WASTE MINIMIZATION OF A STEEL MANUFACTURER : A CASE STUDY OF SIAM UNITED STEEL CO., LTD.

by

Mr. Supradit Rojhirun

A Final Report of the Three-Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
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Approval Committee:

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ABSTRACT

This project aims at searching the information on Waste minimization (WM) techniques, a kind of Environmental Management System (EMS), and its advantages when implementing it to the production process in Steel Mill, Siam United Steel Public Co., Ltd.

Waste Minimization is a part of Pollution prevention and Environmental management that is primarily focused on the production process. Waste Minimization means any source reduction or recycling activity undertaken by a generator that results in the reduction of total volume or quantity of hazardous waste, the reduction of toxicity of hazardous waste that is either generated or subsequently treated, stored, or disposed. Such activity must be consistent with the goal of minimizing present and future threats to human health and the environment.

The reason why I chose to do this topic is that environmental issue is a big concern for doing business or as trade barrier. Customers are highly aware of the environmental and natural resources. This can cause the business to pay attention to save the environment. Investing in WM in some cases may require for a huge amount of money. Many businesses hesitate to invest in WM because they see only the expense. They overlook to the advantages of investing in WM. Siam United Steel Co., Ltd. invested in WM and they can gain competitive advantages in terms of financial concerns and company image. They can gain more profit margin and improve productivity

Since WM can be achieved by using through many techniques such as Recovery Process, Recycling, Reuse or whatever so called, the objectives usually focus on protecting the environment. It will be different in the way of implementing. Investing in WM will be huge, but it is worth to investing for save our environment.

ACKNOWLEDGEMENTS

First of all, I would like to thank my parents who are my hidden drives, pushing me up to this position to achieve my master's degree.

Without A. Smith Tungkasmit, my project will not be completed. So I would like to use this opportunity to express my deepest gratitude to A. Smith Tungkasmit, my advisor, for his valuable suggestion and guidance towards this project.

Moreover, I would like to thank Mr. Apichart Laomalor, Safety officer of Siam United Steel Co., Ltd., who gave me very useful information on Waste Minimization. The valuable answers and material that he gave to me are a part of this project.

Finally, I am grateful to all lecturers of MS – CEM program, who have imparted their knowledge to me and made me prepare to take up this project, as various subjects taught, and various course assignments given by them have a relationship in some way or the other to the project.

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I. INTRODUCTION

1.1 Background

Nowadays, environmental concerns have moved into various industries not only consumer market but also industrial market and are increasing consumer awareness in buying products. Without a good Environmental Management System (EMS), some companies can not enter to the Free Trade Market. Therefore, EMS is a free trade barrier.

Many individual business have put the environmental policy in the mission of the company in order to just have the good public image or getting prepared to achieve ISO certificate or cost Minimization and Pollution Prevention or whatever reasons. Since changes in technology have expanded the variety of the products available for consumption, increased their quantity through increases in productivity made products and packaging more complex, and raised the rate of obsolescence through rapid innovation. All of this has added to the waste disposal problem. In addition , the toxicity of many materials was initially unknown or not given much concern, with the result those procedures for the abatement of these pollution problem have lagged far behind technology of manufacture.

One of the serious drawbacks of the technological era is the steadily increasing amount of hazardous waste being produced daily by industry, agriculture, government, hospitals and laboratories. To protect human health and the natural environment it is imperative that waste minimization technique for these wastes being used. Increasingly, environmental managers at all levels of government will be required to make decision on how to cope with hazardous waste

The Siam United Steel (1995) Co., Ltd. (SUS) is a steel mill located in Eastern Industrial Estate in Rayong Province has used a waste minimization technique which is called "Acid Recovery System" to reduce Hydrochloric acid and recover back to use in the process of production. They use this technique to minimize their cost of raw material and in another hand this helps in reducing waste disposal to the local community. They also use a various other waste minimization techniques in order to minimize their cost and gain the highest benefit form those activities.

In this project, I would like to study how Waste Minimization Technique can create cost minimization and pollution prevention from the steel mill, SUS. I will gather information and analyze on them. The result of this project will be a useful case study for other steel mills or other related businesses which have similar production process to apply to its business in order to have a good environmental management or cost-saving.

1.2 Objectives

(1) To clearly understand the word "Hazardous waste and Waste Minimization".

(2) To show the relationship between Waste Minimization, Cost Minimization and Pollution Prevention.

(3) To study how a company gains profitability by using Waste Minimization.

1.3 Scope

This project focuses on Waste Minimization Technique in steel mill and is aimed to study and analyze the way they gain from this technique both in terms of pollution prevention concerning with the environment and cost reduction concerning with the business expenditures.

1.4 Deliverables

The deliverables of the project are as follows:

(1) To know the relationship of Waste Minimization, Cost Minimization and Pollution Prevention.

(2) To be a useful case study for other steel mills or related industries in Thailand.

(3) To be a powerful advantage against the competitors

II. LITERATURE REVIEW

In the last 15 years there has been a growing worldwide movement among governments and industries to change the way industry interacts with the environment. The focus of this movement has been to reduce environmental impacts from industry through changes in industrial behavior and technology. There are a number of environmental management terms that are used to describe both the movement and the approaches being used. All of them are based on what is commonly known as the "Precautionary Principle", also known by the old saying, "an ounce of prevention is worth a pound of cure". It is better, and usually much less expensive, to prevent environmental problems from happening than to fix them once they are created. And if we do not know what effects our actions will have on the environment, we should proceed with caution and try to minimize any potentials effects that might occur.

2.1 What Is Pollution Prevention?

Pollution prevention consists of all those activities that reduce the generation of hazardous waste. Many terms are used to describe these activities: waste minimization, waste reduction, source reduction, waste diversion, pollution prevention, recycling, and reuse.

Pollution prevention clearly has now become a top priority for both industries and regulators. As the commitment to pollution prevention increases, the problems created by the generation of wastes will begin to lessen. For Industry, this means that pollution prevention must be an integral part of a company's overall operational strategy. Industry must also view pollution prevention as a continuous process of searching for new areas to assess, investigating new method of pollution prevention, and analyzing and implementing these methods.

