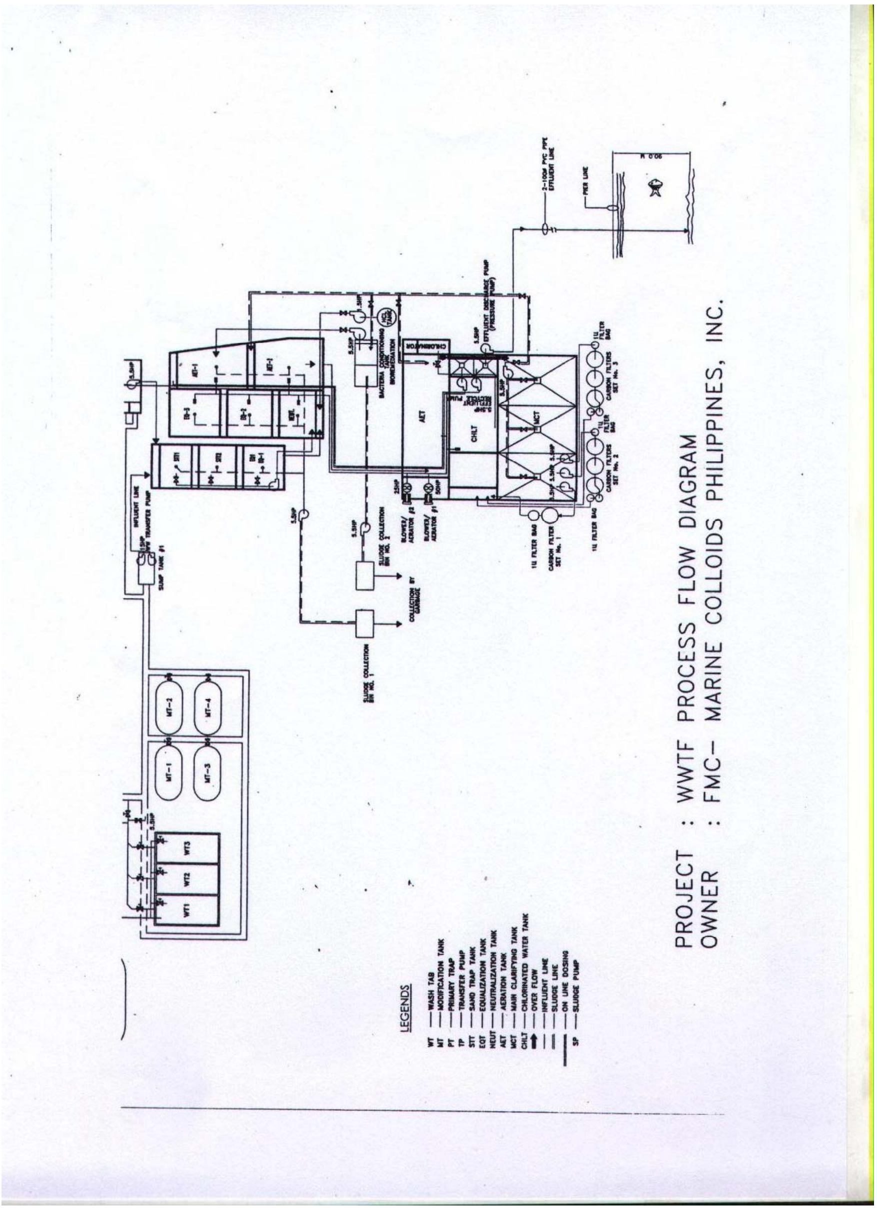
4. FMC Marine Colloids Phil., Inc.

Fig. 6.4. 7. Process Flow Diagram of the Production of a Carageenan (AMF).



1.0 Waste Stream Description and Current Waste Management Practices

Solid wastes generation and air emission are the major concerns of CIFC. Liquid wastes generated are minimal. The succeeding sections describe the various wastes generated at CIFC.

◇ Solid Wastes

The solid wastes generated by the CIFC Plant are as follows:

- Slags (30,000 kg/year)
- Sand (900 kg/year)
- Scrap refractory bricks

- Fly ash
- Iron filings
- Used sand paper
- Metal spillages

The amount of slag generated by CIFC amounts to 30,000 kg/year. The other solid wastes had not been quantitatively determined yet.

◇ Liquid Wastes

The liquid waste generated by Cebu Iron is the spent scrubbing water, which they used to abate the air pollutants from their chimney. This wastewater passes through a 3-chamber cooling pond before it is discharged to the storm drain.

◇ Air Emission

Air emissions are generated from the furnace or cupola. At the time of the visit, brown gases were observed during the start of firing of the cupola. However, these gases had not been analyzed yet. Thus, there is no available data in terms of the specific air pollutants or their quantity.

◇ Current Waste Management Practices

CIFC has been implementing several recycling programs to manage their solid wastes. All of the metal spills and defective products are recycled by remelting them and use as input material. Molten metals left in the cupola, waste cast iron chips, and metal filings are also recycled. Sand from molds is reclaimed.

Fine sand, which cannot be used anymore in the plant, slags, and fly ash are disposed by landfill within the compound and adjacent agricultural land which is still owned by the company

To abate air pollution coming from their furnace, CIFC has installed a wet scrubber. In addition, dust collectors were also installed to collect the dust coming from grinding and shot blasting machines. Moreover, the company has plans of converting the wet type scrubber to the dry type of scrubber.

The company is also practicing the 5S program and does not allow the entry of non-biodegradable materials, such as plastic, into the compound.

2.0 WM Recommendation

The following options (Table 6.4. 12) are recommended for the management of wastes generated by the processing plant of CIFC:

Table 6.4. 12. Recommended Waste Minimization Options

Options	Rationale	Expected Impact
1. Monitor the quality of coke purchased; use better quality fuel.	The pollutants emitted come from fuel. Low quality fuel may contain more air pollutants.	Reduce air emissions
2. Study the effectivity of scrubber in controlling air pollution and make improvements/adjustments. Experiment using lower air pressure at the start of firing.	Strong air blowers may blow off the water curtain of scrubber.	Reduce air pollution
3. Check air-fuel ratio at various stages of the melting process to get the optimum adjustments and proportion.	Too much air has a cooling effect while insufficient air causes incomplete burning and pollution	Minimize waste of fuel/energy and costs
4. Find or tap other sources of water, such as rainwater from roofs of plant/office, for putting off embers at the end of daily production.	At present precious drinking quality water is used for putting off embers but this process does not need high quality water.	Save and conserve water and costs
5. Evaluate the substitution of some low quality materials with better quality materials. The higher cost of better quality materials must be weighed versus the costs for re-working/re-melting.	The higher cost of better quality materials must be weighed versus the costs for re-working/re-melting, and time delay.	Minimize metal spills and products with defects, re-melting/re-working to save on costs.
6. Collaborate with other industries for the utilization of other solid waste materials. Slags can be utilized as materials for cement while waste sand, fly ash, and bentonite can be utilized by the pottery industry, which exists in this area.	Waste utilization minimizes wastes.	Eliminate waste. Potential revenue from waste materials

2.0 Future WM Activities

The recommended waste minimization options developed for CIFC were the result of the rapid one-day WM assessment. It is highly recommended that a more comprehensive assessment be conducted in support to what the EMPOWER WM Pilot Project has initiated. In preparation and in support to this endeavor, the team is recommending some post WM assessment activities. The succeeding sections present these activities.

3.0 Monitoring And Testing Requirements

One critical aspect of WM is monitoring. The monitoring process helps the company track down and record progress in their WM implementation. For CIFC, it can start by performing a more comprehensive source inventory of all types of wastes from the different processing areas. This can be done through waste audit.
In addition, the assessment team will be able to identify waste sources that are problematic and decide at what stage of the process waste minimization could be started.
The Team encourages CIFC to establish benchmarks or performance indicators. The following performance indicators can be used by CIFC in their monitoring process:

- Volume of water use per metric ton of production (m3/MT)
- Volume of wastewater generated per metric ton or production (m3/MT)
- Quantity of chemicals per metric ton of production (kg/MT)
- Pollution load per ton of production (ex: kg TSP/MT product)

Benchmarking on every process will help CIFC identify which process has made significant progress in the waste reduction effort.
To know the quality of air emission, the following parameters will be determined: total suspended

particulates (TSP), sulfur dioxides (SO2), oxides of nitrogen (NOx) and lead. In addition, CIFC may want to analyze the spent scrubbing water for the following parameters: pH, total suspended solids (TSS), total dissolved solids (TDS), and heavy metals (Pb, Cd, Cr, Cu).

4.0 Organization Of Waste Minimization Team

To ensure sustainability, an in-house waste minimization team shall be organized to oversee all the activities in the implementation of the waste minimization program of the company. To generate a strong involvement among the personnel, team members must be selected from the different company's departments or processing sections.

5.0 Implementation Schedule

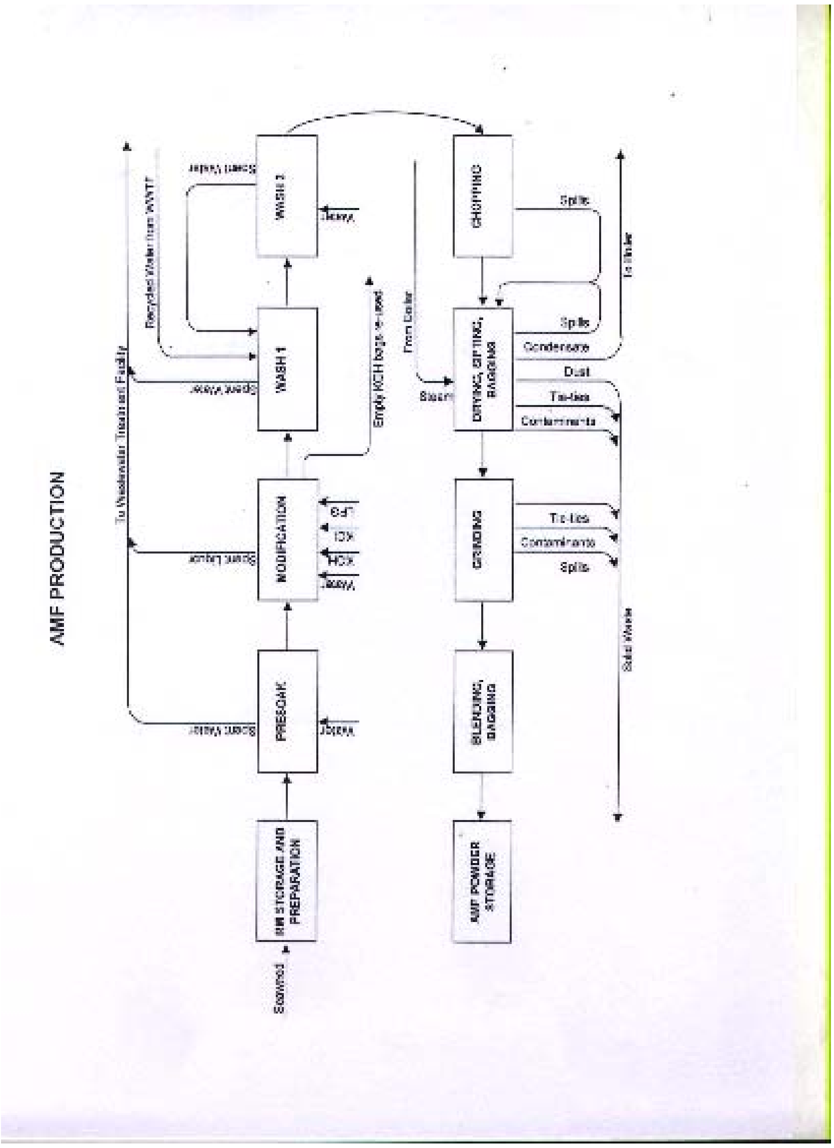
The activities listed in Table 3 presents the short and medium term actions that CIFC can do to support the WM activities initiated though the WMPP. These activities will also help CIFC sustain WM in the plant.

Table 6.4. 13. Recommended Waste Minimization Options

ACTIVITIES	TIME FRAME/DURATION
1) In-house training	Immediate/2 days
2) Organize in-house team	Immediate/1 day
3) In-depth WM assessment	1 to 3 months/2 to 3 days
4) Benchmarking/establishing performance indicators	1 to 3 months/2 to 3 days
5) Facility walk through (for process validation)	1 to 3 months/2 days
6) Brainstorming and formulation of waste minimization options	1 to 3 months/1 day
7) Prioritization and Implementation of Options	1Continuous

5. FMC Marine Colloids Phil., Inc.

Fig. 6.4. 8. Diagram of the wastewater treatment facility of FMC



◇ Raw Material Storage and Preparation

The seaweeds delivered to the plant are stored, cleaned, sorted, spread, and partially dried under the sun in a wide open space with concrete flooring. Some plastic strings and other contaminants are removed manually.

◇ Presoaking

The dried seaweeds are soaked in water in presoaking tanks, after which, the spent water is discharged to the wastewater treatment facility and the seaweeds are transferred to the modification tank.

◇ Modification

A mixture of water, KOH, and KCl (Liquor) is continuously boiled and the soaked seaweeds are cooked in this mixture. LPG is used as fuel for heating the modification tank. After cooking each batch of seaweeds, the chemicals are gradually depleted, thus, the chemicals in this mixture are replenished. After using the liquor several times, the spent liquor is discharged to the wastewater treatment facility.

