CHAPTER 3 WASTE AUDIT

3.1 INTRODUCTION

Waste audit is an essential starting point for identifying waste types, sources and quantities, as well as the areas where waste minimization can be incorporated.

The objectives of conducting waste audit include :

1. identifying every waste stream in specified production line
2. quantifying and characterizing the waste generated

3.2 DESCRIPTION OF WASTE AUDIT PROCEDURE

The waste audit was conducted according to the following steps :

1. Determination the audit scope
2. Collection of background information
3. Distinguish and characterize input materials, product and waste stream, and
4. Evaluation of data and preparation of waste audit report.

3.2.1 Determination of Audit Scope

This is a crucial step prior to the audit being carried out. It helps to determine the issues and elements of the process and site worthy of detailed investigation

3.2.2 Compilation of Background Information

A waste audit protocol/worksheet was prepared, according to the worksheet recommended by the USEPA Waste Audit Guidelines (1990) as shown in Appendix 1 to Appendix 3, and the waste audit worksheets were used to collect essential background information in the plant. This includes information on input materials, manufacturing process, waste material produced and the cost of waste management.

3.2.3 Identification and Characterization Of Input Material, Products and Waste Streams

Identification and characterization of input materials, products and waste streams were carried out by

1. categorizing every waste streams according to production process flow diagram,
2. compilation of data on input and production materials including those categorized as hazardous components, data on the material handling, storage and the rate of generation of the materials, and
3. compilation of quantitative data on the waste streams including volume and generation rate.

3.2.4 Plant survey

A plant assessment was performed to fill the gaps identified during the review of the background information and to achieve a better understanding of the possible root causes of waste generation. This is mainly achieved through a site inspection. The type and the amount of waste generated were monitored at different shift for 4 weeks.

3.3 WASTE AUDIT RESULT & DISCUSSION

3.3.1 Audit scope

Waste audit only focused on 'Phase 6' (Figure3.1) which involves the manufacturing of optocoupler (Appendix 2 and 3) and excluded other production line and office waste generated from office operation. The layout of this area is approximately 30,000 square feet with 78 people working in the department and is fully equipped with automated machines.

The layout adopted here is a combination of process and production flow. The standard processes flow components are Die-Attach, Wire Bond, Coupling, Molding, trim & Form, Solder Dip; Testing, Marking, Packing, Quality Assurance (QA) Buy Off and finally to Finish Goods Store (Figure 3.1). The process where hazardous waste is generated is the coupling process.

Manufacturing process	Production Activity
DIE ATTACH	Attachment of optical chip onto leadframe using silver-laden epoxy paste
WIRE BOARD	Establish the electrical connectivity between the chip and external lead
COUPLING	Epoxy is used to cover the diode and the circuit to provide a total reflective optical transmission medium
MOLDING	Establish a protective cover for the internal circuit
SOLDER DIP	Singulation of units with subsequent lead forming
TRIM & FORM	External lead finish with Pb / Sn
TESTING	Device tested to electrical / optical requirements
MARKING	Labeling of units to denote device type and period of manufacture
PACKING	Packed to fixed quantity in tubes or reels
OQA BUY OFF	Final QC check prior to shipment
FINISH GOODS STORE	Awaiting shipment

Figure 3.1 Manufacturing process of optocoupler

3.3.2 Compilation of Background Information

Only a limited background information was available, because the company do not have some of the documents while some of them were not revealed due to industrial confidentiality. The status of the availability of the background information is presented in Table 3.1.

Table 3.1 Status of availability of background information

Background information	**Availability**
I. Design Information	
1. Process flow diagram	√
2. Material and energy balance	x
3. Operating manuals and process description	√
4. Equipment list, specification and data sheet	√ *
5. Plant layout and elevation plan	√
II. Raw Material & Production Information	
1. Material safety data sheets	x
2. Product and raw material inventory records	√ *
3. Operating procedures	√
III. Environmental Analysis Information	
1. Waste analysis reports	x
2. Waste manifest	x
3. Waste transport and disposal records	√
4. Environmental audit reports	x
IV. Economic Information	
1. Waste treatment and disposal cost	√
2. Product, utility and raw material cost	√ *
3. Operating and maintenance cost	√ *

Note : x Information not available
√ Available information
* Information available but not revealed by the facility

3.3.3 Input Materials, Product and Waste Stream

Input Material

The waste generated is basically the epoxy mix which is used for coupling process. In this process epoxy is used to cover the diode and the circuit to provide a total reflective optical transmission medium. This process requires epoxy to be prepared and is subsequently done in a room. Table 3.2 shows the composition of the raw material used for the epoxy mix.

