SITE CHARACTERISTICS:

Surface Water

Drainage/Runoff

2.0 GENERAL REGULATORY COMPLIANCE

1) Copy of permit:

2) Describe permit conditions: (note time bound items)

3) Describe facility procedure for compliance with permit conditions:

4) AUTHORITY CONTACT/S (Name and Phone Number)

CENTRAL ENVIRONMENTAL AUTHORITY:

PROVINCIAL COUNCIL:

BOI:

DEPARTMENT OF LABOR:
(industry hygiene)

PHI

5) CORRESPONDENCE TO/FROM AUTHORITIES:

	Date	From	To	Subject
1				
2				
3				
4				
5				
6				
7				
8				

6) PAST CONSULTANTS REPORTS:

	Date	Author	Description
1			
2			
3			
4			
5			
6			

7) SRI LANKA STANDARDS INSTITUTION DOCUMENTATION:

3.0 CHEMICAL USAGE AND HANDLING

1) LIST OF RAW MATERIALS/CHEMICALS USED:

State/stage	Chemical/ Material (CAS No.)	Type of container or package	Application	How/ Where stored	Purchase or Usage rates

Other Information:

MANUFACTURING PROCESS:

State/stage	Chemical/ Material (CAS No.)	Type of container or package	Application	How/ Where stored	Purchase or Usage rates

MAINTENANCE:

State/stage	Chemical/ Material (CAS No.)	Type of container or package	Application	How/ Where stored	Purchase or Usage rates

Other Information:

FUEL/ENERGY:

State/stage	Chemical/ Material (CAS No.)	Type of container or package	Application	How/ Where stored	Purchase or Usage rates

2) ANY BANNED CHEMICALS:

3) HEALTH AND SAFETY PROCEDURES FOR MATERIAL HANDLING:

4) STORAGE PRACTICES

- Incompatible substances (e.g. Flammables with Oxidizers)

- Spill containment - receiving/shipping area maintenance

- Run off containment (material storage areas)

- General housekeeping

5) MATERIAL ORDERING PRACTICES:
(e.g. LIFO, FIFO)

6) **MATERIAL USE PRACTICES:**

7) **EVALUATION OF RECOMMENDED VS. ACTUAL MATERIAL/CHEMICAL USAGE:**

8) **CALIBRATION PRACTICES AND CERTIFICATION OF WEIGHING OR MEASURING EQUIPMENT:**

9) **RAW MATERIAL QUALIFICATION PROCEDURES USED:**
(Composition, size, grade etc)

4.0 PROCESS DESCRIPTION

1) **SEQUENCE OF OPERATIONS:**
Provide or attach if available

- **PFD'S/PID's**

- **Material Balance**

- **Historical information regarding process changes**

2) **IDENTIFY MATERIAL INPUTS, CHEMICAL USAGE OR ADDITION POINTS, SUPPORTING UTILITIES, PRODUCTION OUTPUTS:**

3) **IDENTIFY ENVIRONMENTAL IMPACTS:**

- **Air emission sources**

- **Waste water sources**

- **Sludges**

- **Solid/hazardous waste sources**

4) **PROCESS CONTROL INFORMATION:**

- **Parameters (Correlations used)**

- **Instrumentation calibration procedures**

- **Documentation (log books, procedures, operation manuals)**

- Manual Vs. Automatic

- Operator skills and training

5) ENERGY MANAGEMENT:

- Equipment condition

- Insulation condition

- Type of equipment (steam traps, check valves, etc)

6) INTERMEDIATE/FINISHED PRODUCT STORAGE, HANDLING, PACKAGING AND SHIPPING PRACTICES:

7) START UP AND SHUT DOWN PROCEDURES:

8) O & M PRACTICES:

9) MAINTENANCE OR CONSTRUCTION SHUT DOWNS: (Schedule)

10) QC/SAMPLING PROCEDURE:

11) **WASTE WATER TREATMENT PLANT OPERATIONS:**

- Filtration & Chemical Additions

Describe the discharge percentages

Public Sewer	%
Surface Discharge	%
Septic System	%
Others	%

12) **POTABLE OR PROCESS WATER:**

- Usage rate: Potable % Process % Maintenance % Sanitary %

- Source/s

- Treatment Requirements

  * Filtration

  * Demineralization

- Chemical Addition

13) **COST DATA:**

- **RM**
- **Disposal waste**
- **Labor**
- **Energy**
- **Steam**
- **Fuel**
- **Water**
- **Other utilities**
- **Other variable costs**
- **Other fixed costs, (future)**
- **Permit Fees (future)**

5.0 WASTE HANDLING AND DISPOSAL

1) WASTE IDENTIFICATION:

Type	Qty/Rate	Composition	Source	How Handled	How stored	Disposal Re-use (on-site vs.off-site. (If off-site, specify)hauler/sitelocation)

2) WASTE MANAGEMENT PROCEDURES AND RECORD KEEPING:

3) HISTORICAL WASTE DISPOSAL PRACTICES:

- PRODUCTION
- QUALITY CONTROL SAMPLES
- MAINTENANCE

6.0 AIR EMISSIONS

1) EMISSION INVENTORY:

Source	Type	M3/hrs	Key parameters (T,P,DP,BP)	Pollutant	Concentratio n	Control Method/ Equipment

2) RECORD KEEPING PRACTICES:

3) TYPE AND CONDITION OF EXISTING CONTROL EQUIPMENT:
(SCRUBBER, FILTER, ETC)

4) EMISSION MONITORING:

5) CONDITION OF PROCESS EQUIPMENT:
(Pump Seals, Valves, Flanges, etc)

6) PROCEDURES UTILIZED TO OBTAIN AND RENEW AIR EMISSION PERMITS:

7.O WASTE WATER/STORM WATER

1) DOES FACTORY HAVE WATER USE PERMIT?:

2) WASTE WATER CHARACTERIZATION:

Type	Source (sumps floor drains processes etc)	M3/hrs	Pattern of Dis-charge (intermittent Vs. continuous	Pollutant (VOC, Zn, BOD, COD, Temperature O&G)	Concen tration	Discharge Point (Public Sewer/ Dry Well/ Septic/Surface Water Lagoon/Cess Pool