◇ Washing of Seaweeds

The cooked seaweeds are washed twice with water in two wash tanks. The spent water in the 1st wash tank is discharged to the wastewater treatment facility. The spent water from the 2nd wash tank is transferred to the 1st wash tank and used for washing the next batch of seaweeds. Fresh water is used for filling the 2nd wash tank.

◇ Chopping

The washed seaweeds are chopped in the chopping machine. Spilled materials are also sent to the drying machine.

◇ Drying, Sifting, and Bagging

The chopped seaweeds are dried using steam from the boiler, after which the seaweeds flow to the sifter for size segregation, and then bagged. The spilled materials are recycled. The steam condensate is channeled back to the boiler. The dust, tie-ties, and other contaminants such as wood, stones, and shells are also removed during these processes.

◇ Grinding

The products are reduced further in size by grinding. During this process, more tie-ties and contaminants are removed.

◇ Blending and Bagging

The carageenan or alginate is blended with other materials to produce the specified product, packed in bags, and then stored.

1.0 Waste Stream Description and Current Waste Management Practices

◇ Solid Wastes

- The following solid wastes are generated during the production of carageenan:
- Empty KOH bags
- Tie-ties (plastic strings)
- spilled materials during chopping, drying, sifting, bagging, and
- grinding processes
- contaminants
- dust

The empty KOH bags are either sold or reused in the plant. The tie-ties are disposed to the municipal waste disposal site. The spilled materials are collected and recycled. The dust particles produced during grinding are collected by vacuum cleaning and recycled also.

About 1-2 g of contaminants per kilogram of seaweed are generated. The contaminants consist of stones and strings which are separated from the seaweeds by manual picking and disposed with municipal wastes. Figure 2 shows the sources of the above-mentioned solid wastes.

◇ Liquid Wastes

The total volume of wastewater generated by the company ranges from 140-210 m^3/day. The volume depends on the type of product processed by the plant. The wastewater generated by the company are shown in Table 6.4. 14

Table 6.4. 14.Wastewater Generated by FMC Marine Colloids

Sources/Process	Quantity (m^3/day)	Characteristics
Presoaking	6.62	
Modification	0.74	Modification and Wash Processes
Washing of seaweeds	105.6	Influent / Effluent BOD 1,500 / <109 DO — / 7-8 pH 14 / 6-8
Washing of equipment	0.07	
Washing of floor	0.07	
Domestic	0.2	

◇ Air Emissions

The sources of air pollutants generated by the plant are:

- Boilers
- Grinders
- Blenders
- Generators

The plant has 3 boilers. Two boilers are in operation 24 hours/day and 6 days per week. One unit of boiler is on standby. The air emission from the chimneys during the plant assessment does not show any smoke or color. The generators are all standby units and will have emissions only when operated during blackouts or power failures.

2.0 Current Waste Management Practices

The company has already started implementing waste minimization measures. The following major WM measures were implemented:

◇ Collection and utilization of rain water

The cost of water in Cebu is high at P38.00/m^3. A cistern with a capacity of 96 m^3 was constructed to collect rain water and this is used to augment the water supply from the municipal water district.

◇ Reuse of wash water

Spent water from the 2nd washing tank (Wash 2) is sent to and utilized in the 1st washing tank (Wash 1) prior to disposal.

◇ Reuse of liquor in the modification tank

The liquor in the modification tank is reused several times. The chemicals depleted during the processing of seaweeds are replaced. The concentration of the chemicals is monitored by chemical analysis and the number of times that the liquor can be reused is based on the analysis. Thus, water and chemicals are saved through reuse.

◇ Reuse of effluent
Part of the treated water from the wastewater treatment facility is reused for pre-soaking raw materials.

◇ Collection of condensate
The condensate from steam are collected and used again as feed water for the boilers.

◇ Use of heat exchangers
Heat is conserved using heat exchangers.

◇ Recycling of spilled materials and dust
Spilled materials are collected by vacuum cleaners and recycled. Dust particles are collected by cyclones and baghouses and recycled also.

◇ Reuse of empty sacks
Sacks which were used as containers for raw materials were either given back to suppliers for reuse or reused in the plant.

◇ Treatment of wastewater
Wastewater is being treated using an extended aeration system with bio-augmentation and sludge recycling. This treatment facility consists of 2 sump tanks for the equalization of the influent, sand traps, neutralization system with auto dosing instrument, stabilization/equalization tank, three (3) aeration tanks, clarification tank, activated carbon filter system, 1 micron filter system, and polishing tank. The activated sludge from the clarification tank is recycled to the three (3) aeration tanks. Fig. 6.4. 8 shows the diagram of the wastewater treatment facility.

◇ Disposal of effluent
Part of the treated wastewater was disposed to the creek,which flows to the Mactan channel.
The flow diagram is shown in the Annex.

3.0 Recommended Waste Minimization Options

◇ Waste Minimization Options
The following Table 6.4. 15 presents the waste minimization options recommended by the Waste Assessor for implementation in the plant of FMC Marine Colloids Philippines:

Table 6.4. 15. Recommended WM options, rationale, and expected impact

Options	Rationale	Expected Impact
1. Installation of preheater in the LPG line and reduction of LPG flow	Preheating gas usually reduces fuel consumption	Savings on energy/LPG fuel
2. Monitor and determine the optimum temperature and retention time in the	Energy can be saved if the optimum operating conditions are maintained.	Savings in energy and costs

Options	Rationale	Expected Impact
modification process and maintain these conditions.		
3. Study the enclosure of areas or equipment which generates dust.	Enclosure of some areas/equipment prevents the spread of dust to other parts of the plant and reduce the dust collector required to control the dust particles because the collection will be required in smaller areas only.	Savings in dust collection facilities, and costs and protect the health of workers.
4. Maximize the collection of rainwater; collect the rainwater from the roofs of other buildings of the company. This option may require additional water tanks and piping.	Rainwater can be used in the various processes in plant and supplement the water supply from the city.	Save water and costs.
5. Study the utilization of spent liquor from the modification process first and later on the wash water for fertilizer and/or the recovery of potassium from the spent liquor.	The waste liquor still contains potassium which may be utilized as fertilizer or the potassium can be recovered and reused. Zero discharge from the modification process and wash tanks could be the best management practice and should strive to attain this. Very big savings can be derived if the study is successful and implemented by the company.	Reduce considerably the volume and concentration of pollutants flowing to the treatment facility. Reduce wastewater. Reduce considerably the costs for treatment and discharge of wastewater. Save on costs of chemicals. Avoid litigation costs and improve public image. This option may entail high cost.

◇ Wastewater Treatment Options

The following water and wastewater management options including the treatment of wastewater are recommended:

Table 6.4. 16. Recommended Options to Enhance Wastewater Treatment Efficiency

Options	Rationale	Expected Impacts
1. Reduce air pumped to the wastewater treatment system.	Monitoring records show there was excessive aeration in the WWTF. Sometimes DO reaches 10-11 mg/L but aeration data shows that even if DO ranges from 3-4 mg/L only the corresponding BOD of the effluent can already comply with the Standards.	Savings in energy and costs. This is a low cost option.
2. Adjust the dosing of chemical for neutralization based on monitoring data. Reduce the amount of HCl used for neutralization.	Adjustment of the flow of neutralization chemicals was not done based on monitoring data. Operation is not in optimum condition. Use of excessive chemicals for neutralization is waste. Savings in chemicals can be realized if the pH of wastewater is neutralized down to about pH 7.5 only instead of sometimes 6.3	Reduce chemicals in wastewater. Savings in chemicals and costs. This is a low cost option.
3. Study more thoroughly the characterization of wastewater and identify more appropriate wastewater	Although the company can comply with the regulations imposed by DENR, the effluent still looks black, highly polluted, and very dirty and its disposal to the	Save the company costs in defending itself/litigation and improve public image of the company.

Options	Rationale	Expected Impacts
treatment.	creek/Mactan Channel is not acceptable to the community. It does not give a good public image. Thus, the management of wastewater still needs improvement.	This option may entail high cost.

4.0 Future Waste Minimization Activities

◇ Waste Minimization Team Organization
An in-house minimization team will be organized to oversee all the activities in the implementation of the waste minimization program of the company. To generate a strong involvement among the personnel, team members will be selected from the different company's departments or processing sections. A brainstorming session among team members will be organized to formulate waste minimization options.

◇ Monitoring and Testing Requirements
To be able to track down the quality and quantity of wastes generated, the company will conduct periodic monitoring. A source inventory of all types of wastes from the different processing areas through waste audit will be done by composite sampling. By this way, the assessment team will be able to identify waste sources that are problematic and also they will be able to decide at what stage of the process waste minimization could be started. To know whether waste reduction has been achieved, measurement of water consumption and wastewater generation will be done regularly. Benchmarking on every process will also be made in order to identify which process has not made any progress in the waste reduction effort of the team. To know the quality of wastewater generated, the following physico-chemical parameters will be determined: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), alkalinity and pH. BOD, COD and TSS are measurements of the organic matter components of the wastewater. The greater the COD, BOD and TSS values, the higher is the pollutive property of the wastewater.

5.0 Implementation Schedule

The implementation schedule is shown in **Table 6.4. 17**

Table 6.4. 17. Implementation Schedule

ACTIVITIES	TIME FRAME
1) In-house training	2 days
2) Organize in-house team	1 day
3)Facility walk through (for process validation)	2 days
4) Brainstorming and formulation of waste minimization options	1 day
5) Prioritization and implementation of options	Perpetual

(2) Metro Manila District

1. Basic Fruit Corporation

1.1 Facility Description and Background

BFCWI is a banana chips processing plant located in a compound together with its sister company, InChem , a chemical manufacturing plant. The banana chips processing facility occupies a 3,000 square meter space in the compound.

Formerly known as Basic Fruits Corporation, it was renamed BFC Worldwide, Inc. under a new management. It began its operation in 1999 and exports its products to Europe, North America and Asia. It has two provincial plants located in Southern Philippines where both utilize batch-frying process. The Bulacan plant, on the other hand, is the first fully mechanized banana chip frying line in the Philippines. It has recently installed its own wastewater treatment facility.

The company is owned and managed by Mr. Lawrence C. Ong. There is about 120 staff employed in the plant. It has a monthly rated capacity of 220 –240 MT at an operation of 16 hr/day with two (2) shifts per day for 288 d/year. Major products produced by the company are banana chips of different sizes (BFC 90 Regular, BFC 90 wholes, BFC 100, BFC Brokens, BFC Quarters).

1.2 Facility Layout

The process equipment layout of the banana chips processing facility, which is mainly composed of two areas: production and packaging located in the ground floor and mezzanine, respectively.

Fig. 6.4. 9.Ground Floor: Production Layout

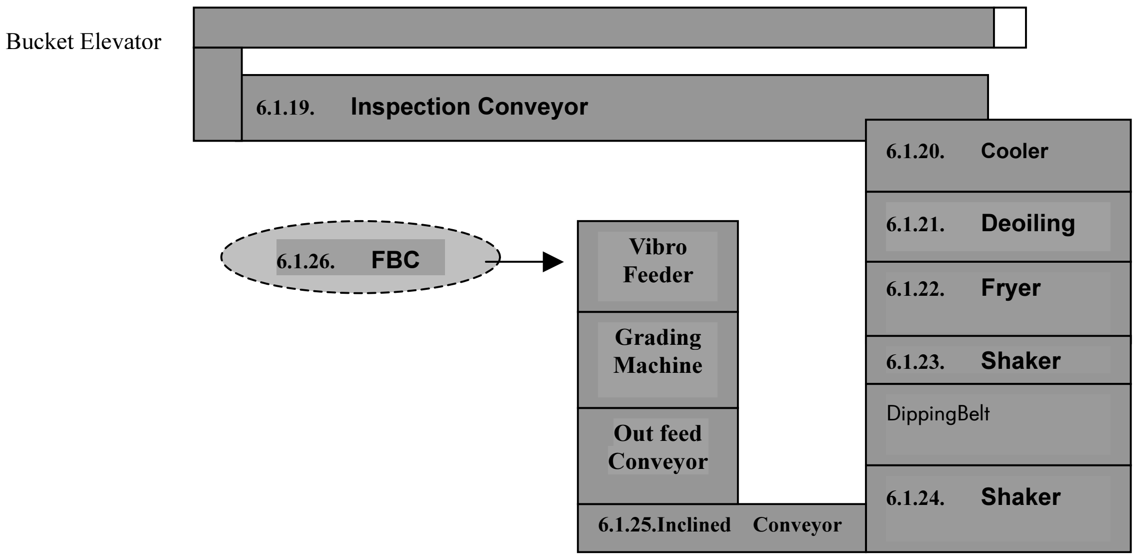
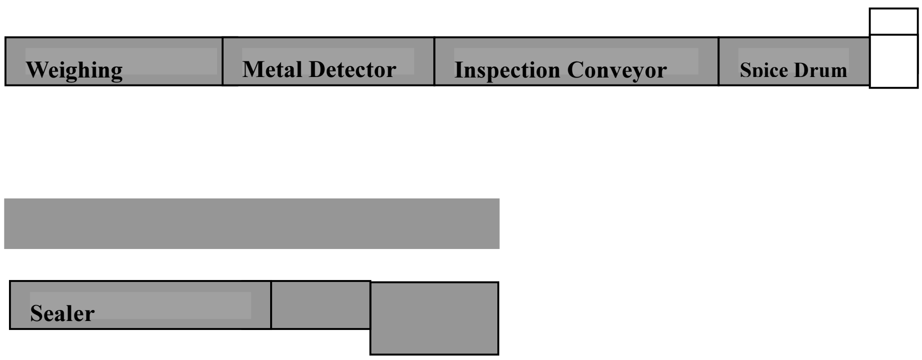