The U.S. Environmental Protection Agency (EPA) defined waste minimization as the reduction of volume or toxicity of waste:

The reduction to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction in total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as the reduction is consistent with the goal of minimizing present and future threats to human health and the environment.

EPA suggested the following hierarchy for pollution prevention. See Figure 2.1.

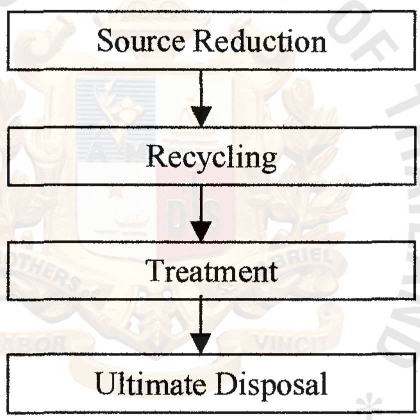

Figure 2.1. Pollution Prevention Hierarchy.

The above hierarchy are preferred approaches to pollution prevention. As one proceed down the hierarchy, more and more waste is prevented, recycled, or treated, thereby reducing the amount of waste generated and released to the environment. According to the Figure 2.1, pollution prevention may be broken down into the following three major components, plus (a fourth) any potential ultimate disposal considerations.

(1) Source reduction,

It consisting of technologies to reduce the volume of wastes initially generated, is the primary approach. The techniques involved are applied to the production process prior to the point of generation. Methods that eliminate or reduce the amount of waste generated by a particular process, either through procedure modification or through material substitution, are employed. Source reduction involves the reduction of pollutant wastes at their source, usually within a process, and is the most desirable option in the pollution prevention hierarchy. By avoiding the generation of wastes, source reduction eliminates the problems associated with the handling and disposal of wastes. A wide variety of facilities can adopt procedures to minimize the quantity of waste generated. Many source reduction options involve a change in procedural or organizational activities, rather than a change in technology. For this reason, these options tend to affect the managerial aspect of production and usually do not demand large capital and time investments. This makes implementation of many source reduction options affordable to companies of any size.

(2) Recycling

The secondary approach, attempts to recover a usable material from a waste stream. The methods involved can take place within the process or at the end of the process and can be implemented either on-site or off-site. Recycling or reuse can take two forms: preconsumer and postconsumer applications. Preconsumer recycling involves raw materials, products, and by-products that have not reached a consumer for an intended end use, but are typically reused within an original process. Postconsumer recycled materials are those that have served their intended end use by business, consumer, or institutional source and have been separated from municipal solid waster for the purpose of recycling. Regarding preconsumer recycling, recycling techniques allow waste materials to be used for a beneficial purpose. A material is recycled if it is used, reused, or reclaimed. Recycling through use or reuse involves returning waste material either to the original process as a substitute for an input material, or to another process as an input material. Recycling of wastes can provide a very cost-effective waste management alternative. This option can help eliminate waste disposal costs, reduce raw material costs, and provide income from salable waste.

Since recycling is the second most preferred option in the pollution prevention hierarchy, it should be considered only when all source reduction options have been investigated and implemented. Reducing the amount of waste generated at the source will often be more cost-effective than recycling since waste primarily is lost raw material or product that requires time and money to recover.

(3) Treatment

For the waste remaining after all possible source reduction and recycling techniques have been employed, the next approach is the use of physical, biological, and chemical treatment methods, including incineration. This results in a reduction of the toxicity and volume of waste requiring ultimate disposal.

Recognizing that not all wastes can be eliminated through source reduction methods or recycling efforts, viable treatment processes must then be look to for managing remaining wastes. These include incineration and a be look to for managing remaining wastes. These include incineration and a host of additional treatment alternatives. According to the EPA definition, treatment is " any practice, other than recycling, designed to alter the physical, chemical or biological character or composition of a hazardous substance, pollutant, or contaminant, so as to neutralize said substance, pollutant, or contaminant or to render it nonhazardous through a process or activity separate from the production of a product .

(4) Ultimate Disposal

The last approach for managing wastes is ultimate disposal, consisting of landfilling, landfarming, deep-well injection, and ocean dumping.

2.2 Pollution Prevention Techniques

(1) Volume Reduction

An appropriate place to initiate waste minimization investigations is to examine ways to reduce the volume of hazardous waste. This can be accomplished by a number of methods including modifying production processes, segregation, and re-use. It should be noted that under some regulatory schemes, simply reducing the volume of the waste without an accompanying reduction in toxicity wold not be considered " waste minimization " For example, under California's Hazardous Waste and Management Review Act of 1989,[29] " actions that merely concentrate the constituents of a hazardous waste to reduce its volume " are explicitly excluded from the definition of "source reduction" .

(a) Process Modifications

Process modifications include changes in:

(1) Raw Material

(2) Equipment

(3) Operating procedures

(4) Materials storage

(5) End products

Raw material substitution includes such simple items as cleaning materials. In the printing industry, the common practice of using organic solvents for cleaning presses has been replaced with water based cleaners. Sometimes conversion to a higher quality raw material can eliminate the generation of hazardous waste where the compound causing the waste to be considered hazardous is due to contamination of the raw material.

A final important aspect of any process change is the need to coordinate with production management. They must be an integral part of the planning, design and implementation of any waste minimization efforts. Production supervisors must be committed not only to the changes in equipment, but to training staff as to the reasons for the changes. Creatively designed waste minimization efforts can fail due to a lack of understanding on the part of production staff as to the need for the changes.

(b) Segregation

A primary tenet of source reduction is to avoid mixing wastes. A mixture of a small amount of hazardous waste with a larger amount of non-hazardous waste creates a large amount of material that must be treated as a hazardous waste. Housekeeping operations as simple as sweeping prior to washing floors can substantially reduce waste volumes.

Keeping wastes segregated greatly facilitates any required treatment. Proper labeling of all lines and containers will greatly increase the likelihood that plant personnel will follow any changes in practices intended to enhance segregation of wastes. Where hazardous waste treatment is required, segregation permits treating smaller quantities of waste.