Table 3.2 The raw materials used in the epoxy mix

Raw materials	Grams/mix
Titanium oxide(powder)	1000
Die Electric Gel	1666.8
Silane	12

The operators will mix the three raw materials using an electric stirrer. After mixing, they place them on a roller.

The mixing room is isolated from the production line for safety reasons. Entry into epoxy mix room requires respirators, goggles, safety gloves and safety aprons (PPE). The epoxy prepared in the mix room is used at the coupling machine. The reservoir where the epoxy is used is brought back to the epoxy room for washing every 2 hours (epoxy becomes viscous). Washing is done using solvent known as Pre-clean. The consumption is 36 litres per shift.

The hazards in the epoxy room are air contaminant, mineral dust (TiO_2), slippery floor and chemical and epoxy spillage on body/eye. The hazards present at the coupling machines are, operating machine with unsecured machine guards. This department 'Phase 6' and this area in particular the coupling process has recorded the highest number of accidents both in the year 2000 and current 2001. Among the raw material mentioned above, titanium oxide is considered as hazardous. Inhalation of titanium oxide can cause cancer in the long run.

The input material are delivered to the facility by lorry. The titanium oxide is packed in paper or plastic bag while the two types of gel will be in drums. All the raw material are stored in the warehouse which is in their facility. Forklift are used to transfer the input materials to the preparation room beside the production line. Drums used to contain the raw material will be recycled to fill in the waste.

Products

Coupling is one of the step in the whole process of producing optocoupler. The product of this step is a lead-frame with optical chips attached on it. The coupling process provide a total reflective optical transmission medium.

Waste Stream Assessment

Various waste types are generated, ranging from the packaging material, empty carton boxes, plastics and housekeeping waste. Basically the only waste at coupling process is the epoxy mix. Once it has been used, the waste will be placed in a 300kg drums.

3.3.4 Data Evaluation

Beside the waste at coupling process, there are other waste from different processes and department. The summary of various waste type is shown in Table 3.3.

Table 3.3 Summary of various waste types generated at Fairchild Optoelectronics

Type of waste	Average amount in kg / day
Boxes	42
Polystyrene	7
Tube	137
Paper	15
Plastic container	34
Moulding compound	150
Compound + metal dust	320
Others	80

Waste such as paper comes from the administration office. While the others are mostly from the production site.

3.3.5 Wastewater

Beside analysing the solid waste from Fairchild Optoelectronics, a test was also carried out on the waste water. The waste water was coming from all the production lines in the facility. The water is treated in the Fairchild plant itself. The treatment method was neutralisation. The waste stream was treated by pH adjustment by adding acid to it. The pH of the initial waste stream was 13.5. By adjusting the pH of the effluent to pH 11or 12, most of heavy metals can be converted into insoluble metal hydroxides. The insoluble component required separation from the metal-free solution. This was carried out by coagulation process. Coagulation is the addition of chemicals to cause aggregation of dispersed materials. Than the aggregates is separated from the liquid. The metal free solution was further treated with acid to reduce the pH .

Four samples were taken from four different places at the treatment facility. Sample 1 and 2 is taken before the neutralisation while Sample 3 and 4 is taken after the neutralization process. The pH before the treatment was 13.5 and after the treatment was 8.1. After the waste water was neutralised, it is release to the drain nearby. ICP-AES was used to analyze the elements in the wastewater and the analysis is displayed in Figure 3.2. As can be seen in Figure 3.2 the treatment which was carried out has reduced some of the elements in the effluent. The parameter limits of the effluent is based on the Environmental Quality Act 1974 (Sewage and Industrial Effluents) (Appendix 1). The element content before the neutralization was already below the Standard A or B limit. Neutralization was carried out mainly for the high pH.. The pH before the neutralization was 13.5 and after the treatment was 8.1.