3) LOCATE DISCHARGE POINTS ON PLANT LAYOUT:

4) DESCRIBE ON-SITE LABORATORY CAPABILITY:

5) STORM WATER: (Show on site plan)

Annual Rainfall
Drainage flow directions
Discharge point
Collection point

6) DESCRIBE STORM WATER POLLUTION PREVENTION MEASURES:
(Covered shipping/Receiving Docks/Storm Water retention/Basins/Area Segregation)

8.0 SPILL CONTAINMENT AND ACCIDENT RELEASE CONTROL

1) **PAST HISTORY OF SPILLS, RELEASES, ENVIRONMENTAL INCIDENTS:**

2) **PROCEDURES FOR EMERGENCY RESPONSE: (fire, flooding, spills, air releases)**

- **Availability of equipment & Personal Protective Equipment (PPE)**

- **Evacuation procedures (inside and outside plant)**

- **Emergency Training**

- **Clear responsibility for reaction/response**

- **Power failure re-start procedures**

3) **SPILL CONTAINMENT:**

- **Raw material storage areas (bermed material storage pads, etc.)**

- **Adsorbents**

  * **where stored**

  * **how used**

  * **how disposed**

9.0 OTHERS

1) NOISE:

Source	Level	Limits

2) ODOR:

- Past incidents

- Source

3) HEAT/VENTILATION:

4) PCB'S: KNOWN OR SUSPECTED PCB-CONTAINING EQUIPMENT:

Transformers :

Hydraulic Oil:

5) **ASBESTOS: LOCATION AND CONDITION**

Duct/Conduit :

Roofing ("Transite") :

Pipe or vessel insulation :

Ceiling or floor tile :

6) **PESTICIDES AND HERBICIDES:**

- Where used

- Storage Practices

- Preparation and Handling

- Application

- Disposal

- Empty Container Management

APPENDIX 2

SRI LANKA ENVIRONMENTAL ASSESSMENTS
PRO FORMA REPORT OUTLINE

I. Background
- Assessment objectives
- Facility location
- Product/industry description
- Historical problems (brief)

II. Site Considerations
- Topography and surface features
- Surrounding land use
- History of site
- Geology/hydrogeology
- Meteorology
- Well locations

III. Process Description
- Describe processes (ref. plant layout, PFD's, site plan, etc.)
- Raw material usage
- Description of wastes generated (tabular form)
  - air emissions
  - wastewater
  - hazardous waste
  - nonhazardous solid waste

IV. Health and Safety Considerations
- Chemical handling
- Personnel protection
- Equipment (guarding, noise, condition)
- Housekeeping
- Fire protection
- Emergency response

V. Site Impairments
- Waste piles, lagoons, landfills, spills
- List of potential environmental impacts of the facility's operations

VI. Regulations
- Permits and status; compliance issues
- Banned materials
- Regulatory trends
- Industry standards and requirements

VII. Recommendations

PART II SAMPLE ENVIRONMENTAL AUDIT INDUSTRIAL CHEMICALS MANUFACTURER

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- EMERGENCY RESPONSE

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- OCCUPATIONAL HEALTH AND SAFETY
- EQUIPMENT, INSTRUMENTS AND PROCESS CONTROL
- PVA/RESINS
- MIXING/REPACKAGING
- PLANT MAINTENANCE
- WASTEWATER TREATMENT
- SOLID WASTE DISPOSAL

APPENDIX

I - Site Map
II - Environmental Protection License and Other Related Documents

Note:

This report was developed using examples from several industries to illustrate and help guide reporting on abbreviated environmental assessments/audits, often referred to as "green" audits, that industrial plants are beginning to undergo in Sri Lanka. It therefore should be read to help those learning about the actual conduct of an audit -- industrial plant managers and environmental engineering consultants -- understand what environmental auditors should look for, what observations are important, how they should be presented, and what kinds of recommendations/information can be helpful.

Great liberties have been taken with technical information, process information, and environmental situations to design this fictitious audit. While composed of actual facts, and although each individual section contains accurate facts, it is not as a whole technically accurate. Because it is a composite of various industrial plants it does not represent any existing industry in Sri Lanka or elsewhere

BACKGROUND

ASSESSMENT OBJECTIVES

An environmental assessment was conducted at Industrial Chemical Manufacturers (Pvt) Ltd. to provide an environmental assessment of the facility's current operating status with respect to the Sri Lankan environmental regulations and industry standard practices for:

- Worker Health and Safety
- Process and Chemical Safety
- Waste Management Practices

Additionally, waste minimization and pollution prevention opportunities were identified.

FACILITY LOCATION

Industrial Chemical Manufacturers (ICM) is located at 1000/1 Gale Road, Colombo 2, in a heavily industrialized area of metropolitan Colombo.

PRODUCT/INDUSTRY DESCRIPTION

ICM provides a full range of industrial chemicals to the local industrial market. Approximately 70% of its sales are derived from the repackaging of bulk chemicals imported for resale. The remainder of its sales are derived from the manufacture of PVA, synthetic resins, sulfuric acid, and paint.

HISTORICAL PROBLEMS

ICM has been located at its present site since 1974. Initially ICM operated solely as a chemical repackager. Starting in 1988 they began to produce resins and in 1990 purchased and installed equipment for the production of sulfuric acid.

SITE CONSIDERATIONS

TOPOGRAPHY AND SURFACE FEATURES

The facility occupies a 5 acre site. The site is generally level with a gentle 1% downward slope to the north east. A small swale cuts across the east end of the site which terminates in a drainage ditch which runs to the Beruwaua Canal approximately 500 meters to the Northeast.

SURROUNDING LAND USE

While the facility is located in an industrial area, it is bounded on the north, east and south sides by a large number of residences. To the west is Gaul Road and Kapplan Tiger Knitting Ltd.

HISTORY OF SITE

Prior to the company building its facility, the land consisted of a low lying marshy area. After ICM purchased the site, the land was drained and the low lying areas filled.