(c) Re-Use

The acid recovery process used by the steel industry provides an example of reuse of a liquid waste stream. Iron scale is removed by an acid cleaning process referred to as "picking" The spent pickle liquor is a hazardous waste that must be neutralized and the resulting sludges are still considered hazardous and require further treatment or secure land disposal.

(2) Toxicity Reduction

A number of waste minimization techniques reduce the concentration of contaminant in a liquid or solid waste stream, without necessarily reducing the volume of wastes produced. It is often possible to lessen the toxic characteristics sufficiently so that the remaining waste is no longer considered a hazardous waste.

(a) Process Modification

Some specific examples of modifications that result in a less toxic waste stream include dry power painting and solvent recovery methods.

As in the discussion of volume reduction, many pieces of equipment can be modified to reduce waste characteristics.

(c) Housekeeping Practices

Perhaps the simplest and most inexpensive methods of reducing hazardous waste at the source is through revision of housekeeping and maintenance procedures.

Material handling procedures provide a good place to initiate the search for opportunities to reduce waste.

Training must be a major element of housekeeping practices. The best designed waste minimization plan will not work without adequate instruction of the personnel involved.

Labeling is a simple housekeeping task that can reduce the unnecessary generation of hazardous waste.

Finally, once a new housekeeping program is underway, it should be monitored to determine that the objectives are being met. Employees should be encouraged to suggest additional practices that will further reduce waste generation.

(d) Material Substitution

Most manufacturing processes were designed with product quality and profitability as the primary design criteria. Among the many material changes that have proven to be cost-effective and reduce wastes are the use of less toxic solvents in cleaning operations.

2.3 What Is Hazardous Waste?

The term hazardous waste gained acceptance starting about 1970 with the first national study of the issue and it became vogue in the mid-1970s with the development of legislative initiatives to regulate it. Long before then the wastes that we now know as "hazardous" were referred to by such terms as special industrial waste or chemical waste.

A waste is a movable object which has no direct use and is discarded permanently (D. La Grega, 1994).

Therefore, the following working definition of hazardous waste, virtually as prepared under the United Nations Environment Programme auspices in December 1985.

Hazardous wastes mean wastes (solids, sludge, liquids, and containerized gases) other than radioactive (and infectious) wastes which, by reason of their chemical activity or toxic, explosive, corrosive, or other characteristics, cause danger or likely will cause danger to health or the environment, whether alone or when coming into contact with other waste.

Simply speaking, hazardous waste is a waste material that has the potential to harm life forms and the environment. A hazardous material is not a hazardous waste until it is no longer useful, or has been abandoned or discarded. A toxic chemical (benzene, for example) is not a hazardous waste until it becomes part of a waste stream from which it cannot be separated for reuse. As long as the chemical is properly labeled and stored in the laboratory or factory, it is a hazardous substance but not a hazardous waste. Some waste material in itself may or may not be hazardous, but if it has the potential to become hazardous after interaction with the environment it is considered a hazardous waste. Hazardous waste typically comprise organic elements and compounds.

Many of which are known to be toxic to life forms-including humans. Regulatory agencies such as the U.S. Environmental Protection Agency (EPA) have developed an elaborate definition of hazardous waste, to comply with the laws. Specific tests have been developed to evaluate hazardous waste characteristics. Many substances have been included in a special list because of their known toxic or hazardous nature.

2.4 Categories of Hazardous Waste

It could be spilt up among the following subcategories:

(1) Acid- inorganic acids; aqueous liquid with pH values of 2 or lower

(2) Acid with metals- acidic wastes with metal contamination (e.g. ferric chloride solution and spent pickle liquor)

(3) Alkali- inorganic alkalis; aqueous liquids with pH of 12.5 or higher

(4) Alkali with metals- alkali wastes with metal contaminants

(5) Cyanide-spent cyanide solutions from plating, stripping, and cleaning; and Hexavalent-Chrome-aqueous liquids containing hexavalent chromium in excess of a specified limit

2.5 How the Hazardous Waste Was Generated?

Hazardous wastes can originate from a wide range of industrial, agricultural, commercial, and household activities. They are generated by manufacturers of many everyday products, by manufacturers of specialty articles, by both service and wholesale trade companies, as well as universities, hospitals, government facilities, and households. After a waste is generated, the generator can either manage the waste on site or transport it off site for treatment, disposal, or recycling, typically to a commercial hazardous waste facility. Hazardous waste managed on the site where it is generated is termed on-site waste. Waste managed at a site other than where it is generated is termed off-site waste and requires, in the United States, the use of a document termed a manifest for tracking its transport on a "cradle-to-grave" basis.

2.6 The Benefits of Hazardous Waste Reduction

Frequently, inadequate information makes it difficult for waste generators to access the benefits of a one-time, up-front investment for waste reduction versus the costs of ongoing pollution control efforts. Because pollution controls measures constitute a familiar operation, while waste reduction implies innovation. Perhaps new equipment, certainly new processes control measures seem to lend themselves more readily to cost-benefit analysis. Uncertainly and reticence on the part of industry in implementing waste reduction practices also arise because waste reduction, as a measure of materials productivity, is inevitably subordinated to other measures of the efficiency of industrial operations, such as labor productivity and energy consumption.

As a result, waste reduction, which can both save money for industry and protect the environment, is being implemented in an uneven and largely undocumented fashion. Yet those companies that have implemented waste reduction effectively see it as a way to improve profitability and competitiveness.

In order for waste reduction to be successful, it must result in an environmental benefit through the prevention of pollution and an industry cost savings that will result in an economic improvement. With both the environment and economics benefiting, all concerned parties are satisfied.

2.7 Approaches to Hazardous Waste Reduction

Waste treatment is essentially an addition to the end of the industrial process, while waste reduction, or waste minimization, is intricately involved in all aspects of the production process. People with " end-of-pipe" pollution control jobs are not motivated to unilaterally reduce waste; such efforts must involve upstream workers and facilities, for waste reduction succeeds only when it is part of the everyday consciousness of all workers and managers involved with production rather than only of those responsible for complying with environmental regulations.