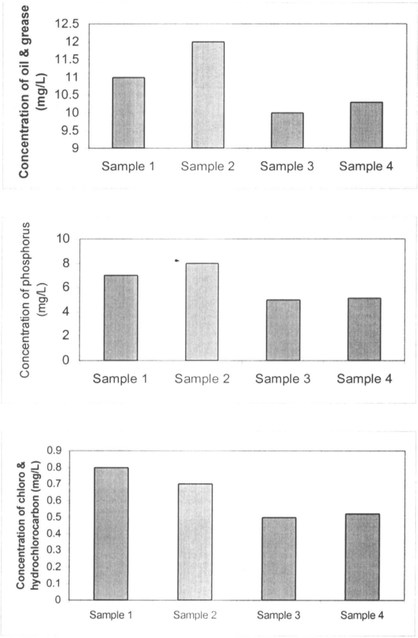


Figure 3.2(a) Concentration changes for oil & grease ,phosphorus and chlorocarbon and hydrochlorocarbon before (Sample 1 and Sample 2) and after (Sample 3 and Sample 4) treatment.

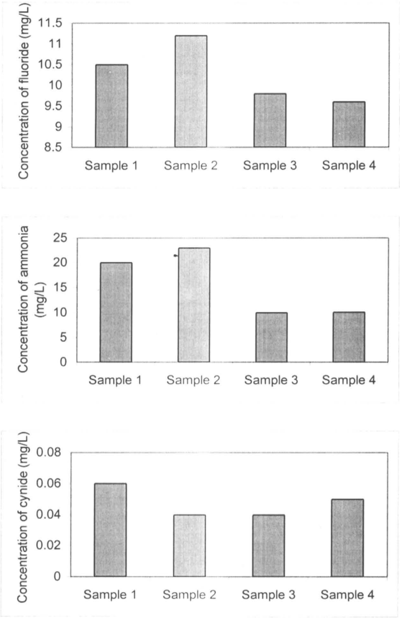
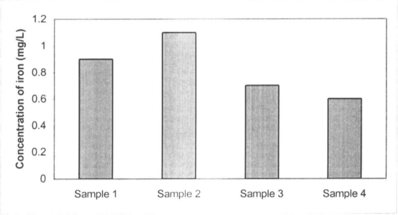
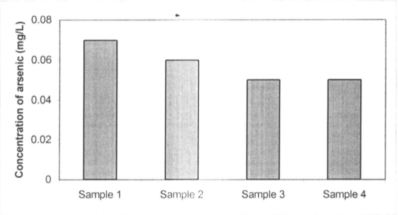


Figure 3.2(b) Concentration changes of fluoride, ammonia and cyanide before (Sample 1 and Sample 2) and after (Sample 3 and Sample 4) treatment.





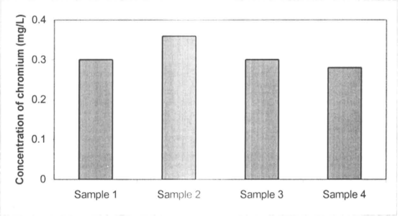


Figure 3.2(c) Concentration changes for iron, arsenic and chromium before (Sample 1 and Sample 2) and after (Sample 3 and Sample 4) treatment.