GEOLOGY/HYDROGEOLOGY

The ground water is estimated to flow from the southwest to the northeast. This observation is based on the declining depth of the surrounding wells in the adjacent areas. Seasonal high ground water is estimated to be 1 - 2 meters.

METEOROLOGY

Approximately 270 cm of annual rainfall is received in this area. This rainfall occurs primarily during the monsoon seasons.

WELL LOCATIONS

The facility receives its water supply from two wells (see attached site map - Appendix I) located on the property. Additionally, each of the surrounding residences has a dug well. These residential wells are located in close proximity to the facility's parapet walls on the north, east, and south sides. To the west, Kapplan Tiger Knitting Mill has several wells on its property.

PROCESS INFORMATION

PROCESS DESCRIPTION

The facility processes can be divided into 4 different areas: repackaging, mixing, and resins and PVA, and acid production.

Repackaging

The finished product is purchased from international suppliers and imported in bulk quantities by ICM (generally 55 gallon drums). Depending on the product, these materials are decanted in to small containers for resale. The containers range in size from 250 ml glass bottles to 4 l plastic jugs. Occasionally steel cans are used for the more viscous products.

The decanting of these materials is a simple process using a shallow tub which is repeatedly filled from a spicket attached to the drum. Product is then ladled out and poured into the smaller containers using funnels. Once a filled container has been sealed, a paper label is affixed and the product is stacked to await movement to finished stores.

Mixing

The company sells a full range of industrial and domestic cleaning products which includes waxes and polishes, alkaline and acid based cleaners, as well as various oil and latex based paints. For the most part all these products are made using similar processes.

In a large industrial mixer the components are combined and mixed. Depending on the material this mixing is sometimes performed at an elevated temperature (two of the five mixers are fitted with steam jackets). If pigments are required, they are milled in pug or ball mills prior to their being added to the mixer. When completed the mixed product is decanted into an open top steel drum from which it is hand ladled into one and four liter cans and bottles.

Resins and PVA

Acid

The Double Contact Double Absorption (DCDA) process is used to manufacture Sulfuric Acid (H_2SO_4) in the plant. In this process Sulfur (S) is reacted with Oxygen (O_2) in air at two stages to produce SO_3.

The first reaction is carried out in a sulfur furnace while the second reaction is carried out in a catalytic convertor. The SO_3 obtained is absorbed in 98.5% H_2SO_4 in two absorption columns and the resulting 99.3% H_2SO_4 is diluted with water to obtain 98.5% H_2SO_4 (the final product). The process is known as the DCDA process because there are two stages of contact with catalyst each followed by an absorption stage.

RAW MATERIAL USAGE

The following raw materials are used at ICM:

Table 1 - Raw Material Usage

Chemical/Material	State	Monthly Usage
Sulphur	S	
MIBK	L	24,800 l
MEK	L	5,000 l
Xylene	L	12,000 l
Methanol	L	12,600 l
B.G	L	90 kg
LAWS	L	6,300 l
IPA	L	3,000 l
Butyl Acrylate	L	800 l
Kerosine	L	2,200l
VAM	L	800 kg
PVA	L	300 kg
Methacrylic add Methacrylate	L	23 kg
Phthalic Anhydride	L	1,200kg
Maleic Anhydride	L	26 kg
PentaErythritol	L	2,900 kg
Tall oil fatly acids TOFAR-2-2 TOFA 10P 130 TOFA OULU 102	L	12,000kg
Calcium Carbonate	P	500 kg
Hydrated Magnesium	.P	300 kg
Potassium Aluminum Silicate	P	650 kg
Aluminum Silicate	P	100 kg
Carbon Black	S	50 kg
TiO2	S	750 kg
Iron oxide red	S	300 kg
Toluidine red	S	100 kg
Chrome yellow	S	250 kg
Pthalo eyaniegreen	S	50 kg

Chemical/Material	State	Monthly Usage
Chemical/Material	State	Monthly Usage
Sodium hexamita phosphate	S	1000 kg
Sodium benzoate	S	750 kg
Sodium bicarbonate	S	2000 kg
Serad 601	S	100 kg
Serad 504	S	150 kg
Proxel benzoisothiazonate	S	20 kg
Sodium metbisulphite	S	40 kg
Serad GBS	S	100 kg
Pb,Co,Ca,Zn drier	S	200 kg
Bentoxe SD1	S	100 kg
Hydroxyl ethyl cellulose	S	2000 kg
NaOH	L	35,000 l
HCl	L	15,000 l
Paraffin	S	2,000 kg
Carnauba	S	750 kg
Sasol	S	500 kg
Micro Mica	S	250 kg
Rosin	S	300 kg
Pine oil	L	100 l
Lime oil	L	100 l
Lemon oil	L	200 l
Antorox	S	200 KG
Unison E-70	S	130 KG
Empilon 2450 (C2H5)2NH	L	60 kg

FUEL, ENERGY AND WATER

Table 2 - Energy and Water Use

Source	Container	Application	How stored	Usage rate
Diesel Fuel	Above ground tanks	Process heat & Back-up generators	Above ground tank (1,000 l)	800 L/d
Water		Process Sanitary Boilers	Above ground tank (2,000 l)	3,000 lpd 200 lpd 2,000 lpd
Electricity		Lighting & Equipment		12,150 units (Rs.50,000/m)

WASTES GENERATED

Air Emissions

Boilers

At start-up the boilers release black smoke for 5-10 minutes. In the past the company received numerous complaints with respect to soot coating the nearby residences. To reduce their particulate emissions ICM upgraded their boilers to burn fuel oil instead of furnace oil within the last 9 months.

Mixing/Repackaging

Most of solvents used by ICM are moderately toxic and three are highly toxic. Since the minimum total loss of solvents is about 400 l/d (Assuming a 1% evaporative loss is accounted,) the effect due to inhalation of these will be firstly felt by the workers of the factory. In the absence of proper ventilation systems and the use of improperly sealed or/and open vessels used for mixing and processing purposes, the vapor can escape freely from these vessels and accumulate in the working surroundings.