Successful waste reduction efforts have generally been a consequence of attempts to increase the efficiency of industrial operations. Most commonly, waste reduction has been a by-product, not a focus of altered industrial processes. For example, minimization of waste often comes as a result of efforts to converse materials that may be scarce, strategic, or expensive.

Waste reduction should be viewed as a criterion to assess all industrial processes and operations rather than as a unique type of technology, or even as a specialized field of expertise. The technological means to reduce waste are imbedded in all aspects of the production system. Therefore, the phrase "waste reduction technology" although it is convenient to use, can lead to confusion. There are several approaches to waste reduction:

(1) Recycling a potential waste or portion of it on the site where it is generated

(2) Improving process terminology and equipment that alter the primary source of waste generation

(3) Improving plant operations such as better housekeeping, improved materials handling and equipment maintenance, automating process equipment, better monitoring and improved waste tracking, and integrating mass balance calculations into process design.

(4) Substituting raw materials that introduce fewer hazardous substances or smaller quantities of such substances into the production process

(5) Redesigning or reformulating the end products

Recycling is usually the step before pollution control, which may make it the easiest option to recognize and implement. But there are important economic limits to recycling, and many times there are other waste reduction opportunities that offer greater benefits even though they are not as easy to identify.

2.8 Priorities in Hazardous Waste Management

Waste reduction is a near-term practical option, even though it is not possible to estimate accurately the upper limit of how much is technically and economically feasible. Because it is the most certain means of preventing environmental risk and because it is also preferable to most other waste management practices, leading as it does to lower direct costs and higher indirect benefits, waste reduction should be given priority over the means of waste management in industry, and the allocation of public and private resources should reflect the priority.

Under this scenario, the first priority should be to reduce the generation of hazardous waste at the source. The ideal situation would be to completely eliminate the production of hazardous waste by whatever practical means possible. Since it is normally impractical to completely eliminate the production of hazardous waste from an industrial process, the minimization of waste volume is a realistic and desirable goal. A reduction in volume will lessen the environmental impact, lower the operating cost, decrease the complexity of waste management, and reduce the potential liability of the hazardous waste. Waste reduction may be accomplished through improved plant housekeeping and process control. Changes in the process itself may be possible to reduce the amount and toxicity of the wastes generated. See Figure 2.2.

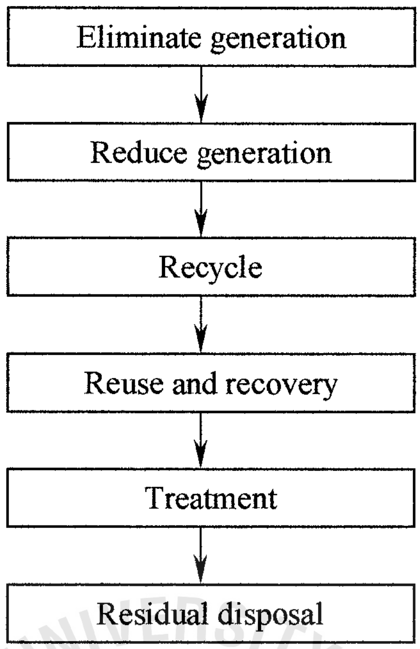

Figure 2.2. Hierarchy of Priorities in Hazardous Waste Management.

Once a reliable quantitative flow diagram –showing all incoming, intermediate, and outgoing streams at the facility- has been achieved, it forms the basis for developing the relationships within the waste management systems shown in Figure 2.3 which has the relationships as follows:

(1) Material Procurement

Incoming materials are obtained by procurement or purchasing personnel according to predetermined specifications and competitive economics. Following delivery, the materials are generally placed in storage vessels or warehoused, depending upon their physical and chemical properties.

(2) Material Utilization

The materials are then distributed from storage to be utilized in plant processes as needed. As these incoming materials undergo physical and chemical process changes, products are created , streams are recycled, and wastes are generated.

(3) Waste Accumulation

The process waste that is generated is then accumulated through a collection system and placed in storage. Some of the wastes may be reusable in the process following physical or chemical treatment. Wastes may be further processed to be recovered as valuable by-products.

(4) On-site & Off-site Management

The remaining steps involving waste management must focus on waste treatment to reduced the waste generated and minimize its discharge and disposals costs, whether the treatment takes place on-site or off-site.

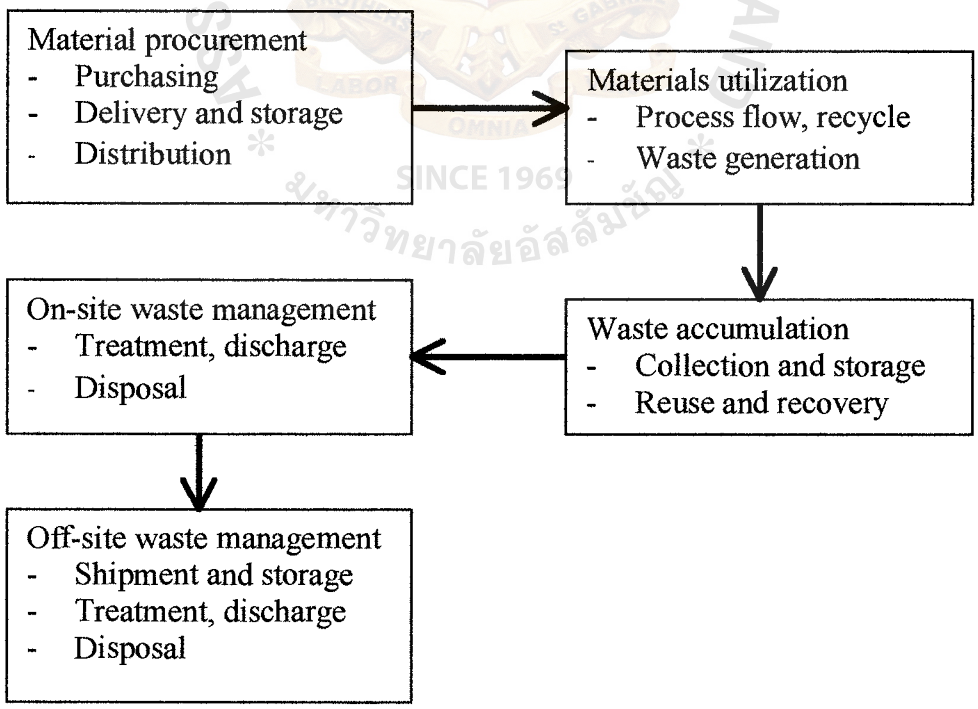

Figure 2.3. Relationship Within the Waste Management System.