Fig. 6.4. 10. Mezzanine Floor: Production Layout



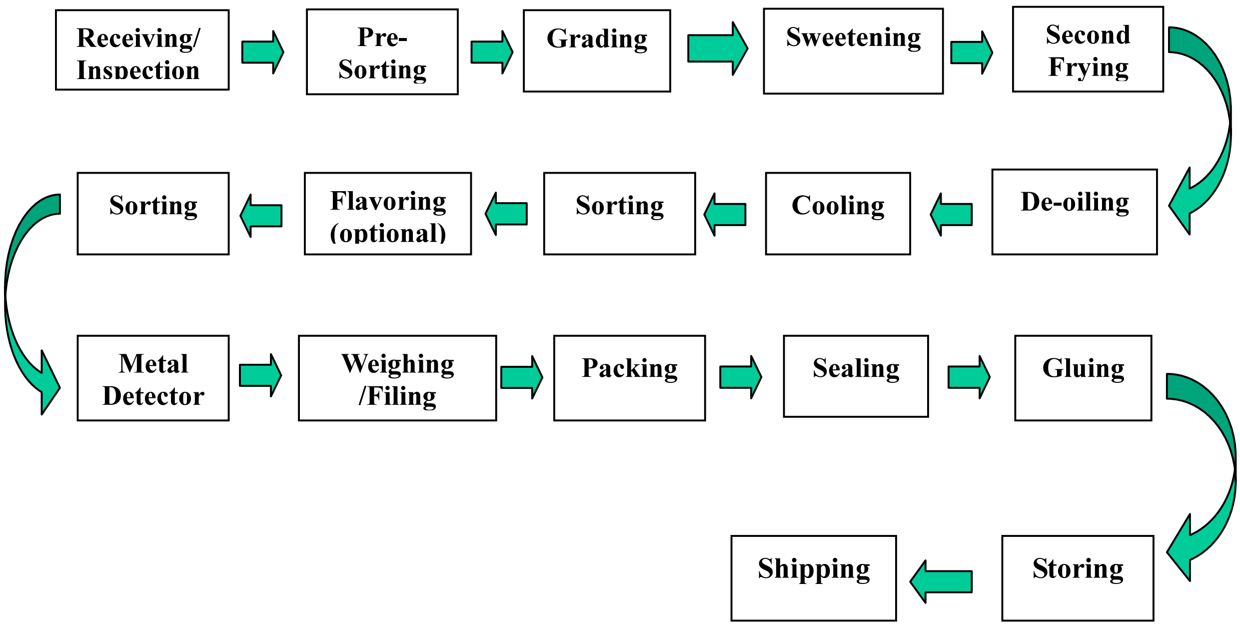
1.3 Process Flow

This section describes the process involved in the second frying operation of BFCWI. The process flow diagram is illustrated in Fig. 6.4. 11.

The fried banana chips (FBC) is hand sorted for extraneous objects such as stray strips of polyethylene plastic, fried slices of banana peel, etc. The FBC is also sorted for oily and burnt chips. The sorted FBC is stored back in new PE plastic bags in crates.

The sorted FBC is fed into the in feed hopper of the frying line and are conveyed onto a grading machine where the chips are separated according to size. Only chips with the size that is fit for the day's production are conveyed to the shaker. The chips that do not meet the size requirements are collected and stored in containers. Off-spec chips are mixed and processed together with another batch where size specification is not critical or if not these are sold to scrap buyers.

Fig. 6.4. 11. Process Flow Diagram



Banana chips that meet the specifications, on the other hand, are fully dipped in the prepared syrup. The syrup coated banana chips are then deep fried in coconut oil, previously heated to a temperature between 146-164 ^{o}C. The newly fried banana chips passed through a shaker where excess oil is drained. Excess oil is passed through a strainer to remove contaminants and other solids. Strained oil is recycled and reused for the next frying. The de-oiled banana chips pass through a counter flow cooler to cool down banana chips.

A final visual inspection is conducted to the chips for unsightly and unacceptable chips such as those that are too oily, burnt, have visible caramel coating, etc. Rejected chips are sold as feeds to scrapbuyers. Powdered banana flavor is sprinkled over acceptable banana chips in a rotating drum.

The banana chips pass through a metal detector for the presence of metal contaminant. If such contaminant is present, it is immediately brought and surrendered to the Quality Control Laboratory for record file and reference. After passing the detector, the banana products are weighed to the customer specified weight and fed into polyethylene lined cartons. The filled bags are properly packed in cartons with the folded plastic bags sealed using a vertical sealer. Then the corrugated boxes are sealed manually by applying glue and sealing with magnetic tapes. Under clean dry conditions, sealed boxes are stored in the warehouse

1.4 Waste Stream Description and Current Waste Management Practices

This section presents the various wastes generated at BFCWI and their current waste management practices.

◇ Solid Waste

BFC generates various solid wastes as part of its production process. The solid wastes produced are discussed in the following sections.

- Banana chips /grains littered on the floor
  During the sorting or grading of the banana chips according to size, some chips littered on the floor. This oftentimes goes directly to the drainage during cleaning operation.
- Hardened syrup
  About 6,500 kg/yr of hardened syrup is generated in the sweetening process of the banana chips. The syrup is sold to scrapbuyers.
- Rejected plastics
  In the packaging area, the filled bags are properly packed in cartons with plastic bags folded ready to seal. Polyethylene plastics used for sealing, which are found to be torn-out or have holes are rejected at the rate of 82,000 pcs/yr.
- Rejected boxes
  The corrugated boxes used in packing banana chips are sealed manually by applying glue. This activity produces about 113 MT of rejected boxes in a year due to incorrect labeling or printing, gluing, marking and size and fit.

◇ Liquid Wastes

Some liquid wastes were also observed from the processing of banana chips. These are discussed in the following sections.

- Used cooking oil
  Coconut oil used for frying the chips is recycled many times in a week operation. At least 47,000 kg/yr of cooking oil have to disposed of at the end of the three day continuous frying owing to significant oil discoloration which renders it unfit for reuse in chips frying. Scrapbuyers purchase the waste oil in bulk.

◇ Water for cleaning the equipment and the facility

The wastewater being directed to the treatment facility is generated from cleaning the equipment. The total estimated volume of wastewater during the morning and afternoon cleaning operations is about eight (8) cubic meters per day. Wastewater analysis performed by the Department of Environment and Natural Resources on the effluent was determined to be 924 mg/l BOD and 2,500 mg/l COD , respectively which are above the standards set by the regulatory body.

◇ Air Emissions

Air emissions are generated from the operation of two units furnace, one unit thermal oil heater/boiler and one unit stand-by power generator. The results of air quality analysis by CRL Environmental Corporation shows that all the units meet the allowable limit for sulfur dioxide and nitrogen dioxide (Table 6.4. 18). For particulate matter (PM) however, the two furnaces do not meet the emission standard with a concentration of 257 mg/Ncm & 181 mg/Ncm, respectively.

Table 6.4. 18. Air emission analysis of four units of burning equipment.

Stack No.	PM	SO_2	NO_2	CO	Opacity
Furnace # 1	257	133	ND	10	1
Furnace # 2	181	116	19	5/1	1
Thermal Oil Heater/Boiler	86	207	62	13	1
Power Generating Set (stand-by generator)	77	39	234	29	1
1) DENR Standard	**150**	**1,500**	**2,000**	**500**	**Ringelman Shade # 1**

1.5 Current Waste Management

The company in order to promote environmental protection has established some in-house waste management activities in the form of recycling and re-use. For instance, the plant is recycling some of their solid wastes by selling their scraps and rejects to scrap buyers. In order to reduce the use of water for cleaning, frying of banana chips is done for 24 hours for 3 days instead of 12 hours for 5 days.

During the on-site visit, the team observed some good housekeeping practices such as the following:

- Working and storage areas are kept clean and well organized
- Adopted a "first in, first out" policy so that older materials are used up before new ones are opened
- Inspected materials upon delivery, and immediately return unacceptable material to the supplier
- Installed and maintained level indicators and control devices where overflows are likely to occur
- Practiced preventive maintenance in their equipment
- Improved the scheduling of the sorting and frying operations

1.6 Recommended Waste Minimization Options

This section presents the recommendation of the WM Assessment Team to enhance the existing waste management practices of BFCWI.

◇ Waste Minimization Options

To reduce waste WM options were presented shown below as Table 6.4. 19

Table 6.4. 19 Waste Minimization Options for BFC Worldwide, Inc

WASTE MINIMIZATION OPTIONS/ RECOMMENDATIONS	RATIONALE	ENVIRONMENTAL IMPACT
Keep the working and storage areas clean and well organized and have all containers properly labeled.	To improve productivity and protect workers from any accident inside the facility	Minimized the production of contaminants /pollutants
Store dry materials such as bags of sugar or syrup drums, off the floor and away from the liquids by placing catch pans beneath the material. Apply strainers in floor drains in material storage area. Promote the use of dry cleanup by removing all dried solid waste from the	To prevent spilled materials from entering the drainage To reduce the use of water in cleaning the floor	Reduced organic loading in discharged wastewater Minimized the volume of wastewater discharged in

WASTE MINIMIZATION OPTIONS/ RECOMMENDATIONS	RATIONALE	ENVIRONMENTAL IMPACT
floor and the equipment before cleaning with water. Provide brooms, vacuum, and absorbents.		receiving body of water
Scrape the dried oil from the frying line and sell this to scrap buyers.	This will result to less oil in the wastewater and at the same time reducing the amount of water and chemicals needed to clean the equipment.	Reduced the oil content and chemicals/detergents of wastewater discharged in receiving water body
Emphasize minimum water usage to all employees and management. Automatic controlled faucets shall be installed in areas where personnel often use water.	To conserve water properly	Minimized the volume of wastewater discharged in receiving body of water
Install automatic dispensing systems for small ingredient make-up such as cooking oil and sugar syrup	To better monitor resource use	Reduced the quantity of wastewater discharged
Collect banana chips and other solid wastes, which were unintentionally littered on the floor to prevent its entry to the wastewater treatment facility. Canals shall be installed with aluminum screen in the working area.	To minimize lost of resources To prevent solids from clogging the drainage and entering the wastewater treatment facility	Reduced the generation of solid wastes Minimized discharging highly concentrated wastewater
Recycle rejected packaging materials such as boxes and polyethylene plastics or reuse for other purposes.	To promote recycling and reuse of resources To reduce the production of rejected packaging materials	To minimize the generation of solid wastes
Conduct a training/seminar focusing on the techniques and skills needed in the packaging line including the proper handling of instruments	To reduce the production of rejected packaging materials	Minimized the generation of solid wastes
Recycling and reuse of treated wastewater for purposes which are not too critical such as cleaning the floors, flushing of toilets, watering the plants and also for the water needed to dilute concentrated influent.	To promote recycling and reuse of resources To reduce the volume of water consumption	Reduced volume of wastewater to be discharged
Install meters on high use equipment or specific work areas to monitor consumption.	To monitor the use of resource consumption	Avoided the production of unnecessary contaminants/pollutants
Conduct R & D activities for the utilization of oily, sugary and fermented sludge. Tap the expertise of both the government and private laboratories in this area.	To avoid wastage of oil and sugar waste materials To develop technology that will effectively utilize oily, sugary and fermented sludge	Reduced the generation of solid waste
Keep up to date with technology developments	To fully utilize best available technology that is low in cost To ensure the company is aware of best practice standards.	Minimized the production of unnecessary pollutants

1.7 Wastewater Treatment Options

The company has an existing wastewater treatment facility (WTF) consisting of :oil water separator, equalization tank, cooling tank, dissolved air flotation, holding tank, sequencing batch reactor system (SBR) and effluent storage tank. In order to improve further the treatment efficiency of WTF the following are recommended:

- A screen or a strainer should be installed prior to the equalization tank to filter out and minimize solids entering the treatment facility. This will result to the reduction of organic loading in the influent.
- Review the efficiency of existing treatment facility. Conduct treatability study on the existing systems to determine the need for modifications.
- Segregate storm and sewer water (e.g. covering wash bays, installing diverters in wash bay drains, etc.) to avoid unnecessary treatment and disposal costs.

1.8 Future Waste Minimization Activities

◇ Organization of Waste Minimization Team

An in-house minimization team shall be organized to oversee all the activities in the implementation of the waste minimization program of the company. To generate a strong involvement among the personnel, team members must be selected from the different company's departments or processing sections. From among the team members, a coordinator will be appointed that will also serve as liaison officer between the management and the team. Overall, the waste minimization team will be responsible in organizing and implementing the waste minimization program of the company.