Resins/PVA

Though there is no proper pollution control equipment or emission monitoring system, attempts have been made to trap the vapors liberated from the P.V.A latex and P.V.A adhesive processing kettles by increasing the cooling water to the reflux on the kettles.

Sulfuric Acid

Since the reactions involved in the process of manufacturing H_2SO_4 involve gases, air emissions are generally significant in H_2SO_4 plants. The major air emissions as observed by the audit team are as follows :

Sulfur Fumes

Sulfur odor was present in the plant, mainly near the sulfur melting pit. Since there was no air tight cover for this pit molten sulfur fumes escape into the atmosphere and get dispersed due to wind action.

Sulfur Particulate

Another lessor source wa the open air sulfur storage area where raw sulfur particles from broken bags were lying on the ground.

SO_2 Emissions

SO_2 emissions could occur due to leaking flanges, corroded pipes and leaking equipment from the point of the generation in the sulfur furnace up to the 2nd absorber. Since there was no SO_2 detector it was not possible to verify the SO_2 level.

SO_3 Emission

SO_3 emissions could occur due to leaking flanges, corroded pipes and defective equipment of the 1st catalyst bed of the converter. Since an SO3 detector is not available in the plant it was not possible to say whether such leaks were occurring. Apart from possible pipe leaks, other SO3 emissions are scrubbed before leaving the stack. The effluent gas from the 2nd absorber is sent through a CaCO3 scrubber in which CaCO3 reacts with acid gas. If there is good control over gas and liquid flow rates as wells the concentration of acid fed into the absorption column the content of SO3 from the 2nd absorber will be very low and the CaCO3 scrubber should be able to handle it.

According to laboratory analysis reports available at the plant, SO3 and acid mist emissions are within the CEA requirements. However, since sampling and analysis is done just once a day, what happens during the rest of the day is unknown.

H2SO4 Acid Mist Emission

H2SO4 acid mist emission could be discharged via stack gas in the H2SO4 manufacturing. The level of acid mist in the stack gas depends on the efficiency of the gas absorption process and the efficiency of the mist eliminator located down stream of the 2nd absorber. The latter requires good control of H2SO4 inlet concentration and gas-to-liquid flow ratio.

Acid concentration is manually controlled with the aid of an acid concentration indicator in the control room. However there are no instruments to measure and indicate the flow rates of acid and gas entering the absorbers. The absorption operation is indirectly controlled by means of the inlet gas pressure. Hence there is a high probability of variable liquid to gas flow ratios leading to acid mist emission. The acid mist eliminator is cleaned only during major shutdowns. Hence the efficiency of the eliminator may drop with time. According to analytical results, taken after a recent maintenance shutdown, acid mist emissions from the H2SO4 plant stack are well within specifications. Moreover, since the stack is very tall (20 meters) emissions should be well dispersed when maintained below permitted levels.

<u>Wastewater</u>

Wastewater at ICM is generated in 3 areas. Each area has its own wastewater treatment system.

<u>Resins & PVA</u>

Approximately 400 m^3 of waste water is generated daily. The wastewater is predominantly generated from the washing of the kettles and drums used in the production of resins and PVA. Prior to being discharged in a soak pit, the waste water is collected in one of three cisterns where it is retained for two weeks. At the end of two weeks, the water is pumped to another tank where alum is added. The precipitate is allowed to settle prior to the effluent being discharged to the soaker pits. The precipitate is periodically removed from the precipitation tank and spread on one of 4 sludge drying beds. The sludges are periodically removed from the drying beds and hauled away by a local contractor with the rest of the facility's solid waste.

<u>Sanitary</u>

Sanitary waste water is collected in a septic tank and pumped to a series of three cesspools.

Sulfuric Acid

Process waste water arising from washing of sulfuric acid cans, scrubber blowdown, is sent into the drainage swale after neutralization with Ca_2CO_3. Most of this wastewater gets absorbed into the soil. Most of the vegetation has been destroyed in these areas.

Hazardous Waste

Very little hazardous waste is generated. Off-spec raw materials and product are usually sold to local brokers who in turn resell the material for less critical uses. Spent catalyst to the manufacturer is returned to be regenerated.

Solvents

Dirty solvents (10 to 20 liters per day) generated during the cleaning of the mixers, and not re-used for other products, are allowed to evaporated from 2 horizontally cut steel drums. The accumulated sludge is periodically removed and disposed with the facility's solid waste stream.

Sulfuric Acid (H_2SO_4)

Sulfuric acid spillage could occur during the process of filling acid into cans, bursting or toppling of acid filled cans, leaks in acid pipe lines or during maintenance of the plant. According to the plant management the spillage of acid due to the above is very small.

Nonhazardous Solid Waste

Non hazardous solid waste generated in the plant are as follows:

Sulfur Flakes From Broken Bags

Sulfur flakes from broken bags could be seen scattered in the sulfur storage area as well as near the melting pit. These particles could disintegrate due to the heat and can get absorbed into the ground due to moisture and rain, or blown to the neighboring residences.

Used bags and cans

Empty bags and cans used for packing of raw materials after use are generally purchased by dealers. Many of these used containers contained materials with lead, cadmium, and other toxic substances. Those which are damaged beyond use are dumped in an area of around 50' x 100' and burnt from time to time.

Scrap steel, used steel components

Off cuts of sheets, pipes, old equipment, etc. which cannot be used are dumped in a small yard close to the main entrance. This scrap is sold to metal dealers from time to time. The amount of steel scrap generated in not significant.

Stormwater

Stormwater run off drains to the adjacent lands to the north and east. Since the plant is contaminated with sulfur, spilled pigments, and other raw materials, etc., the run-off could be contaminated and have adverse effects on health of the surrounding residents. This could also lead to well water contamination as the water table is very close to the ground surface.

HEALTH AND SAFETY CONSIDERATIONS

CHEMICAL HANDLING

Current store rooms do not provide for adequate storage and protection of chemical materials. Incompatible materials (i.e. flammables and oxidizers) are stored together in various store buildings located throughout the facility.