2.9 What Is Waste Minimization?

Waste minimization is any source reduction or recycling activity undertaken by a generator that results in:

(1) the reduction of total volume or quantity of hazardous waste;

(2) the reduction of toxicity of hazardous waste that is either generated or subsequently treated, stored, or disposed.

Such activity must be consistent with the goal of minimizing present and future threats to human health and the environment. Formal definitions of waste minimization and source reduction have not been issued by the EPA. Differentiation of these and other terms is helpful for a discussion of the subject matter and assists in clarifying the primacy of waste reduction as a national policy goal.

The definition of waste minimization implies that waste reduction can take place either before the wastes are generated or after. Source reduction as applied in the context of waste minimization has no precedence over recycling techniques. This is the primacy of the national policy on source reduction is lost. Source reduction activities are front-end practices which by their nature minimize hazardous substances and therefore lessen environmental impact. Recycling and other waste minimization techniques serve the national policy objectives but assume greater risk to human health and the environmental simply by the fact that hazardous waste has been generated and must be handled.

Hazardous-waste disposal was once an inexpensive and simple matter of discarding materials no longer needed, but has become a complex and expensive process with potential legal liabilities. As a result, the concept of waste minimization is developing into a policy issue for the United States Government and possibly an increasing beneficial practice for industry. Reducing the amount of hazardous waste ultimately requiring disposal is a laudable goal with obvious economic and environmental benefits. Yet Industry has been slow to adopt widespread waste-reduction practices for a number of reasons.

The United States environmental protection movement of the past two decades has succeeded in implementing laws and regulations designed to control and clean up pollutants after they are generated. Key pieces of legislation, such as the Clean Air and Water Acts (CWA), the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA or Superfund) have provided the basic of control programs on the transportation, storage, discharge, and disposal of hazardous wastes.

Compliance with environmental regulations costs industry billions of dollars annually and is not totally effective in reducing the impact of pollution on human health and the environment. Rather pollution control technology has been implemented to reduce toxicity or concentrate pollutants to levels where they can be transferred from one environmental medium to another.

2.10 Waste Minimization Technique

Various techniques of waste minimization are shown in Figure 2.4. Source reduction includes any activity that reduces or eliminates the generation of hazardous waste at the source, usually within a process. Source reduction can be accomplished by product changes and source control; the latter includes changes in the input (raw) materials, changes or modifications in the existing technology, and good operating practices.

Recycling involves use, reuse, or reclamation of any material. A material is used or reused if it is either used as an ingredient to make a product or employed in a particular process as an effective substitute for an existing product. A material is reclaimed if it is processed to recover a useful product of if it is regenerated. Recovery of lead from spent batteries and silver from photographic film processing are examples of reclamation.

A viable waste minimization program should place greater emphasis on source reduction than on recycling. This hierarchy of effort is desirable from the environmental standpoint, because source reduction techniques avoid generation of hazardous waste, thereby reducing the quantity of hazardous waste generated (pollution prevention). Recycling , on the other hand , explores the possibilities of utilizing hazardous materials for a beneficial purpose; it does not reduce the volume of waste.

(1) Source Reduction

Any activity that reduces or eliminates the generation of a hazardous waste in a process. Source reduction includes good operating practices, technology changes, and material or product changes which are discussed in the following:

(2) Good Operating Practices

Good operating practices are related to human aspects of manufacturing operations. Any procedural, administrative, or institutional measures that a company may adopt to reduce waste would constitute good operating practices. These can often be implemented with little cost, and therefore have a high return on investment. These practices can be implemented in all areas of a plant, including raw materials and product storage, production, and maintenance operations.

(3) Technology changes

Sometimes owners of manufacturing plants take for granted that the particular process used in manufacturing their product optimizes the use of raw materials, energy, and personnel to yield the most desirable quality and quantity of the product. This attitude precludes any consideration of introducing change in the process technology. However, taking a careful look at the process and considering equipment and process modifications can lead to a significant reduction in hazardous waste. Technology changes include changes in production process, changes in equipment used and layout, use of automation and changes in process operating conditions, such as flow rates, temperatures, pressures, and residence times. Some of these changes can be accomplished in a few days at low costs; others may involve long times and large capital investments.

(4) Input Material Changes

Input material changes accomplish waste minimization by eliminating or reducing hazardous materials that enter the production process. By cleaning the input material (feedstock), it is possible to avoid hazardous waste generation within the production process. Input material changes can be accomplished by material purification and material substitution.

(5) Product Changes

A manufacturer may eliminate or reduce hazardous wastes by substituting a nonhazardous material for a hazardous one, through product conservation, or by changing the product composition.

(6) Product Conservation

This involves careful management of inventory of hazardous material. Chemical that have short sheft-lives should not be stocked beyond their expected shelf-life. Either smaller quantities of such hazardous materials should be stocked, or they should be replaced by similar materials that have longer sheft-lives; both will ensure complete utilization of such materials, avoiding treating the otherwise unused materials as hazardous wastes. The American Chemical Society(1985) recommends purchasing many small containers rather than one large container for the most cost-efficient and safest way.

(7) Change In Product Packaging

Sometimes the simple process of changing the packaging from metal cans to paper containers can eliminate hazardous waste. Dow Chemical Company used to manufacture a wettable powder pesticide and sell it in 2-lb cans. The empty cans, if not properly decontaminated before disposal, constituted a hazardous waste. The company now sells the pesticide in a 4-oz water-soluble package that dissolves when the product is mixed with water before use (U.S.Congress, Office of Technology Assessment,1986).