◇ Monitoring and Testing Requirements

To be able to track down the quality and quantity of wastes generated, the company shall conduct periodic monitoring. A source inventory of all types of wastes from the different processing areas through waste audit shall be done by composite sampling.

In addition, the assessment team will be able to identify waste sources that are problematic and also they will be able to decide at what stage of the process waste minimization could be started. To know whether waste reduction has been achieved, measurement of water consumption and wastewater generation shall be done regularly. Benchmarking on every process shall also be made in order to identify which process has not made any progress in the waste reduction effort of the team.To know the quality of wastewater generated, the following physico-chemical parameters shall be determined: biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), alkalinity and pH. BOD, COD and TSS are measurements of the organic matter components of the wastewater. The greater the COD, BOD and TSS values, the higher are the pollutive property of the wastewater.

1.9. Recommended Waste Minimization Activities

Table 6.4. 20. shows the WM activities of the company.

Table 6.4. 20. Waste Minimization Activities

Activities	Time Frame
1. Conduct in-house training	2 days
2. Organize in-house team	1 day
3. Facility walk through (for process validation)	2 days
4. Brainstorming and formulation of waste minimization options	1 day
5. Prioritization and implementation of options	Continuous

2 International Chemical Industries (Inchem)

2.1 Facility Background and Location

Inchem was established in 1957 as International Chemical Industries, Inc. It is one the largest electrochemical complex in Asia, which supply most of the chemical needs of the fast growing industries in the Philippines. Hydrochloric acid (HCl), sodium hypochlorite (NaOCl), ferric chloride (Fe_2Cl_3), potassium sulfate (K_2SO_4), and calcium chloride ($CaCl_2$) are some of the chemicals produced by Inchem.

Inchem is being looked up for its wide experience and good track record as supplier of chemicals. Among its customers are the largest and most prestigious corporations in the Philippines engaged in the manufacturing of adhesives, power generation, agricultural production, food and food processing, chemicals, oil and petroleum refining, textile, pulp and paper, and semiconductor industries. Aside from bulk users of its products, Inchem also services many other medium and small scale enterprises (SME's) and institutions through its network of dealers. Its products also find their way to household through repackers and compounders.

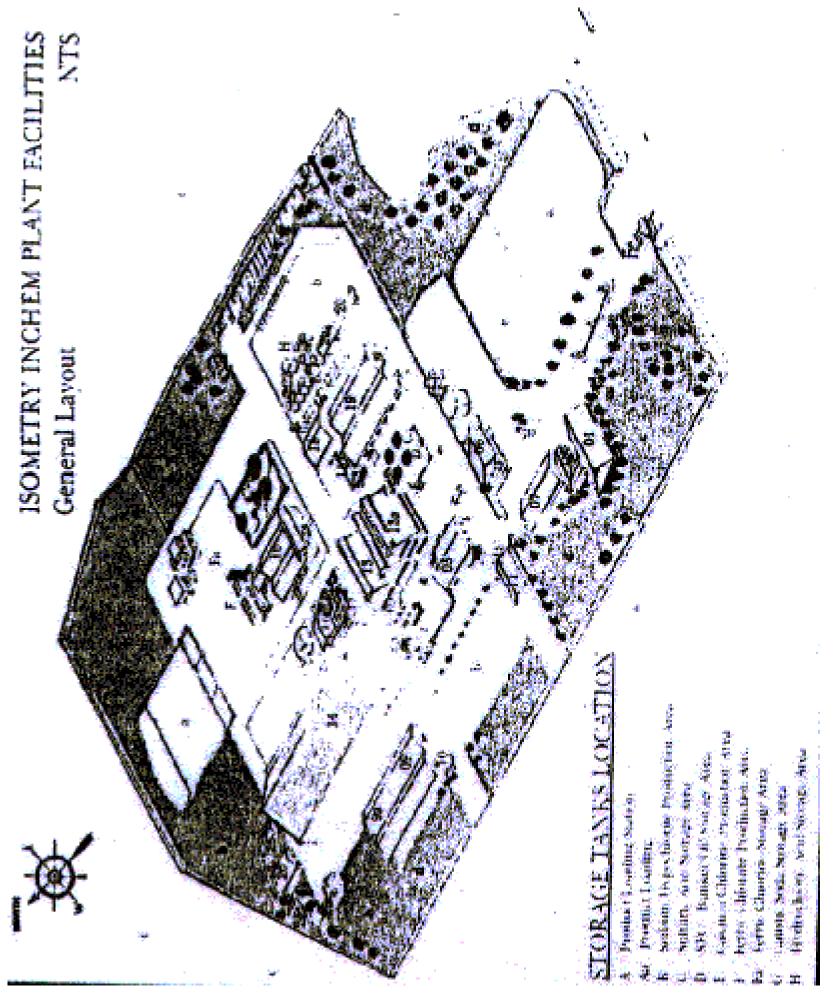
Inchem's main plant is located on a 22 - hectare site in Guiguinto, Bulacan (Figure 1). Its Manila Office is located in Binondo District in the hub of commerce and industry in Manila. The company also operates bulk handling and storage depots in: Pasig in Metro Manila; Davao City, Cebu City, Bacolod City and Zamboanga City.

On July, 1999, the company was awarded the ISO 9002 certificate on quality management system (QMS).

2.2 Facility Layout and Equipment

The general layout of Inchem plant facilities is shown in Fig. 6.4. 12 General services, operation and office building, storage tanks location and landscape area are the facilities located in the compound. The site is also occupied by Inchem subsidiaries, the BFC Worldwide, Inc. and Inchem Environmental Inc.

Fig. 6.4. 12. Inchem plant facilities

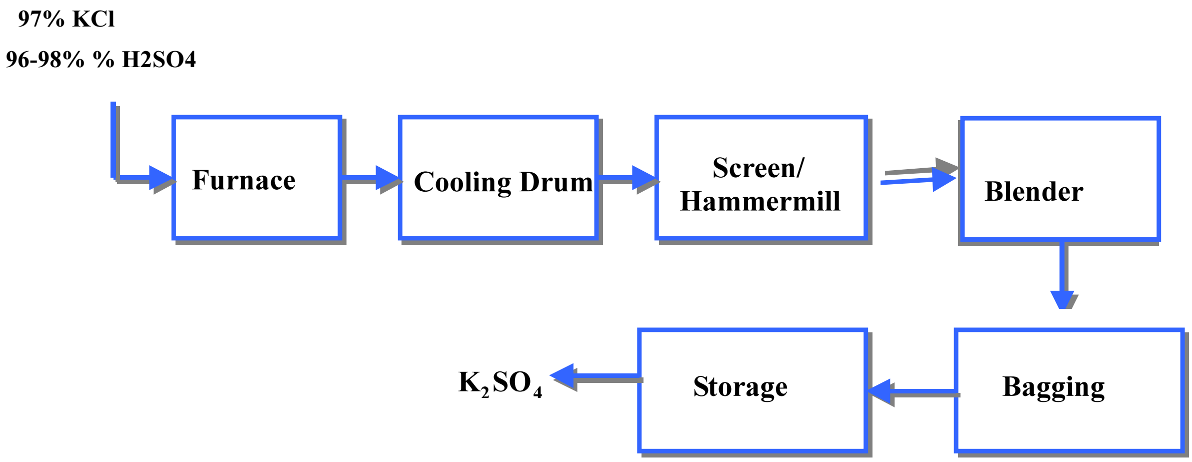


2.3 Process Description

◇ Manufacturing Process of Potassium Sulfate (K_2SO_4)

Sulfuric acid (H_2SO_4) of 96-98% purity and potassium chloride (KCl) of 97% purity are charged in the furnace at 520-540 ˚C. The cooked product is passed through a cooling drum and screened. Hydrochloric acid (HCl) as by product is collected for processing. The product is conveyed to the storage tank for bagging. Process flow diagram of potassium sulfate is shown in.

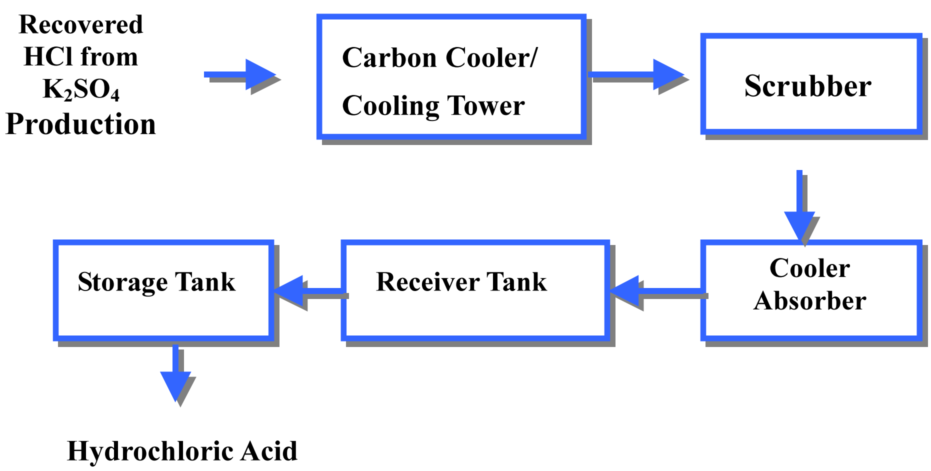
Fig. 6.4. 13. Process flow diagram of potassium sulfate



◇ Manufacturing Process of Hydrochloric Acid (HCl)

Recovered HCl in the potassium sulfate production passes through a horizontal cooler then to the absorber where process water is introduced to produce aqueous hydrochloric acid. Process flow diagram of hydrochloric acid is shown in Fig. 6.4. 14.

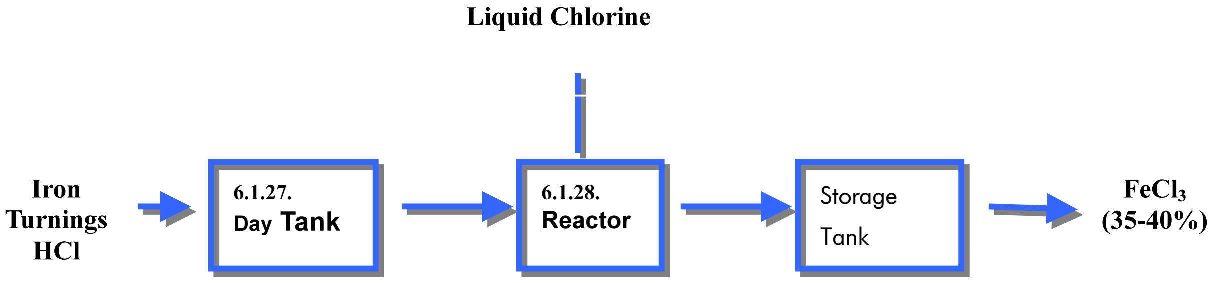
Fig. 6.4. 14. Process flow diagram of hydrochloric acid



◇ Manufacturing Process of Ferric Chloride ($FeCl_3$)

Iron turnings and HCl are mixed in the day tank then passed through a reaction tower with liquid chlorine to produce ferric chloride solution. Process flow diagram of the ferric chloride is shown in Fig. 6.4. 15.

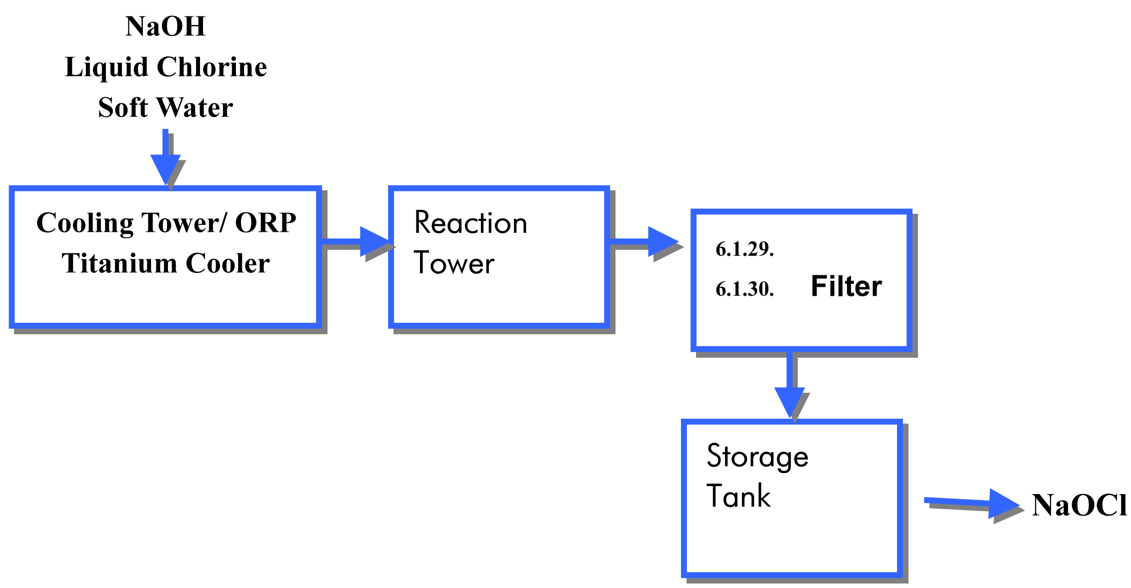
Fig. 6.4. 15.Process flow diagram of ferric chlorid



◇ Sodium Hypochlorite (NaOCl)