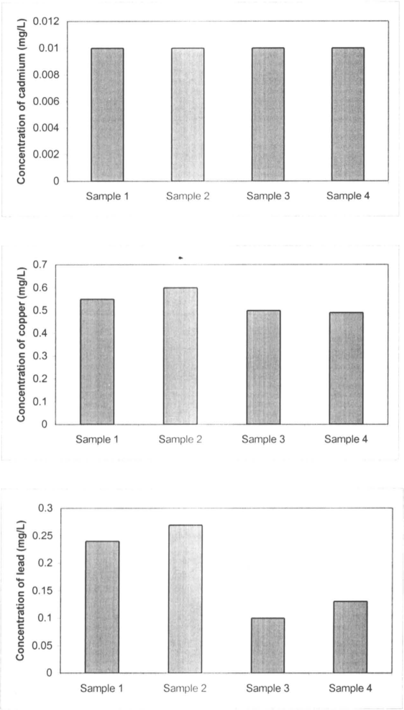
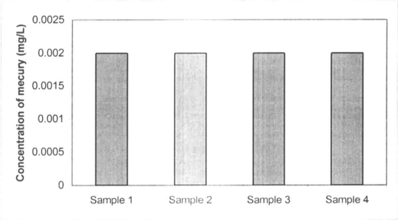
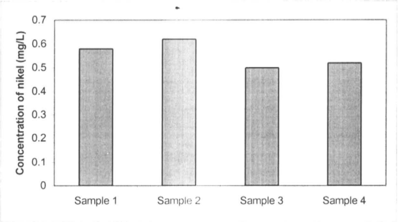


Figure 3.2(d) Concentration changes for cadmium, copper and lead before (Sample 1 and Sample 2) and after (Sample 3 and Sample 4) treatment.





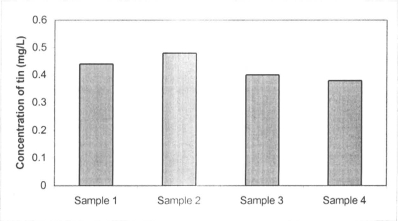


Figure 3.2(e) Concentration changes for mecury, nikel and tin before (Sample 1 and Sample 2) and after (Sample 3 and Sample 4) treatment.

After the treatment some of the element has been reduced and some remain unchanged. Mercury and cadmium is the two element which did not change with the treatment. which have a drastic reduction is lead, ammonia, fluoride and oil & grease. Ammonia is reduced because of the neutralization while lead has a lower solubility at pH around 8. Oil and grease is basically removed by filtration. The rest of the elements had small changes. Most of these elements are transition metal and they have a high solubility in both high and low pH.

3.3.6 Current Control Measures in Fairchild

Some control measures have been recommended by the Safety, Health and Environment Department.

1. Warning signs to be pasted and operators to be informed that stern action would be taken.
2. In addition, safety shutoff device to be installed in the coupling machines to prevent further accidents in case of operator's negligence.
3. Regular monthly inspection on machine guards to ensure effectiveness of control measures undertaken.
4. Eliminate the use of pre-clean in the washing process and replace with disposable foil lining in the reservoir.

5. Installing of an improved and effective local exhaust ventilation system in place of the old ineffective system (which allows titanium oxide dust and other toxic contaminants in the air).
6. Refresher training and education for all the operators, technicians and supervisors on safe operating procedures (annually).
7. Operators working in TiO_2 mix area should be subjected to medical exam, x-ray and pulmonary lung test (requirement by factories and Machinery Act).

To review the effectiveness of the control measures recommended, regular monthly inspection and quarterly audits are to be conducted.

3.3.7 Generation Rate

The rate of generation of the waste are reported as in Table 3.4. This waste is including all types of waste which is generated from all the department and production sites.

Table 3.4
Generation rate of the waste for the year 2001 and 2002

	2001	2002
Annual (metric tonnes/year)	40	45
Maximum (metric tonnes/month)	4	4.3
Average (metric tonnes/month)	3.5	3.8

Source :Fairchild Optoelectronics KL

Based on the table, the waste generated for year 2002 has increased 12.5% metric tones compared to year 2001. The maximum weight of waste per month has also increased 7.5%. This is mainly because increase in production. This also shows that there is no action taken to reduce or minimize the waste generated. The same condition applies for the waste water. There is no waste audit have been done before in this company. According to the Environmental Officer, the company was not very keen in carrying out any waste minimization program for solid and water waste . Lately a committee was set up to look into this. At the moment all the hazardous waste are still sent to Kualiti Alam, Bukit Nanas. The water waste is treated in the company facility.