(8) Reclamation

Reclamation is the recovery of a valuable material from a hazardous waste. It is different from use and reuse techniques because the recovered material is not used in the facility where it was generated, rather it is sold to another company.

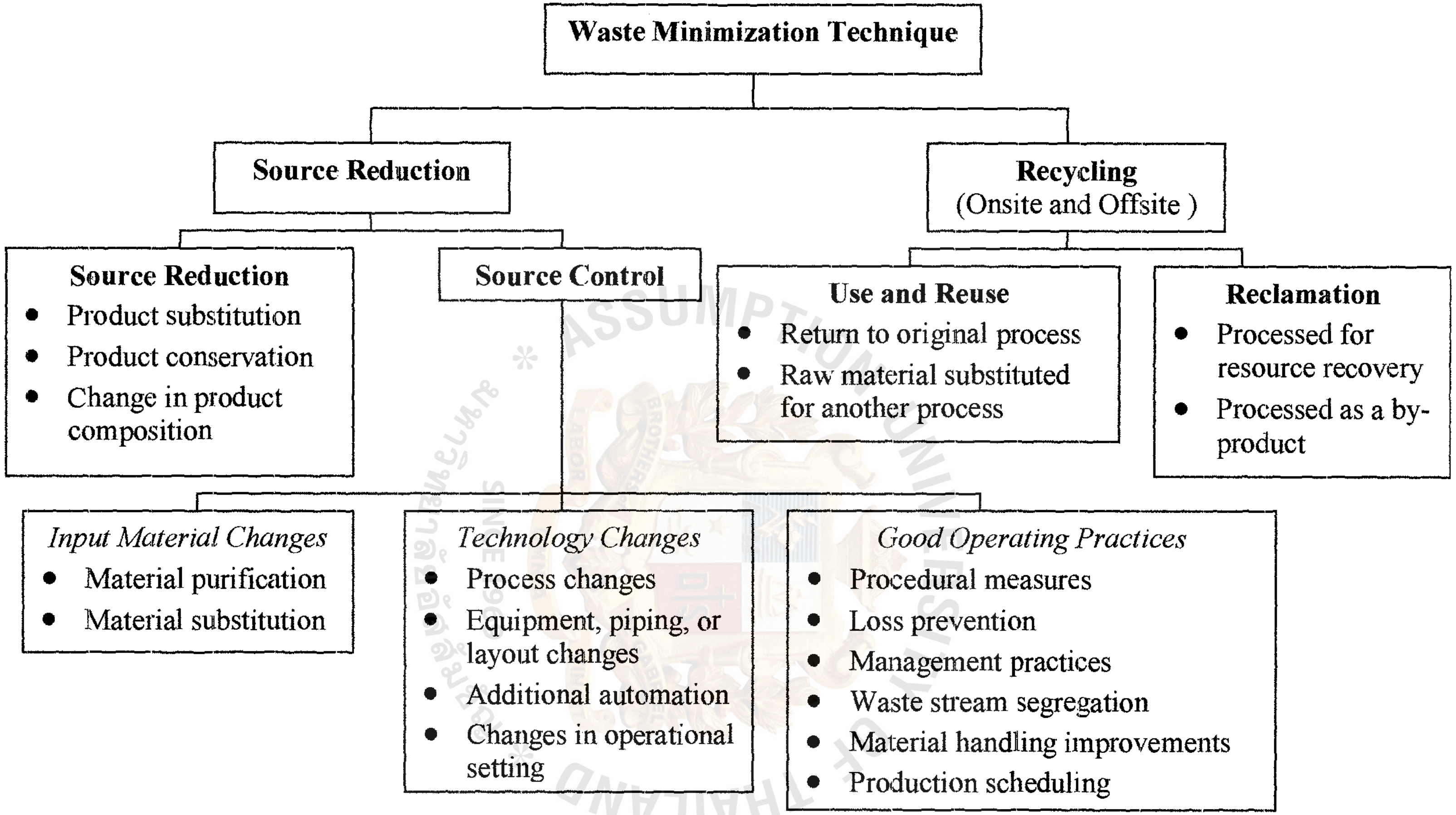

Figure 2.4. Waste Minimization Techniques.

III. WASTE MINIMIZATION TECHNIQUES OF SUS

3.1 Siam United Steel Background

The Siam United Steel (1995) Co., Ltd. (SUS) was formally established on October 30, 1995. Leading companies from three countries, Thailand, Japan and Korea, had joined forces, registering the company under Thai law earlier in July of the same year, to produce and market annual volume of one millions ton of Cold Rolled Steel Sheet for the fast-growing industries in Thailand, such as automotive, construction, home electric appliance, furniture, foodstuff canning, etc., manufacturers of parts and supplies for those industries, and their warehousing partners.

Main equipment and technologies of SUS are provided by Nippon Steel Corporation and Kawasaki Steel Corporation, two of the leading steel manufacturers in the world, along with additional support from the world-renown Sumitomo Metal Industries, Ltd. of Japan and Pohang Iron & Steel Co. of Korea. This will enable SUS to meet any requirements from customers, quality or otherwise.

Thai partners of SUS are the Siam Cement Public Co., Ltd., Thai Tinplate Manufacturing Co., Ltd. Siam Tinplate Co., Ltd. Bangkok Metal Works Co., Ltd. and Siam Industrial Corporation Ltd. Also joining SUS are Mitsui & Co., Ltd. and Mitsubishi Corporation.Construction of SUS plant has been in progress in Eastern industrial Estate in Map Ta Phut, Rayong Province. Start-up of operations has been since 16 November 1998. The total number of workers is 815 workers. The total company areas is around 259 Rai.

3.2 Siam United Steel Environmental Policy

The Siam United Steel (1995) Co., Ltd. has the objective for employees at all levels and all units to have realization and consciousness on the importance of the environment with the policy & vision as follows:

Environmental policy : "We shall produce cold-rolled steel with high quality as customer satisfaction with consciousness on the environment concern"

Vision : "To be the company was accepted from the society in emphasizing to the environment conservation"

3.3 Objective of SUS Environmental Management

SUS has set the objectives for all employees to be activated in order to concern with the environmental conservation as follows:

(1) All employees at all levels in the company must be realized the value and necessity in environmental conservation.