The Powell technology is adopted in the production of sodium hypochlorite. Charging of raw materials is carried out automatically by pressing the push button system in the control panel. Mixture of NaOH and water is cooled and reacted with liquid chlorine in the reaction tower then resulting product is filtered and placed in the storage tank. Process flow diagram of sodium hypochlorite is shown in Fig. 6.4. 16

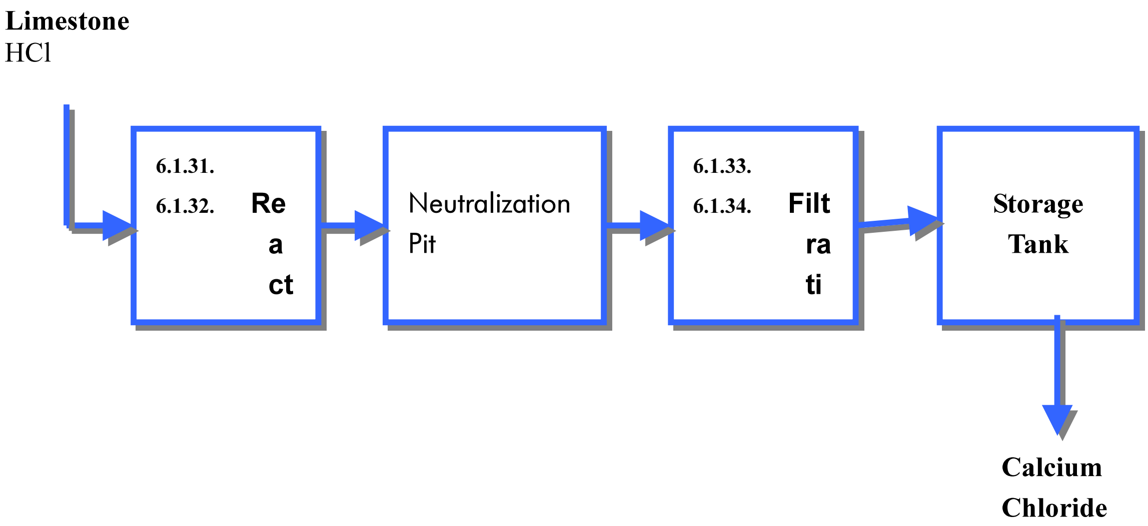
Fig. 6.4. 16. Process flow diagram of sodium hypochlorite



◇ Calcium Chloride ($CaCl_2$)

Limestone is dissolved in the reactor in the presence of HCl and neutralized. The mixture is allowed to settle prior to filtration process. Process flow diagram of the calcium chloride is shown in Fig.6.4.17.

Fig. 6.4. 17. Process flow diagram of calcium chloride



2.3 Waste Stream Description and Current Waste Management Practices

The type and potential sources of wastes generated by Inchem are listed in Table 6.4. 21

Table 6.4. 21.Type and Potential Sources of Wastes Generated at Inchem

Type	Nature of Waste	Temporary Storage/Pollution Control Facilities	Disposal Procedures
Solid	Damage PP bag/sacks	KCl area	Sell to scrap buyer
Liquid	Sludges from $CaCl_2/FeCl_3$ Plants Sludge/wastewater for NaOCl filter backwashing Sludge from fuel day tanks, waste oils from cleaning of fuel day tank	Pit Pit Fuel pit	Sludge Impounding Lagoon IEI saturator tank for re-use and recycling Picked up by supplier
Gas Emission	Potassium Sulfate Powder Flue Gas HCl Gas Cl_2 gas CO_2	Suction Blowers, Dust Collector Silos 20 m high smoke stack water scrubber water scrubber and ORP water scrubber	Recycled as product N/A Solution recycled Solution recycled Solution recycled

Inchem is commited to protect the environment by instituting some in-house waste management practices these include:

- Practice of waste classification, segregation and temporary storage in specific areas in the plant. Each area is provided with garbage bins with 4 compartment for color coded plastic bags. Garbage that are collected are segregated and then stored at the temporary garbage bins prior to its collection and disposal.
- Waste monitoring and inventory of solid wastes (process and non-process) are being monitored and recorded. Information is used as a basis in the waste reduction program

of the company.

- Waste Disposal-segregated solid wastes are deposited in designated compartment. Some wastes are collected by municipal garbage collector and others are sold to scrap buyer. All the sludges generated from the different plant processes are disposed to the sludge-impounding lagoon and wastewater goes to the wastewater treatment plant for neutralization and settling. Treated wastewater is pumped to the saturator tank for re-use in the process of Inchem Environment, Inc., another subsidiary of Inchem.

The management is keen in implementing the following good housekeeping practices:

- Maintaining safe handling and storage of chemicals
- Employing color coded plastic waste bins
- Keeping the inventory records accurate and updated
- Wearing appropriate clothing and rubber lined gloves to prevent contact of the liquid to the skin and hand
- Using safety goggles to prevent eye contact with the solution. An eye wash station is available in any or near the place where caustic soda is being handled
- Posting of signage about proper handling, storage, precautions and disposal of raw materials products
- Ensuring proper ventilation of work area

During the waste assessment, the waste minimization team observed the following:

- In the potassium sulfate production, chemical spillage on floors and around the conveyor unit is evident and too much dust accumulated in the bagging area.
- The concentration of HCl gas emission in the hydrochloric acid plant sometimes is less than 100 mg/l.

2.4 Recommended Waste Minimization Options

Table 6.4. 22 presents the recommended WM option that Inchem may implement to reduce wastes.

Table 6.4. 22.Proposed Waste Minimization Options for Inchem

WASTE MINIMIZATION OPTIONS/RECOMMENDATIONS	RATIONALE	ENVIRONMENTAL IMPACT
Enclose the sides of conveyor leaving the top open	Prevent product losses while maintaining natural cooling techniques	To avoid formation of air particulates in the workplace
Installing a coupling around the feeder spout wherein the bag can be tighten/enclosed to the mouth	Prevent any escape of very fine particles of product to the surroundings	To avoid formation of air particulates in the workplace
Installation of high capacity/efficiency bag filter in the packaging area	Recovery of valuable products and maintain safe workplace	To properly collect air particulates in the surrounding
Replace the final tower with $CaCO_3$ as packing materials instead of water	Remaining HCl will react will the packing material to form $CaCl_2$.	The system will positively reduce the concentration of HCl emission to the atmosphere

2.5 Future Waste Minimization Activities

◇ Organization of Waste Minimization Team

An in-house minimization team will be organized to oversee all the activities in the implementation of the waste minimization program of the company. To generate a strong involvement among the personnel, team members must be selected from the different company's departments or processing sections.

◇ Monitoring and Testing Requirements

To be able to track down the quality and quantity of wastes generated, the company will conduct periodic monitoring. A source inventory of all types of wastes from the different processing areas through the waste audit will be done by composite sampling.

In addition, the assessment team will be able to identify waste sources that are problematic and also they will be able to decide at what stage of the process waste minimization could be started. To know whether waste reduction has been achieved, measurement of water consumption and wastewater generation will be done regularly. Benchmarking on every process will also be made in order to identify which process has not made any progress in the waste reduction effort of the team. To know the quality of wastewater generated, the following physico-chemical parameters will be determined: biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), alkalinity and pH. BOD, COD and TSS are measurements of the organic matter components of the wastewater. The greater the COD, BOD and TSS values, the higher are the pollutive property of the wastewater.

Also, for strict compliance to clean air act, much attention will be considered in monitoring the air emissions in the workplace.

Testing and analysis of samples could be done by private and government laboratory. Currently, the Standard and Testing Laboratory (STD) of the Industrial Technology Development Institute (ITDI) does not conduct the above tests, which is delegated to private water quality laboratories.

2.6 Recommended Waste Minimization Activities

The future waste minimization activities of the company are summarized in Table 6.4. 23

Table 6.4. 23 WM Future Activities

ACTIVITIES	TIME FRAME
1. Conduct in-house training	2 days
2. Organize in-house team	1 day
3. Facility walk through (for process validation)	2 days
4. Brainstorming and formulation of waste minimization options	1 day
5. Prioritization and Implementation of Options	Perpetual

3 Metal Engineering Resources Corp.

3.1 Facility Background and Location

The company started in 1947 as an importer of construction materials for post war in Manila. It was then known as Claude Wilson Trading Company, after its founder, Mr. Claude Wilson, Jr. Eventually, the company ceased to import and instead began to manufacture for the local market. It was renamed to *PHILIPPINE SEWING MACHINE CORPORATION* in order to identify its main product line.

In 1974, the company changed its name to METALS ENGINEERING RESOURCES CORPORATION (METERCOR) to reflect its more diverse manufacturing capabilities. Today sewing machine account for 5% of its manufacturing load; main product lines are automotive parts (brake rotor discs and drum), pumps and various cast iron products for export.

METERCOR had also produced prototype machines for its foundry operations like: 16-inch grinders, roll-over shell core shooting machine (rate at 40 cores per hour) and Tumblast equipment (rat at 500 kgs per batch).

It occupies a 32.5-hectare lot with a production area of 1 hectare, located at the National Road, Tunasan, Muntinlupa City. It is being managed by the following: Loreto P. Matibag, Vice President/General Manager, Cipriano P. Perez, Manager- Foundry Division and Valentino R. Araos, Manager – Machining Division. The company has a production capacity of 600 tons per month and employs 104 employees (managerial, 5; supervisory and staff, 34; factory workers, 65). It utilizes the following raw materials in its production: scrap iron, pig iron, alloys, sand, fire bricks, coal and cupola fuel (100%coke with consumption rate of 70 tons per month).

Its main products are Mitsubishi Honda car parts with a consumption rate of 480 tons per month (constitutes 80% of total production), sewing machine parts (constitutes 5% of total production), with a consumption rate of 30 tons per month , air-con parts/pumps, glass mold parts/jobbings.

3.2 Present Plant Facilities

The following are Metercor's facilities per production area:

◇ Foundry

- 2 Cupola furnaces rated at 3.5 tons per hour
- Induction furnace rated at 300 kilos per batch (600 kg per hour) 1 unit
- 1 ton, 350 KW Fuiji Dempa Coreless induction furnace
- 18 jolt squeeze molding machine
- 12 semi-automatic molding machine
- molding machine
- sand reclamation system
- automatic shellcore machines and automatic shotblast hanger blasting machine/tumblast machine/annealing furnace
- Sand conditioning plant : 50 cubic metr capacity per hour
- Chemical sand mixer: Baker Perkins "Fastcold" for chemical molding with a capacity of 12 tons per hour
- Fully automatic high pressure molding machine: "Diamatic 1095", with a capacity of 300 molds per hour

◇ Foundry Laboratory

Quick lab CE meter, speedomax recorder CE meter, Olympus metallurgical microscope with grinder polisher, Mitutuyo Rockwell type hardness tester, Kubota permeter, Sand strength tester, Rotap sand sieve analyzer

◇ Machine shop

12 CNC lathes, conventional lathes and milling machine, drilling and tapping machine, CNC double disc grinder and internal grinder

◇ Laboratory Equipment

Metercore has the following laboratory equipment which it uses in testing its products:

- Speedomax recorder CE meter - to get equivalent of gray cast iron with graph
- Setallurgical microscope - to analyze microstructure of metal without photo
- Hardness tester - to evaluate Rockwell hardness of metal
- Sand strength tester - to get the green strength of molding sand
- Permeter - to evaluate the permeability of molding sand
- CNC coordinate measuring machine – to get the dimension of part and its form tolerances as run-out, parallelism, roundness and others
- Surf tester – to evaluate the roughness structure of machined surfaces
- Balancing machine – to evaluate the static unbalance of drum and disc brake.

Metercore also has the following equipment which it uses in testing the quality control of its products:

- CNC Coordinate measuring machine
- Height gauges, surf test, hardness tester
- Automatic balancing machine,
- Calipers and micrometers

3.3 Process Description

NPMI operate the four (4) basic steps in the processing of a foundry facility are provided below. These are design, patternmaking, mouldmaking and casting. The succeeding sections present these processes which are generic for the foundry industry.

◇ Design

The first production step for all castings takes place in the design office where ideas are converted into manufacturing patterns which guide the production team in creating the solid metal end products. The specified shape and size of the final products is determined so that the correct metal can be chosen and the number of castings to be made be known. All these factors indicate the molding techniques that will be adopted.

◇ Pattermaking

Once the customer and the rest of the production team have approved the design, a pattern or model is made. This is produced in wood, metal or plastic or from a combination of all three. With one production technique, wax is used to form the pattern. Patterns must be precise in their shape and finish because any mistakes from it are reproduced in the moulds which may affect the formation of the final cast. Patterns should have provision for the shrinkage of the metal when it cools and they can include channels to allow metal to flow into the casting shape. From the initial pattern, a prototype or production sample is usually made wherein the customer can select to ensure that the final casting will conform to their specification.

◇ Mouldmaking

The next manufacturing step is molding in which the pattern is packed in a molding material and then removed to leave the right shape for the casting. Moulds can be made by hand or machine. In one casting process, the mould is made from a heat resistant metal. Moulds are usually made in at least two parts and for very large castings; they can even start out as large holes dug into the sand floor of the foundry. Different types of sand are used for molding with additives like water and clay and various chemicals, depending on the size of the mould and type of metal that are being cast.