None of the storage areas inside or outside are equipped with concrete floors, spill containment, or berms to prevent stormwater run-on. As a consequence any spills are quickly adsorbed into the ground. Powder spills are often washed from the buildings by stormwater run-on as evidence by the stained earth down gradient of many of the store sheds.

All solvents in containers greater than 25 liters are stored outside in various locations around the facility. These areas are often not shielded from the sun. Additionally these areas are often used for dispensing of solvents.

LAWS thinner is stored in a 10,000 liter underground storage tank. This tank was installed in 1974 when the plant first opened. Currently no inventory control records are kept nor is the tank tested for leaks.

PERSONNEL PROTECTION

ICM provides the following personnel protection equipment (PPE) to its workers. According to the plant manager the following equipment is available to the employees:

Respirators
Helmets
Gloves
Boots
Acid proof coats
Goggles/safety glasses

The plant manager additionally stated that enforcement of the use of personnel protection equipment was just beginning. The following observations were made:

Respirators

Overall only one worker was observed to be wearing a respirator. Respirators were prominently hung in most work areas. However, there was no means of tracking when the cartridge was last changed.

Sulphur Pit - Should be worn when working on or near the sulfur pit, where sulfur fumes were very strong.

PVA kettle - Should be worn during the charging and monitoring operations.

Mixing/Repackaging - Respirators should be worn when charging and monitoring the kettle operation. Operations should be evaluated for respirator use during the decanting operation.

Chemical Stores - Should be worn during the dispensing and measuring operations of solvents, pigments and other dry powders.

Safety glasses

Should be worn by all workers especially during:

Sulfuric acid filling operations
Kettle and mixer loading
Product repackaging

Other PPE

Workers who were filling H2SO4 into cans wore gloves and boots but no goggles or acid proof coats.

EQUIPMENT (guarding, noise, condition)

For the most part equipment appeared to be well maintained. The audit team observed the following:

- Several of the mixers were very noisy especially when compared with other mixers being used.
- Bearing and shaft balancing should be checked.
- There were several valves and flanges in the steam lines that were leaking.
- In the roof of the acid plant control room, plaster had deteriorated due to acid attack.
- Many pipelines in the plant had corroded surfaces.
- The continuous stack gas SO2 monitor is missing (being repaired).
- Sulfur pit steel covers had corroded surfaces on them.
- Surface corrosion on some of the acid storage tanks.
- Visible leaking of thinner during pump operation of the LAWS underground storage tank.
- Many cooling systems spray risers were clogged, preventing the full potential of the evaporative cooling from taking place.

HOUSEKEEPING

The following deficiencies in house keeping were observed by the audit team during the plant visit:

Unacceptable sulfur storage and handling procedures result in sulfur bag breakage and spillage of sulfur flakes in the sulfur storage area and near the sulfur pit. Moreover only a part of the sulfur storage area is under roof. The sulfur in the uncovered area is exposed to the elements.

Soil contamination due to the previous sulfur storage area not being cleaned. This area is contaminated with sulfur from broken bags when sulfur was previously stored in this area.

There were four plastic drums containing off specification sulfuric acid with their lids open, near the scrubber discharge neutralization pit. These could accidentally topple or their contents could overflow during rainy periods contaminating the surrounding area thereby causing a potential employee health hazard.

Storage sheds were poorly organized and many containers were leaking or ripped. Considerable soil staining was observed around all material storage areas.

FIRE PROTECTION

A number of large foam fire extinguishers were strategically placed around the facility for fire fighting. Fire extinguisher access was blocked by material storage.

EMERGENCY RESPONSE

Satisfactory measures have not been taken for containment of any spills but the fire extinguishers were present for fire fighting and the work force is given fire drills. However, emergency exits and enunciators are absent.

Frequent power failures are a major problem and the discontinuation of mixing and reaction operations could lead to unnecessary generation waste. The available power generator on-site is undersized to meet the required power demand. Also it's "unbearable" noise causes neighborhood complaints. Procurement of a properly sized generator to ensure continuous supply of power to the PVA plant will therefore reduce downtime and generation of unwanted wastes.

SITE IMPAIRMENTS

The north side of the site has become a residential area with 15 wells adjacent to facility boundaries. One well (see Appendix I) is known to be contaminated with oily substances with mild to strong smell. This could be either due to some leakage present in the existing more than 18 year old LAWS storage tank or leakage and spillage from barrels stored in this area.

The current WWT system has only been in operation for one year. Prior to that, all wastes from the formulation of PVA and Resins were discharge in a number of soaker pits.

The ground around the fuel oil tanks shows evidence of numerous spills of fuel oil.

Due to the shallow watertable, there is a higher likelihood of the groundwater being contaminated with solvents and other chemicals used by ICM.

REGULATIONS

Initial application for Environmental Protection License was made on the 15th July 1991 and a conditional EPL was obtained on the 15th October 1992 after exchange of letters clarifying the position of ICM. License No. 1234/93 describes the permit condition including the time bound item like the noise abatement measures (relevant documents are annexed in Appendix II).

Currently the CEA is satisfied with the facility's progress in implementing noise reduction and waste water treatment projects.

Past consultants Reports

The following consultants' reports have guided the facility's implementation of environmental projects:

No	Date	Author	Description
01	07-8-90	CISIR	Waste water treatment system
02	12-6-91	E L L Ltd.	Effluent analysis report
03	05-3-91	EISIR	Noise abatement studies
04	08-2-91	CISIR	Pollution control project-WWT
05	17-2-91	E L Ltd.	Pollution abatement-WWT
06	01-3-91	CISIR Part I Part II	 Analysis of treated water - Do -.

RECOMMENDATIONS

HOUSEKEEPING

a) Efforts have begun to clean up sulfur flakes strewn around the area. This practice should be continued to remove this potential contamination source, particularly from storm water run off.

b) Install a covered storage area for sulfur which facilitates FIFO material handling and is sufficiently ventilated to prevent a dust explosion.

c) Off-specification H_2SO_4 barrels with open lids should be either put back into the acid circulation tank or neutralized and disposed.