(2) To emphasize in utilizing the natural resources and power with effective and efficiency for the maximum profit, including the least impact to environment by supporting the Clean Technology which stress on reuse, recycle and selective and maintenance machine including with production process generated least pollution.

(3) The company's environmental management must be operated accurately and better than the legal regulated.

(4) Promote and support the society all round for thinking of environmental conservation.

3.4 Techniques in Environmental Management of Siam United Steel

Siam United Steel has set the "7 Re" for all employees to follow in order to achieve in Environmental conservation as the Environmental management policy set.

Table 3.1. Techniques in Environmental Management of SUS.

7 Re	Description
Realize	All understanding with the important and necessity in environmental conservation
Reduce	Reducing of garbage, pollutant, raw material and minimizing power utilization
Reuse	Try to reuse in any objects that is possible
Recycle	Try to recycle in any objects that is possible
Regulate	Controlling environmental management to be higher level that the government defined
Remind	Remind to thinking of environmental conservation
Recognize	To be accepted by society and community

3.5 What Is Cold Rolled Steel Sheet ?

Cold-rolled steel is currently applied to various fields including automobiles, electric household appliances, furniture and office equipment. In particular, as the sophistication of our economy accelerates, cold rolled sheet has become a necessity in today's society.

SUS's cold-rolled steel products have clean surface and excellent drawability. They are also characterized by their superior formality and paintability. They are making every effort to satisfy their customers through top quality production and sales management and continued improvement in their production system toward an environmental friendly steel industry.

3.6 Purpose Utilization in Cold Rolled Steel Sheet

Cold Rolled Steel Sheet can be used in several purposes which are as follows:

(1) Commercial Steel

This type of steel is used for general purposes. In particular, it is appropriate for manufacturing refrigerator doors, drums and furniture as well as for automobile roofs, fenders, hoods, quarters, oil pans and spring houses.

(2) Structural Steel

This structural steel does not need drawability but require strength.

(3) Enameling

This type of steel can be classified into deep drawing, drawing and general types, depending on manufacturing methods and final usages. Generally, drawing and deep drawing steels are used for bathtubs, washers and household appliances while commercial sheets are mainly used for kitchenware, which does not require much drawability and goes through more than three firings.

(4) High Tensile Strength Steel

This type of steel can be divided into commercial, drawing, deep drawing and TRIP steels, depending on manufacturing methods and end applications. In general, commercial steel is used for automobile seats, rail levers and parking brakes while drawing steel is used for center floors and brackets. Deep drawing steel is appropriate for fenders and hoods, and TRIP steel for car doors and bumpers.

3.7 Types of SUS Cold Rolled Steel Sheet

SUS has produced the three main kinds of their products as below:

(1) Cold Rolled Steel Sheet for general use which is CRS type of product, this type mostly is Automotive part and Furniture, it will be the mid-thickness steel sheet. See Table 3.2.

(2) Cold Rolled Steel Sheet for Galvanized Iron Substrate which is GIS type of product, this type mostly is construction part and roofing, it will be the highest thickness steel sheet. See Table 3.3.

(3) Cold Rolled Steel Sheet for Tinplate and Tin free steel which is TMBP type of product, this type mostly is Stationary part and battery case, it will be the lowest thickness sheet. See Table 3.4.

Table 3.2. Cold-rolled Steel Sheet for General Use (CRS).

Classification	Designation	Characteristics	Main Application	Corresponding Specification
Cold-rolled steel sheet	SPCC SPCCT (Commercial Quality)	Commercial quality, Widely applicable for bending fabrication and simple forming. Designation ending with "T" means tension test and/or Erichsen test values are guaranteed.	Automotive parts, furniture, home appliances, pipes, drums, and other usage	JIS G3141 equivalent
	SPCD (Drawing Quality)	Superior in drawability than commercial quality	Automotive floor and roof panels, home appliances, etc.	

Table 3.3. Cold-rolled Steel Sheet for Galvanized Iron Substrate (GIS).

Classification	**Designation**	**Characteristics**	**Main Application**	**Corresponding Specification**
Cold-rolled steel sheet for galvanizing	SPCC	Generally, in full-hard condition. If required, annealed condition is available. SUS can provide from thinner gauge to thicker gauge.	After galvanizing, applicable for roofing, construction parts, reinforcements, etc.	JIS G3141 equivalent

Table 3.4. Cold-rolled Steel Sheet for Tinplate and Tin Free Steel (TMBP).

Classification	Designation	Characteristics	Main Application	Corresponding Specification
Tin mill black plate	SPB	Superior in beautiful surface, Dimension accuracy, and flatness. Due to these features, this product is widely applicable as black plate of tinplate and tin-free steel. SUS can provide from T3 to T5 grades.	After tin or tin-free plating, applicable for can ends and bodies, large –sized containers, crowns, battery cases, stationary parts, etc.	JIS G3303 equivalent

3.8 The Manufacturing Process of Cold Rolled Steel Sheet

(1) CDCM (Continuous Descaling and Cold Rolling Mill)

This is the main manufacturing process of the cold roll steel sheet prior to the three minor production line of their product. These three kinds of production line need to input the product finished from CDCM.

In this process, Hot rolled coils was put into the process as a raw material. Then it will be put into the first part which comprised of the scale breaker which will eliminate rust from the Hot rolled coil surface. On the process of scale breaker, it generates waste which is FeO. SUS apply Waste Minimization technique in order to get rid of this FeO by the method of Dump in the ground.

Next step, it comes to the pickling tank. In this stage the coil was cleaned again by using Hydrochloric acid with the concentration of 9-13 %. This is another process that generates waste which is called Hydrochloric Acid, This HCL acid will be taken to the ARP (Acid Recovery Plant) which was established for minimize waste and recovery waste to use again.

After finishing the first part, the second part is Tandem Cold Mill which will adjust the Hot roll coils (passed cleaning by Hydrochloric acid) as the size & shape requirement. This process use palm oil with the concentration of 15% in order to decrease the temperature and will adjust the Hot roll coil as the required thickness and shape. Therefore on this process, it also generates waste which is used oil. SUS handle with this used oil by dispose to Siam Cement group. Siam Cement will arrange the contract to handle with this used oil. They will eliminate this waste by burning it. The average quantity used of used oil is around 130 Ton / month.