One important feature of the mould is the running system which is a network of small channels that leads to the molten metal down into the casting shape. The shapes and sizes of these channels have to be carefully calculated to ensure that the molten metal does not solidify before it gets to the casting shape and to make sure that it does not flow too fast when it could wear away the mould. Many castings are designed to have cavities in them-engine blocks for example.
The shapes or cores as they are known, are placed in the mould and after the molten metal has solidified, the core material is removed leaving a precisely shaped cavity behind.

◇ Casting

When the mould is fully assembled, molten metal, at the right temperature, is carefully poured into it. The metal is usually of prescribed grade with the correct mechanical and chemical properties when it has solidified. When the casting has solidified and cooled, it is knocked out of the mould. Superfluous metal, such as that which has solidified in the flow channels is removed – this clean up operation is known as fettling. Grinding and then shot blasting is then used to produce a clean finish. Some castings may also go thru a series of tests such as x-raying or pressure testing to ensure that they do not contain unwanted cracks or flaws. The metal may also be tested to check its strength, its resistance to sudden knocks, chemicals or high temperatures.

3.4 Waste Stream Description and Current Waste Management Practices

◇ Waste Stream Description

Solid Wastes:

Metercor generates dust, waste sand, slag and scrap refractories as solid wastes. Dust is produced through the operation of furnaces, mold manufacture, shakeout and cleaning. Large amount of waste sand is generated during shake-out of the mould to remove the solidified cast iron. Slag are used in sandmolding process and as a result of breakdown of refractories in induction furnaces and disposed by landfilling. Scrap refractories are also generated in the induction furnaces.
There was no information provided on the volume of solid wastes generated by the company per annum.

Gas Emissions:

Sulfur oxide is generated from coal which contains 0.44% sulfur. Other emissions come from the binder systems used in mold making, the vapors from metal melting and airborne sand used in pouring and shakeout steps.

Liquid Wastes:

Based on information gathered, Metercor generates a very minimal amount of wastewater in its operation and therefore does not pose a problem to the company.

◇ Waste Management Practices

Metercor observes the following waste management practices:
Metal products are arranged on top of the racks to avoid contamination.

- Dust particles are removed by scrubber and deposited in a water tank.
- Sludges are disposed by landfilling.
- Sand is not recycled due to high cost of equipment for recycling. It is disposed by

landfilling.

- Slag is also disposed by landfilling. If the slag has sufficient metal content, they are fed back into the furnaces to reclaim the remaining metal dust.

3.5 Waste Minimization Options

Based on the assessment conducted, the following waste minimization options were generated by the WM team as shown Table 6.4. 24

Table 6.4. 24.Waste Minimization Options for Metercor

WASTE MINIMIZATION OPTIONS	RATIONALE	EXPECTED POSITIVE IMPACT
Maintain cleanliness of storage areas.	To facilitate the issuance of raw materials and to avoid contamination	Less time consumption in location of raw materials
Label containers properly.	For identification of chemicals inside the containers	Reduced time in locating the chemicals
Inspect materials upon delivery.	To detect any defect in raw material ordered	Return to supplier defective materials ordered
Keep accurate records of raw materials usage	To keep track of volume of raw material consumption	Orders can be made on non-existing raw materials
Conduct periodic inspection of tanks, tank liners and other equipment as well as valves, pumps and other water sources	To properly maintain the equipment	Maintained smooth operation in its production process; Reduction in maintenance and operation costs
Repair malfunctioning equipment as soon as possible.	To maintain the equipment	Smooth operation of equipment; Reduction in maintenance costs
Stored chemicals in such a way that spills, if any, can be collected.	To reduce chemical spillage	Reduction in operating costs
Install drip trays and splash guards	To contain spills and leaks	Recycling of wastewater; Reduction in operating costs
Use dry cleanup whenever possible	To conserve water	Reduction in volume of wastewater generated
Install dry dust collection systems such as bag filters for induction furnaces	To control emission of dust particles	Improved company corporate image; compliance to DENR standard regulations
Attach cupola furnaces to emission control systems which are usually either high energy wet scrubbers that use water	To remove air pollution from the gas stream or dry baghouse systems that use fabric filters to capture the emissions.	Improved company corporate image; compliance to DENR standard regulations
Provide hoods for cupolas must be provided. Reclaim molding sand after the removal of binders.	To control emission of dust particles	Improved company corporate image; compliance to DENR standard regulations
Perform regularly scheduled sump and machine cleaning and gasket, wiper and seal maintenance	To maintain the equipment	Reduced operating costs; Ensured smooth operation of equipment
Provide ear plugs to workers	To protect eardrums of workers from damage caused by noise pollution brought about by machine operation	Reduced incidence of sickness of workers
Distribute parts on racks	To allow good cleaning and minimize solvent holdup	Avoidance of contamination
Use greaseless or water-based binders	To reduce use of hazardous and toxic chemicals	Reduced treatment costs
Use selected and clean scraps of	To reduce the release of pollutants	Production of good quality

WASTE MINIMIZATION OPTIONS	RATIONALE	EXPECTED POSITIVE IMPACT
metals	to the environment	products
Store metal scraps under cover or provide storage area for raw materials/tin cans.	To avoid contamination of storm water	Avoidance of contamination /corrosion
Use induction furnaces instead of cupola furnaces	To reduce emission of dust particles	Improved company corporate image; compliance to DENR standard regulations
Use alkaline cleaners instead of solvents in degreasing operations.	To use less toxic and hazardous materials	Reduced generation of toxic and hazardous wastes
Install automatic flow controls	To conserve water	Reduced manpower; water flow will automatically be controlled
Spray rinses the work pieces as they emerge from the process tank.	To conserve water	Cleanliness of work pieces promoted; Reduced water usage
Purchase paint in bulk. If not practical, purchase the paint in the smallest amount required	Reduce paint wastes requiring disposal	Minimized amount of residual remaining in the can; Reduction of toxic and hazardous waste generation
Use enclosed conveyor belts as well as wind barrier and other dust suppression measure	To reduce the formation of dust fugitive.	Improved company corporate image; compliance to DENR standard regulations
Cover iron runners when tapping the blast furnace and use nitrogen blankets during tapping	To reduce dust emissions at furnaces	Improved company corporate image; compliance to DENR standard regulations
Provide workers with masks.	To protect workers from dust particle emission	Reduced incidence of sickness among workers; reduced health maintenance costs
Collect iron rich waste dusts collected from cyclones and fume arrestors in foundries	To recycle iron-rich waste dusts	Waste recycling promoted

One of the technologies being employed by a foreign firm which could be utilized by Metercor is a briquetting technique that involves mixing the dust with an organic binder and water and palletized using a ring die pellet mill, one used in the animal feeds industry. These palletized dusts could be introduced back to the top of the cupola as part of the charge at the rate of 10% of the normal charge. Tests showed that 60% of the irons in the pellet are recovered in the cast product. For waste with iron content of 50%, the financial benefit to the foundry is estimated to be within the range of 22-33 pounds per ton.

As provided in a literature search, another waste minimization option for Metercor is the re-use of waste sand using sand reclamation wherein the sand is filtered to remove fines that develop from the process. Additional sand is added to account for the sand that is lost. Then the sand is remolded for a different metal piece. The object of sand reclamation is to remove residual binders and contaminants from the sand grains so the sand can be reused without affecting the quality of the mold.

3.6 Future Waste Minimization Activiteis

◇ Organization of Waste Minimization Team

An in-house minimization team shall be organized to oversee all the activities in the implementation of the waste minimization program of the company. To generate a strong involvement among the personnel, team members must be selected from the different company's departments or processing sections. In this regard, the JICA-PBE-ITDI team will conduct an in-house seminar to discuss on how waste minimization program will be set-up in the company.

◇ Monitoring and Testing Requirements

To be able to track down the quality and quantity of wastes generated, the company shall conduct periodic monitoring. A source inventory of all types of wastes from the different processing areas through waste audit shall be done by composite sampling.

In addition, the assessment team will be able to identify waste sources that are problematic and also they will be able to decide at what stage of the process waste minimization could be started. To know whether waste reduction has been achieved, measurement of water consumption and wastewater generation shall be done regularly. Benchmarking on every process shall also be made in order to identify which process has not made any progress in the waste reduction effort of the team.

3.7 Schedule of Recommendation Activities

The following Table 6.4. 25 shows the WM recommended activities.

Table 6.4. 25.Schedule of WM Recommended Activities

Activities	Time Frame
1. In-depth assessment of foundry model company	3 months
2. In-house training	2 days
3. Organize in-house team	1 day
Activities	6.4.5. **Time Frame**
4. Facility walk through (for process validation)	2 days
5. Brainstorming and formulation of waste minimization options	1 day
6. Prioritization and implementation of options	Perpetual

4. United Coconut Chemicals, Inc.

4.1 Facility Background and Location

Founded in December 1981, COCOCHEM's modern plant is situated in a 42-hectare Special Economic Zone called the Cocochem Agro-Industrial Park (CIP). The plant facilities are located in a natural harbor in Bauan, Batangas, which is approximately 120 kms. away from Manila and can be accessed via the new South Expressway extension.

COCOCHEM is a modern cocochemical plant and country's leading manufacturer of oleochemicals. With the Philippines abundant supply of coconuts, COCOCHEM mostly relies on local coconut oil as its raw materials. The company's corporate aim is to lead the national effort in increasing the downstream utilization of coconut oil and contribute to the worldwide efforts to increase the use of natural oils in the production of higher value-added products.

COCOCHEM has a production capacity of approximately 36,000 MT of fatty alcohol, 29,000 MT of fatty acid, 8,500 MT of glycerin. It processed about 75,000 metric tons of crude coconut oil per year.

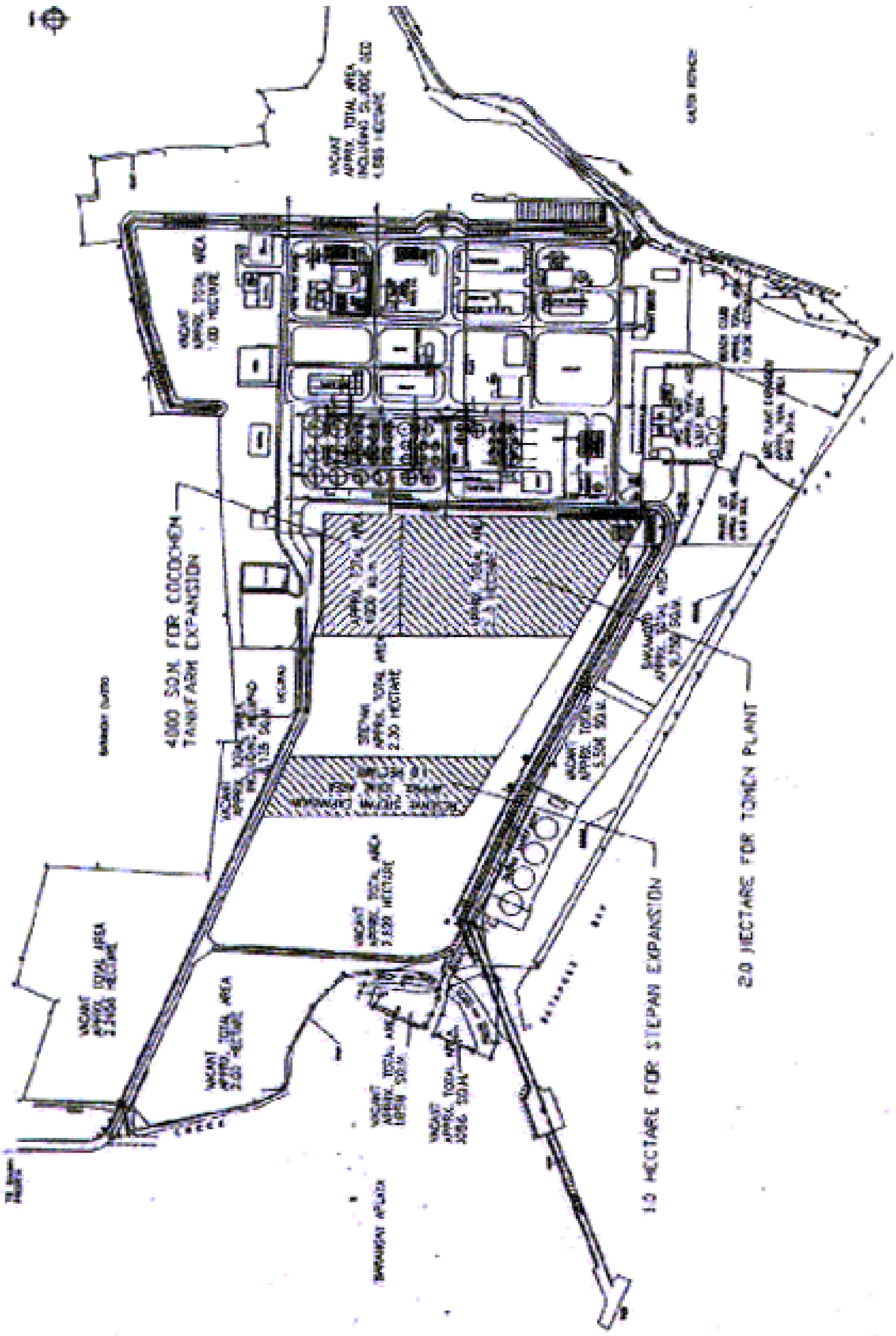
The plant has other operating auxiliaries, such as the hydrogen plant, nitrogen section, utility plant, power plant, laboratory, and mechanical, electrical and instrumentation workshops.