PREVENTION OF GROUND WATER AND STORM WATER CONTAMINATION

a) Sealed concrete pads for the acid filling area and around the acid circulation, acid transfer and acid storage tanks, should be installed. Appropriate spill containment berms should be incorporated into the design.

b) Conduct pH monitoring of any discharges from the acid neutralization pits.

c) Provide proper stores facilities that include concrete floors, spill containment, and stormwater run-on control for all store areas.

d) Provide concrete pads and spill collection traps for all areas doing solvent storage and dispensing.

e) Replace leaking LAWS thinner underground storage tank. Since it has been used for more than 18 years and the existing problem of contamination of the nearby well, replacement by a new double-walled tank and accurate pumping system is necessary.

OCCUPATIONAL HEALTH AND SAFETY

a) Use of personal protective equipment should be strictly enforced (e.g., respirators while loading PVA kettles, mixers and measuring dry materials).

b) Barrels containing dilute alkali, such as sodium bicarbonate should be available in areas where acid is being handled so that, if there is an accidental acid spillage on the floor or on a worker, the acid could be neutralized.

c) Plans to install eyewash station(s) and emergency shower(s) should be implemented immediately.

d) Simulated fire exercises should be carried out from time to time to keep the workers trained in case of an emergency. Fire extinguishers should be kept unblocked.

e) Workers should be trained to react to severe SO_2 and SO_3 emissions. Simulated exercises may be carried out at regular intervals to keep the workers alert.

f) Workers should be trained in first aid in case of H_2SO_4 burns, burns sustained due to falling into the sulfur pit, respiration of SO_2/SO_3, eye irritation caused by SO_2/SO_3 and V_2O_5 (catalyst) poisoning.

g) Sound adsorption materials should be installed on the walls and hung from the ceilings in the mixing areas to minimize the sound levels in these areas. Mixer shaft balance and bearing condition should be checked.

EQUIPMENT, INSTRUMENTS AND PROCESS CONTROL

Sulfuric Acid

The manufacture of H2SO4 is a continuous process. If process control is not efficient, the steady state conditions may get disturbed with consequent loss of output, quality, energy efficiency, SOX or acid gas emissions.

The following process control observations were made.

a) Few automatic control systems.
b) Manual control of process variables.
c) Non availability of instruments for critical parameters.
d) Absence of alarms for hazardous emissions or precursor indicators.

Since all the process variables are manually controlled, the efficiency of control is low when compared to automatic control. Since, an operator can not respond to a change in a variable as quickly as an automatic controller, manual control action has an inherent time delay. This leads to situations where the plant operates outside the control limits for short time periods which may negatively impact quality, output, energy efficiency and emissions.

No detectors and alarms are available for the following:

i) Sulfur pit fire.
ii) Waste heat boiler low water level.
iii) SO2/SO3 leaks.
iv) Converter catalyst bed temperatures high and low
v) 1st and 2nd absorption columns, high acid level, which could flood the column and also get into the gas lines, causing corrosion problems.
vi) Air drying column, high acid level, which could result in column flooding, acid getting into the air lines and causing corrosion problems.
vii) Combustion air high moisture level.

Implementation of items listed below relating to **process control improvements** have the potential for payback ranging from 9 months to 21 months based on a cost of Rs. 405,000/= and a 2% yield increase for the sulfuric acid manufacturing process.

a) SOx leak detection and alarm system. (Rs 150,000/=).

b) High pressure fire water sprinkler, or foam system near the sulfur pit for fire fighting.(Rs 75,000 - 250,000/=).
c) Install a ratio controller for automatic control of the ratio of sulfur flow to combustion air flow into the sulfur furnace (Fig 4.3.1). Efficient control of these two streams will improve combustion and catalytic conversion.(Rs 400,000/=).
d) As a lower cost alternative to item c) (and most likely less efficient) install flow indicators for air and sulfur flow and monitor the indicator readouts visually. (Rs 200,000/=).
e) Furnace temperature high/low alarm. (Rs 50,000/=).
f) Waste heat boiler low level alarm. (Rs 35,000/=).
g) Catalytic converter catalyst bed temperatures high/low alarm (USD 1,000/= or Rs 50,000/=).
h) Multi temperature recorder already available to be fitted with additional facilities for temperature indication. (Rs 35,000/=).

> NOTE: If two or more of recommendations a,c,d,e,f,g or h are implemented, modifications to the existing control panel may be necessary. Examples include indicator lights on the graphic display, LCD monitors, etc. (Rs 50,000/=).

i) Installation of either ratio controllers to control the gas to acid flow ratios in the 1st absorber, 2nd absorber and the combustion air drying column, (which is an expensive proposition) or the installation of a differential pressure based alarm and blower/acid pump/sulfur pump cut off system to prevent flooding or starting of the absorption/dryer columns if the acid/gas flow ratio is high and to prevent emission of SO2/SO3 if the acid/gas flow ratio is low. The latter recommendation is estimated to cost the plant around Rs 180,000/=.

j) A lower cost alternative to i) is to install flow indicators to indicate acid flow rates to 1st absorber, 2nd absorber and dryer. (Rs 100,00/=).

k) Installation of an additional mist eliminator after the 2nd absorber so that one could be cleaned while the other is being used.

l) Stack gas SO_2 monitor should be repaired and installed without further delay.

m) Installation of a combustion air moisture indicator (Rs 40,000/=).

n) Water conditioning unit for the waste heat boiler feed water system.(Rs. 200,000/=).

o) Calibration of all the instruments in the plant (This has already been suggested by the plant manager).

PVA/RESINS

a). The manual operations practiced in the PVA latex and PVA adhesives batch operations (for example loading of kettles with raw materials, solvents and other additives, and carrying these containers to the loading level via the ladder) should be replaced by semi-automated filling systems to reduce the evaporation losses during transferring the raw materials and solvents as well as employee safety hazards.

b) The existing system to collect the volatiles from the kettles should be improved by providing a chiller, and enclosed collector system. As stated in the CISIR report(CS 1234) a complete fume hood system to collect all solvent vapors can be installed economically. Additionally, the system could supply increased ventilation to the working environment by air through fume hoods. This will help maintain the following air quality requirements.

Chemical		Exposure Limits
Slightly toxic	TLV	> 500 ppm
Moderately toxic	TLV	100-500 ppm
High toxic	TLV	< 100 ppm

MIXING/REPACKAGING

The present practice of mixing and manufacturing paints (e.g., agitation, the ambient temperature of 33°C, mixing vessels with open and semi-sealed covers) promotes considerable losses of volatile solvents. Further, manual transferring these products into small containers under open air not only has potentially deleterious effects on the health of the employees but also increases losses of these volatiles.

a) Mixing operations should be modified to utilize sealed vessels

b) Dispensing should utilize simple filling equipment that uses a vapor balance to collect solvent vapors generated during filling operations. Optionally, semi-automated systems with vapor capture systems for filling should be investigated.

c) A still should be purchased to recover solvent from the 10-20 i solvent waste stream currently allowed to evaporate. Properly operated, the still should provide a payback of less than one year.

PLANT MAINTENANCE

a) Corroded pipes and surfaces should be cleaned and a temperature resistant, acid resistant coating should be applied to reduce corrosion.

b) Replacement or repair of corroded pipe supports and absorption/dryer column supports.

c) Repair the plaster on the control room roof to prevent further deterioration of concrete structures.

d) Repair of leaking flanges and valves in the steam/condensate lines.

e) Check thermal insulation on the furnace, waste heat boiler and heat exchanger and replace as necessary.

f) Improvements for the existing insulation system in the boilers and hot thermic fluid and steam carrying lines should be looked into after a thorough investigation. Attempts should be made to use acceptable lagging materials rather than use of asbestos fibre cords.

g) Installation of a condenser on one of the three kettles and increase the rate of flow of cooling water

WASTEWATER TREATMENT

The present practice of segregation of wastewater from process wash water should be continued. The wastewater treatment system should be upgraded according to the report given by CISIR (CS 1234). The disposal of dried sludge collected in the sludge drying beds should be sent to a properly managed landfill for disposal.

SOLID WASTE DISPOSAL

a.) A marshalling area should be established on the premises to dispose all off-grade products and damaged containers.

b.) Used packaging materials from hazardous and toxic materials should be destroyed to prevent improper reuse of these packages.

c.) Solid waste collector snould be instructed to ensure that the disposal procedures recommended are followed strictly.

Note:

This report was developed using examples from several industries to illustrate and help guide reporting on abbreviated environmental assessments/audits, often referred to as "green" audits, that industrial plants are beginning to undergo in Sri Lanka. It therefore should be read to help those learning about the actual conduct of an audit -- industrial plant managers and environmental engineering consultants -- understand what environmental auditors should look for, what observations are important, how they should be presented, and what kinds of recommendations/information can be helpful.

Great liberties have been taken with technical information, process information, and environmental situations to design this fictitious audit. While composed of actual facts, and although each individual section contains accurate facts, it is not as a whole technically accurate. Because it is a composite of various industrial plants it does not represent any existing industry in Sri Lanka or elsewhere

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PART III SAMPLE ENVIRONMENTAL AUDIT VARIABLE INDUSTRIES LTD.

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INTRODUCTION

A short visit was made to Variable Industries Ltd. on 25 March 1993 to tour the facility and identify potential opportunities to reduce waste generation and improve material utilization. This report represents a summary of this abbreviated environmental review.

Variable provides printing services and press rebuilding for the packaging, advertising, and printing industries. Printed materials include plastic film, plastic/foil laminates, and various grades of papers. During the facility tour several waste reduction opportunities were identified. The tour was conducted by the Managing Director of Variable and his Technical Manager.

The following discussion is organized according to major process areas reviewed. Environmental management and waste reduction recommendations are placed at the end of each section.

Photographic Chemical Wastes:

Currently these wastes are disposed into the drain. Approximately 8 liters per day are generated. Several years ago a silver recovery unit was purchased, but according to plant staff this unit has not functioned.

Recommendation:

- The operating manual should be found or the manufacturer contacted for a replacement (SANDCO INC., Tulsa, Oklahoma, USA 918-584-2895) and the silver recovery unit restarted.

Copper Electroplating:

Copper electroplating is currently performed in two areas. Two plating baths, one containing 450 gallons and one containing 200 gallons are employed in the preparation of the printing rolls for the flexographic presses.

The older and smaller of the two areas disposes of its plating solution every three to four months. The system is equipped with a small filtration unit for removing small particle contaminants. The second (newer) unit is equipped with a larger multiple filter system. Currently this solution has been in use for six months. Both of these systems drain to a pretreatment system consisting of three tanks placed in series. A large bag of lime is suspended in each of the first two tanks to provide some neutralization of the waste acid copper solutions and some precipitation of copper sludge. After treatment the effluent is discharged to the sewer. It should be noted that the sewer is an open trench which runs along the main access road through this industrial/residential area.

Recommendations:

- Investigate the use of advanced filtration.for the 200 gallon (older) plating bath and potentially the larger bath. Strict control and removal of contaminants can considerably extend the life of the copper solution.

- Modify the small bath unit to prevent contamination of the plating solution with particulate and other contaminants from the roll anvil (spindle).

- The existing waste treatment system may not be able to meet the Sri Lankan effluent standards for the control of pH and copper (6.0-8.5 and 3.0 mg/l, respectively). The system should be monitored for compliance with the required standards and consideration given to upgrading the system to properly treat the effluent.

- Variable should investigate using an electrowinning cell for the recovery of copper from the spent plating baths, prior to the disposal of the effluent. Other options include using a plate evaporator to concentrate the solution for sale or transport to a metal reclaiming operation.