COCOCHEM has a work force of 277 highly technically trained Filipino professionals. Of these, 253 are detailed in the main plant, overseeing the year-round the production and supply of coco-based chemical products.

4.1 Facility Layout and Equipment

COCOCHEM is the first in Southeast Asia to produce fatty alcohols via the fatty acid route using the German-based "Lurgi-designed process" which is the latest advances in coconut oil downstream technology. The current plant layout is shown as following Fig. 6.4. 18.

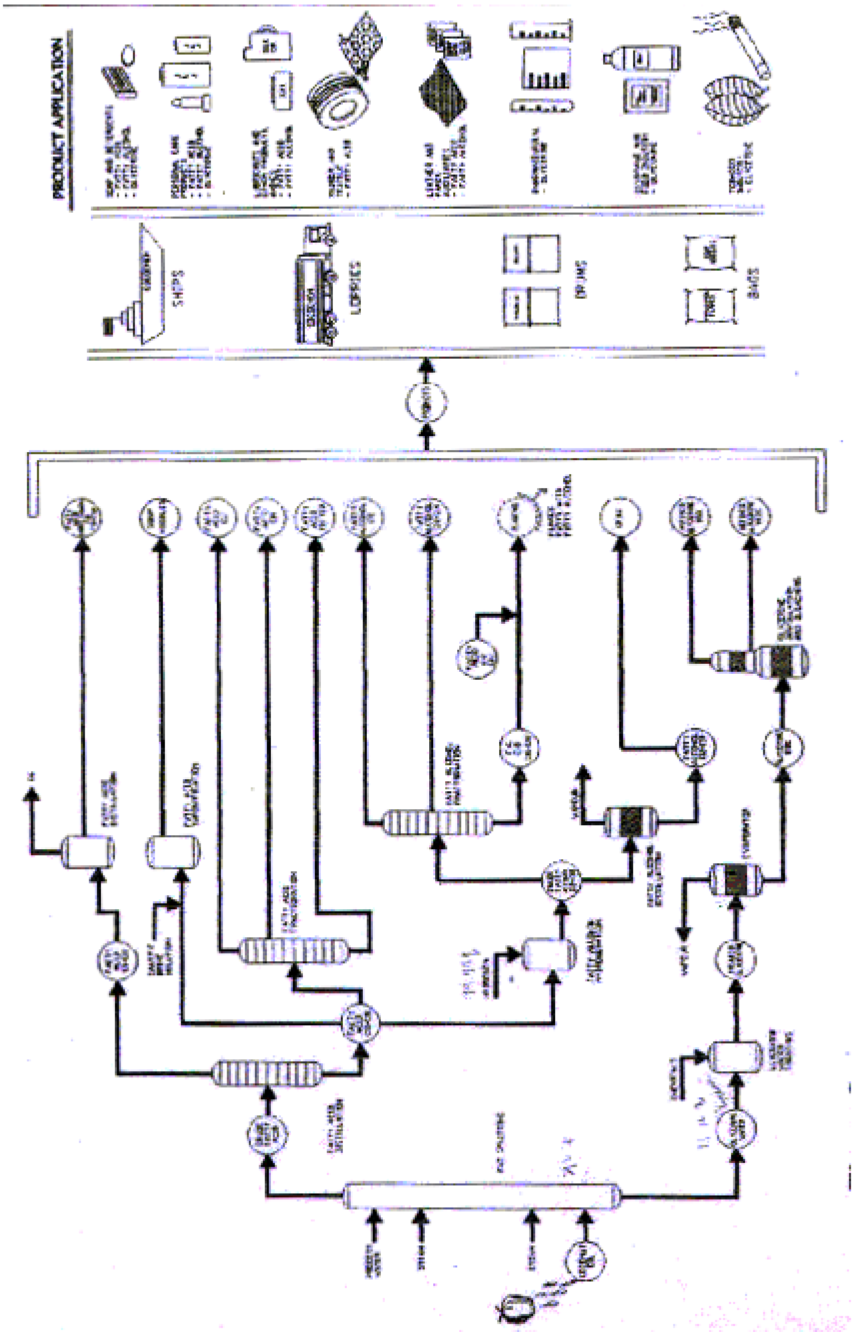
Fig. 6.4. 18.COCOCHEM Plant Layout



4.2 Process Description

Its major process operations include: fat-splitting, distillation, fractionation, hydrogenation, and evaporation in the fatty acid, fatty alcohol and glycerin production. The process flow diagram of COCOCHEM is presented in the following Fig. 6.4. 19.

Fig. 6.4. 19.Process Flow Diagram



◇ Crude Coconut Oil (CNO) Oil Splitting

CNO and reaction water are continuously hydrolyzed in a 27 meter splitting tower. The plant has two (2) splitters each capable of producing 125 MT/day.

Reaction proceeds at 55 bars and 250 °C where the triglyceride is split into crude fatty acids and glycerin, while water is constantly removed.

The fatty acid is depressurized, flashed, and pumped to storage tank. Sweet water contains 14-18% glycerol, which is treated prior to subsequent processing. Splitting efficiency of 98% was achieved in the process.

◇ Glycerin Treatment and Refining

The glycerin sweet water, containing residual fats, proteins, unsplit triglycerines is first sent to a treatment plant where unwanted components are removed upon addition of $FeCl_3$ and caustic soda, then filtered in a plate and frame filter press unit. The treated sweet water is subsequently evaporated in a triple-effect evaporator to concentrate the sweet water and hydrolyze the 88% crude glycerin. During the evaporation process, low-pressure steam (2.0 bars) is used as heating medium. By using the triple effect evaporator, the steam consumption is reduced by 50%.

Part of the crude glycerin is distilled in a distillation plant with post distillation to recover totally the glycerin content from the residue pitch. Remaining crude glycerin is distilled under vacuum in the pressure of line steam to aid circulation and reduce the partial pressure of the glycerin for a lower boiling temperature. The distilled glycerin is passed through a condensation column then bleached in an activated carbon tower and finally filtered in a plate and frame filter press.

About 10% of the total distillate known as glycerin fraction is produced with approximately 95% purity and taken out as by product. The main distillate reaches a purity level of about 99.5% and classified as USP grade quality.

A post distillation is operated in batch process to completely recover the remaining glycerin from residue coming from the main distillation column.

◇ Fatty Acid Distillation

The distillation units for fatty acid is composed of medium size fractionation columns and distillation stills. The column has tray internals with succeeding distillation stills equipped with heating and circulation chambers.

The crude fatty acid of the chain C6-C18 coming from the splitting of coconut oil is sent to the fractionation and distillation plant where a pre-cut fraction composed of short chain fatty acids (C6-C10) is extracted as top fraction. The bottom fraction which is about 85% of the product and compose of C12-C18 fatty acids is distilled to remove the residue before it is sent to the downstream units.

The distillation units are operated under vacuum in the presence of steam for better circulation; reduce partial pressure and boiling temperatures of the fatty acid. Vacuum is maintained by a steam ejector system where the steam is condensed in contact with the organic vapors in a closed loop direct contact cooling water.

Light ends and other low boilers are removed and sold as fuel additive.

The heat used for the fractionation and distillation processes came from a self-contained mineral oil heating system using diesel fuel. Residue acid which is between 4-6% of the crude fatty acid is stored and blended in the splitting towers to totally recover remaining fatty acid and glycerin.

◇ C12-C18 Fatty Acid Fraction

Part of the C12-C18 fatty acids are subsequently fractionated in high efficiency columns using structured packing to produce lauric acid of 99% purity. The plant is also capable of producing myristic acid of 98% purity.

The by-product stearic acid C16-C18 is distilled and mixed with C12-C18 acids and used as feedstock in the operation of soap noodles plant. Lauric and myristic acids are sold as flakes or bulk liquid.

◇ C12-C18 Fatty cid Alcohol Hydrogenation

Part of the C12-C18 fatty acids are directly sold to domestic and foreign markets in bulk or drums.

The plant is also capable of producing detergent grade fatty alcohols from fatty acids of about 36,000 MT per annum. The fatty alcohol hydrogenation plant designed and built based on Lurgi technology operates by direct hydrogenation of fatty acids without esterification to fatty alcohols.

The hydrogenation of fatty acids to alcohols takes place in the liquid phase at 300 bars and 300°C. The overall reaction occurs in two stages over slurried copper chromite catalyst.

The 1^{st} stage is esterification of the fatty acid with fatty alcohol to yield ester plus water. The second stage is hydrogenation of the ester to alcohol. Both reactions occur simultaneously in a single reactor vessel.

The process consists of a high pressure section in which hydrogenation takes place, and low pressure section in which the alcohol is separated from catalyst.

High purity hydrogen (99.9%) is produced during hydrogenation from the steam hydrocarbon reforming using LPG, a locally available feedstock.

A partial stream of the spent catalyst is blend continuously from the process and an equivalent quantity of fresh catalyst is added to the fatty alcohol/catalyst slurry mixture which is then pumped back to the reactor.

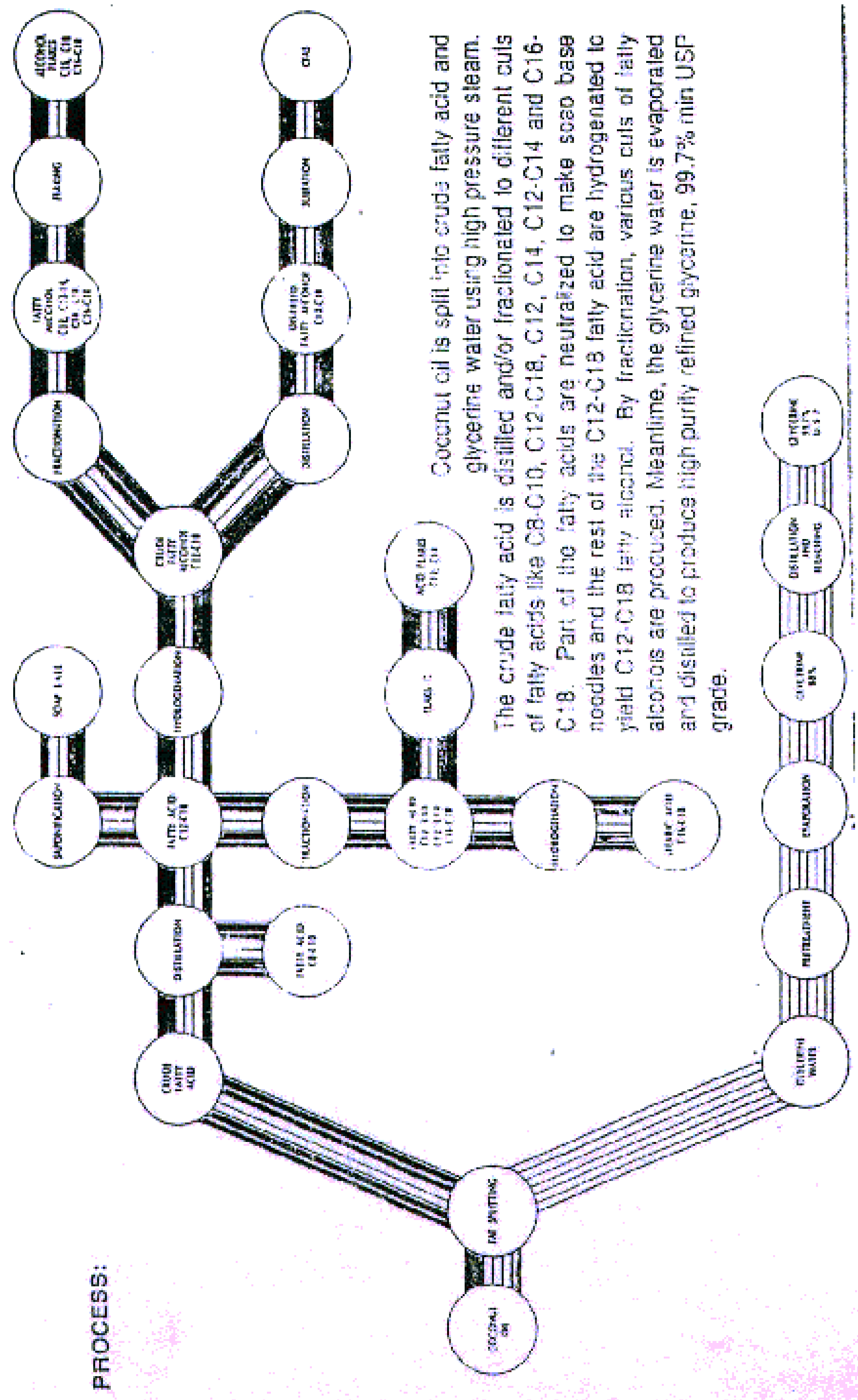
The detergent grade fatty alcohol in the C12-C18 range is either straight distilled or fractionated in fractionation towers of similar design described above for the fatty acid fractionation and distillation.

Tray columns are capable of fractionating C12 alcohols up to 98% min. purity. Also, the plant is producing stearyl and cetyl alcohol up to 98% minimum purity levels which are sold mostly in flake form.

◇ Soap Noodles

The soap noodles plant has a capacity of about 30MT/day of fatty acid soap. Blend of C12-C18 fatty acid and stearic acid is neutralized (saponified) with caustic soda in a saponification reactor and immediately dried under vacuum and extruded as noodles of soap. The soap noodles are usually packed in 25 kg bags. Simplified process flow diagram is illustrated in Fig. 6.4. 20.

Fig. 6.4. 20.Process Flow of Noodle Soap Production



4.3 Waste Stream Description and Current Waste Management Practices

As an indication of continual improvement of its environmental system, the company was able to utilize all the resources including water and energy efficiently and minimized air, water and soil pollution related to operation. Inherent wastes generated in the process are properly contained through strict implementation of waste management measures.

◇ Solid Waste

The type and volume of solid waste generated by the plant are listed in Table 1. Spent activated carbon came from the decolorization or bleaching method of glycerin. This type of waste is placed in bags and temporarily disposed in the storage facility.

Filter cake, filter pad, and filter cloth are the type of solid wastes associated in the filtration process of glycerin. Accumulated filter cake is dried and used as fertilizer. About 4 drums/month of filter pad and 294 pcs/yr of filter cloth are collected and disposed properly.

Glycerin pitch is a sludge-type waste generated in the distillation process of glycerin. In the first distillation process, huge amount of residual pitch is produced; amounting to nine (9) drums/day while in the post distillation process less than one (1) drum is produced. Appropriate collection and disposal are strictly observed by the plant to prevent over loading in the wastewater treatment plant.

The copper chromite catalyst is a bluish black, friable powder and is a satisfactory catalyst for the dehydrogenation of alcohols. No special precautions are necessary in handling or storing the fresh copper chromite catalyst, since it is stable even when directly expose to air or moisture. However, the spent catalyst must be placed in a container with provision for chemical spills and stored in the hazardous waste facility. The plant exerted substantial effort in minimizing the usage of catalyst. In this way, lesser volume of hazardous waste is generated. This spent catalyst is recovered and returned back in the process by mixing with fresh catalyst in similar proportion. The remaining spent catalyst is collected and stored in the hazardous waste facility.

Table 6.4. 26.Solid Waste Generation

SOLID WASTE	APPROXIMATE VOLUME	TOTAL (Monthly)
Spent Activated Carbon	13 bags/mo. (20kg/bag)	260 kg/mo.
Filter Cake	4 drums/day	120 drums/mo.
Glycerine Pitch 1st Distillation Redistillation	 3 drums/shift (pure) 3 drums/4days (pure)	 270 drums/mo. 23 drums/mo.
Spent Catalyst	1 drum/shift	90 drum/mo.
Filter Pad	4 drums/mo.	4 drums/mo.
Filter Cloth	24 pcs/mo.	24 pcs/mo.

◇ Liquid Waste

The characteristic of liquid waste is basically based on the production efficiency of the system. The presence of unrecovered glycerin contributes to high chemical oxygen demand (COD) of wastewater. As such, the plant installed a wastewater treatment facility which consists of activated sludge, sedimentation and thickening processes. The source of liquid wastes are from the process water of about 10 m^3/day and cooling water which is 5 m^3/day. Oil content in the wastewater is scraped, dried and disposed as fertilizer.

◇ Air Emissions

Flue gas is monitored from the operation of the boilers, thermal oil heaters, steam reformer, and peak furnaces. To ensure a good quality of gas emission, air pollution abatement devices were installed in the plant.

4.5 Recommendation Waste Minimization Options

COCOCHEM is committed to safe operations with deep concern for health and environment by introducing a state of the art technology. Through constant monitoring, the plant was able to optimized operating conditions resulting to a cleaner production process. However, some waste minimization options can still be adopted to properly manage uncontrolled wastes in the system. The following Table 6.4. 27 presents these options.

Table 6.4. 27.Recommended Waste Minimization Options

WASTE MINIMIZATION OPTIONS	RATIONALE	EXPECTED IMPACT
Convert glycerin pitch waste into energy (fuel)	Conversion to a useful product and eliminate disposal problem	Reduce the solid waste to be generated in the process
Continuous circulation of water in the cooling tower	Reduce the water consumption in the system and treatment cost	Generate less volume of liquid waste
Regeneration of activated carbon	Material recovery and reduce material cost	Reduce the solid waste to be generated in the process

4.6 Future Waste Minimization Activities

◇ Organization of Waste Minimization Team

An in-house minimization team shall be organized to oversee all the activities in the implementation of the waste minimization program of the company. To generate a strong involvement among the personnel, team members must be selected from the different company's departments or processing sections. From among the team members, a coordinator will be appointed that will also serve as liaison officer between the management and the team. Overall, the waste minimization team will be responsible in organizing and implementing program of the company.

◇ Monitoring and Testing Requirements

To be able to track down the quality and quantity of wastes generated, the company shall conduct periodic monitoring. A source inventory of all types of wastes from the different processing areas through waste audit shall be done by composite sampling. By this way, the assessment team will be able to identify waste sources that are problematic and also they will be able to decide at what stage of the process waste minimization could be started. To know whether waste reduction has been achieved, measurement of water consumption and wastewater generation will be done regularly. Benchmarking on every process shall also be made in order to identify which process has not made any progress in the waste reduction effort of the team. To know the quality of wastewater generated, the following physico-chemical parameters will be determined: biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), alkalinity and pH. BOD, COD and TSS are measurements of the organic matter components of the wastewater. The greater the COD, BOD and TSS value, the higher is the pollutive property of the wastewater.

Also, for strict compliance to clean air act, much attention will be considered in monitoring the air emissions in the workplace.

4.7 Recommended Waste Minimization Activities

The future waste minimization activities of the company are summarized in the following Table 6.4. 28

Table 6.4. 28.WM Future Activities

ACTIVITIES	TIME FRAME
1. Conduct in-house training	2 days
2. Organize in-house team	1 day
3. Facility walk through (for process validation)	2 days
4. Brainstorming and formulation of waste minimization options	1 day
5. Prioritization and Implementation of Options	Perpetual

5. Phil Resins Industrial, Inc.

5.1 Facility Background and Location

PRII is a joint venture company between Tosoh, Mitsubishi Corporation, Bank of the Philippine Islands and Mabuhay Vinyl Corporation. It was established in July 1994 specifically to study the feasibility of developing a new polyvinyl chloride (PVC) plant in the Philippines. Equity in PRII is divided up as follows: Tosoh 20%, Mitsubishi 20%, Bank of the Philippine Islands 11% and Mabuhay Vinyl Corporation 49%.

On 11 December 1996, the decision to set up a PVC plant in the Bataan peninsula was made, with an agreement signed in Manila. The commercial start-up of the PVC plant, with an initial capacity of 70,000 tonnes/year, was initially scheduled for October 1998. Further expansion by another 70,000 tonnes/year is expected to follow within the next few years.

After successfully completing test operations, commissioning and guaranteed performance runs in December 1998, PRII started commercial operation of its 70,000 tonnes/year Suspension Type PVC plant in Mariveles, Bataan in April 1999. Representing the initial phase of the country's overall goal of a fully integrated vinyl manufacturing facility, the PVC plant is designed to fully serve domestic PVC requirements and, to some extent, even the export market.

The PVC plant is one of Asia's most modern. With its world-scale capacity, the plant is expected to provide the domestic market with PVC products of consistent quality and quantity.

The new facility uses Tosoh Corporation's Clean-Wall PVC technology. This technology features closed large reactors as well as a distributed control system (DCS) for process control. Engineering, procurement and construction of the plant was undertaken by Mitsubishi Corporation, in collaboration with two local partners: Chisso Engineering Company and Taisei Philippines Construction, Inc.

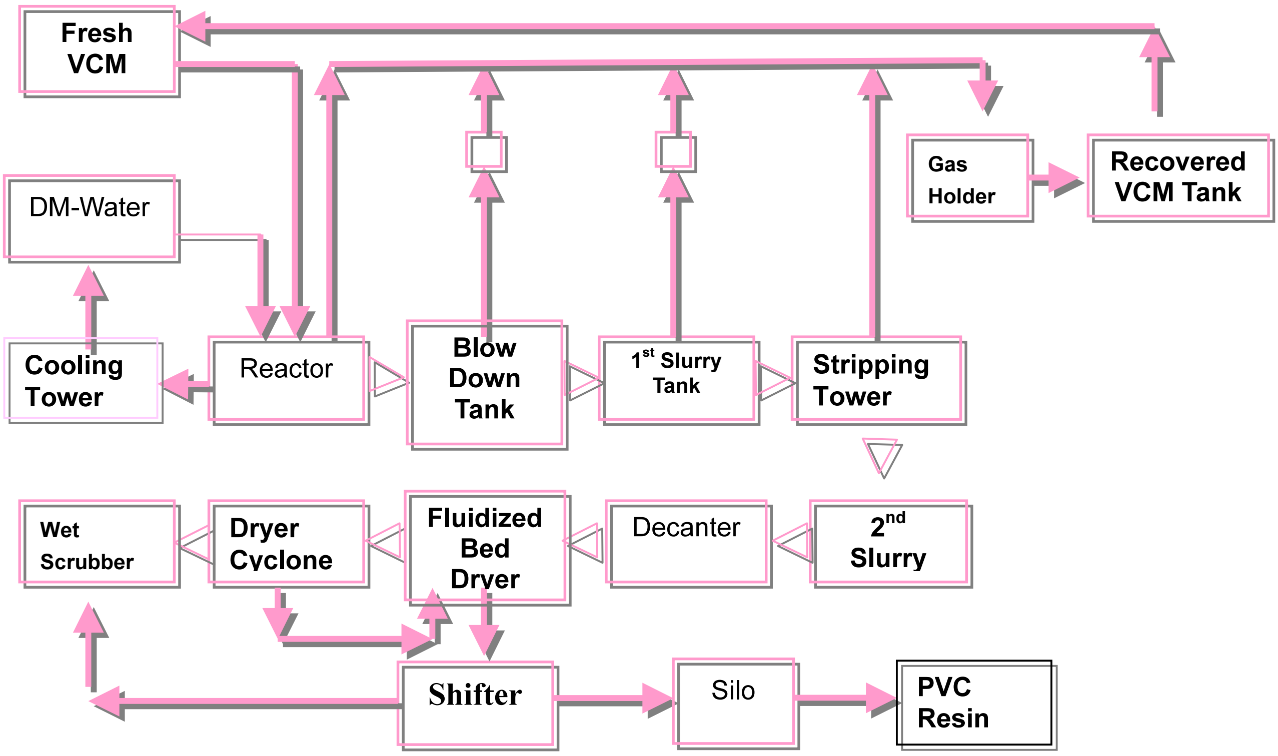
The PVC plant is located in a 6.5 hectare area within the PPDC Petrochemical Industrial Park in Bataan, and has been designed to accommodate a potential capacity expansion of up to 140,000

tonnes/year, and finally to 180,000 tons/year within the next two to three years. To achieve global competitiveness, full integration of the facility with Chlor-Alkali, Ethylene Dichloride (EDC) and Vinyl Chloride Monomer (VCM) plants will be pursued as the local and international market demand warrants.
PRII's PVC plant and its back integration program is a major component of the Philippines government's overall program for encouraging the development of the petrochemical industry in the islands. By providing reliable local supply, it is hoped that PRII will stimulate market demand, spur growth in the local PVC market applications and, consequently, contribute to the overall economic development of the country. More importantly, PRII can now offer its customers just-in-time delivery, reliable after-sales service, and continuous collaborative product development efforts.

5.2 Process Description

PRIIs manufacturing process of PVC uses a suspension-type of polymerization reaction. Detailed process flow diagram is presented in Fig. 6.4. 21.

Fig. 6.4. 21. Process Flow Diagram



In this process, the Vinyl Chloride Monomer (VCM) is received as liquid in a pressurized tank.

The following are the key steps:

- Process water is purified by demineralization and charged to the reactor. Suspending agents and other additives, as needed, are fed to the reactor followed by VCM. The additives stabilizes the suspension and prevent polymer globules from adhering from each other.
- The mixture is then heated by hot water in the reactor jacket to bring the solution to reaction temperature, at which point the reaction becomes exothermic.
- The polymerization temperature is kept constant to achieve a smooth molecular weight distribution of the PVC. Temperature is then controlled by cooling water circulated through the jacket. To produce different PVC-grades, temperature and time of reaction can be varied.

- After reaching final conversion rate, polymerization-reaction is terminated and suspension is discharged into the blow-down tank. Minor quantities of unreacted VCM flushed out in the reactor and blow down tank and transferred to the recovery section.
- The product in the reactor is slurry, which is pumped to storage tank. The stripping tower is integrated in the tank to recover remaining VCM.
- Then the PVC-slurry is dewatered in decanter. The wet filter cake drops into a fluidized bed dryer. In order to achieve gentle drying condition and avoid thermal degradation of the product, the drying of the PVC is first carried out in the fluidized bed drier before it enters the dryer cyclone.
- The dried PVC is separated from drying air, screened and conveyed pneumatically to silo for bagging.

Fig. 6.4. 22.Process Flow Block Diagram