Solid Waste Management:

Plastics

A large volume (approximately 300 kg/day) of plastic waste is generated from the printing operations (i.e., 10-15% of the raw material used). This waste stream includes a number of mixed plastic or plastic/metal foil laminates as well as single sheet plastic waste. Currently this waste is commingled in a large pile in the rear of the facility. When possible the single plastic wastes are separated and sold. The laminated plastic waste is burned in a simple incinerator.

It should be noted that a typical scrap rate for "straight run" printing in the U.S. is in the 5-10% range. However, factors such as limited availability of certain film widths may place additional constraints in this industry in Sri Lanka.

Recommendation:

- Adoption of a strict plastic segregation and collection stream could increase the yield of materials to be sold.
- Investigate the overprinting of rejected printed plastic bags with off-specification or mixed color inks for sale to outside vendor/brokers. These may have a use as single color shopping parcel totes or other less critical packaging needs.

- Conduct a process capability study to identify sources and causes of waste generation. Use statistical problem solving techniques to identify key process parameters controlling waste generation[1]. Annex 1 contains output from a literature search of technical resources which discusses recycling/reuse options for plastic laminates and mixed plastic. Potential uses include plastic-based floor material, chemical recycling approaches, plastic lumber, polymer composites, recycling with additives as property improvers, plastics/textile composites, mobile recycling plants, co-combustion with coal, use in highway construction, and oil production through hydrogenation.

Solvent Management

Currently, three different solvents (isopropyl alcohol or IPA, toluene, and methyl ethyl ketone or MEK) are used to thin inks and clean the printing presses. Approximately 72,000 liters of solvent are purchased annually for an average price of US$ 510 per tonne (i.e., US$ 567 per tonne for IPA and US$ 460 per tonne for toluene).

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[1] Bhote, Keki, "World Class Quality", American Management Association Publishers, 1991. (On hand in Sri Lanka at NAREPP/IRG.)

Recommendations:

- Variable should review their cleaning practices to assure that as much of the ink is first scraped from the equipment and dry wiping is performed to remove excess ink prior to the cleaning of the equipment with solvents.

- Purchase of a small solvent distillation recovery unit should be considered. The still should be sized to handle the average daily volume of solvent laden material generated. Recovery of solvents will reduce the over all consumption and provide Variable with a low cost mixed solvent for cleaning, leaving the virgin solvent to be used for thinning or final cleaning of critical surfaces. Annex 2 contains a payback calculation based on rough order of magnitude (ROM) costs for installation of a solvent recovery system.

- Ventilation in the press room should be increased to reduce worker exposure to harmful vapors and reduce the risk of fire. During the tour, a number of open solvent containers were observed as well as the disposal of solvent coated rags in a pile on the floor. Properly covered containers should be provided for the storage of these materials to prevent the loss of solvents through evaporation, reduce the risks of fire, and health risks to workers.

Painting

Painting of the press frames and other components is currently done outside. In the past this practices has generated a lot of complaints from the nearby residences. During rainy and damp weather, painting is done on the assembly floor. The following recommendations should be considered:

- Spray painting should be carried out inside paint booths having mist trapping and filtering devices. Use of a paint booth with proper filtration and adoption of a more efficient paint spraying technique may reduce the noticeable emission of VOC odors allowing the industry to continue to conduct painting on the premise.

- Strong consideration should be given to replacing the less efficient air spray guns with high efficient spray techniques. A comparison of the material application efficiencies and potential paybacks are given in Annex 3.

- Respirators with a suitable organic vapor cartridge should be provided to all painters during painting operations.

Boilers

In the printing operation dryers are employed when using water based inks. We observed heat loss due to steam leaks, un-insulated steam pipelines, deteriorated insulation, and direct exhaust of hot air from the number 2 dryer, estimated to be 0.2 x 10^6 Kcal/hr.

Although steam traps are provided in the steam lines the collected condensate is not utilized. Approximately 10,000 liters of condensate can be collected per day and recycled to the boiler feed water system.

- Implement necessary simple corrective measures including tightening of flanges and providing adequate lagging for pipelines, savings of Rs 40,000/= per month can be achieved. The present temperature of the environment in this section of the plant can

Fuel Tank Overfill Protection

Significant spillage and drips were observed in the vicinity of the fill and overflow pipes for the above ground boiler fuel oil storage tanks. This has contaminated the soil in the immediate area which is a precursor to ground water contamination.

Recommendations:

- Both fuel oil tanks should be provided with level indicators to prevent spilling when loading.
- Install a concrete pad with a containment berm be installed so that any spill could be retained.

ANNEX 1

Literature Search:
Recycling/Reuse Options for Plastic Laminate and Mixed Plastic.

ANNEX 2

ESTIMATE OF PAYBACK ON SOLVENT RECOVERY DISTILLATION UNIT:

Solvent Usage: 6,000 l/mo x 0.2 kg/l
= 1,200 kg/mo or 1.2 tonnes/mo

Solvent Cost: US$ 510/tonne, average * 1.2 tonnes/mo
= US$ 620/mo

Capital cost of distillation unit: US$ 10,000

For 50% solvent recovery:

Payback = US$ 10,000 / (US$ 620/mo * 50%)
= 32 months

For 30% solvent recovery:

Payback = US$ 10,000 / (US$ 620 * 30%)
= 54 months

ANNEX 3

PAINT APPLICATION METHOD EFFICIENCY

	Application Method	Efficiency
1)	Air atomized, conventional cup guns (current method)	30 - 40%
2)	Air less, air assist spray guns	40 - 60%
3)	Centrifugally atomized, with electrostatic	80 - 90% 85 - 95%
4)	Pressure atomized, with electrostatic	65 - 70% 85 - 90%

COST BENEFIT ANALYSIS OF THE RECOMMENDED PRACTICES

Current Painting Materials Costs Assumptions

App. current paint usage	= Rs 150,000.00
App. current solvent usage	= Rs 90,000.00
Total	= Rs 240,000.00/Month

Potential Savings

Application Method		% Reduction in cost	Savings/Month
1.	With airless, air assist	20%	Rs. 48,000.00
2.	Centrifugally atomized	40%	Rs. 96,000.00
3.	Pressure atomized		