These Are three minor production lines of three categories of their product which are as follows:

(a) Manufacturing process of GIS Product.

This type of product are in form of roof, structure steel. In this process, it will be separated into two parts.

(1) ECL (Electrolytic Cleaning Line):

This part will start by cleaning the surface of Cold rolled coils from CDCM by using brushing and alkali electrolytic process, rinsing with hot water and drying with hot air. During this part, it will generate the water waste. In general, the water used are classified into 2 part which are as follows:

(a) Water used from Factory ------- treated by Chemical treatment

(b) Water used from Office -------- treated by Biological treatment

Both types of water waste will be handled by water treatment with different method as mentioned above.

(2) Coil Preparation Line:

This second part will improve the flatness of strip using tension leveller, checking thickness and inspecting surface defects. It also applying rust preventive oil. It will adjust the coil to the required width and weight. Please see the diagram of manufacturing process of GIS product in Figure 3.1.

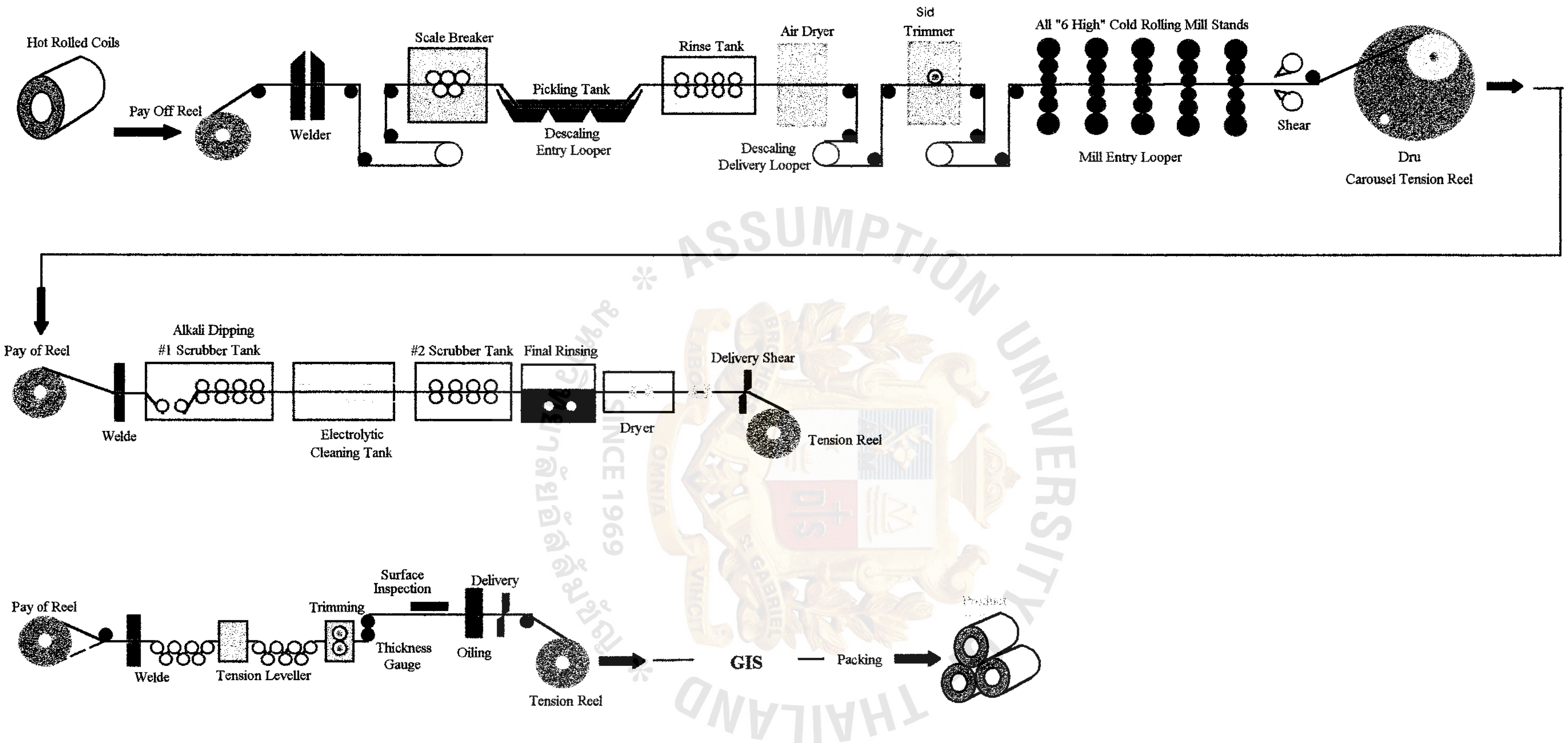

Figure 3.1. Manufacturing Process of GIS Product.

(b) Manufacturing process of CRS product.

This type of product are in form of Automobile part, Furniture, Home appliances and Automotive outer panels. In this process, it will be separated into two parts.

(1) C.A.P.L. (Continuous Annealing and Processing line)

This part will start by cleaning the surface of cold rolled coils from CDCM by using alkali electrolytic process and annealing to improve mechanical properties. Natural gas is used as fuel. Mixture of Nitrogen gas and Hydrogen gas is used in the furnace. On the process of Electrolytic cleaning, it will generate the water waste. This water waste will be transport to water treatment as in GIS Product. Next it comes to Skin Pass Rolling which will improve formability and to get the required surface finish. It will inspect the surface defects and applying rust preventive oil. And it will cut the coil to the required width and weight. During the Skin pass rolling , it will generate waste which is used oil, but this used oil will be eliminated by selling to paint manufacturing.

(2) Recoiling Line

In this part, it will checking the thickness, inspecting the surface defects, and applying rust preventive oil and cutting the coil to the required width & weight. Please see the diagram of the manufacturing process of CRS product in Figure 3.2.

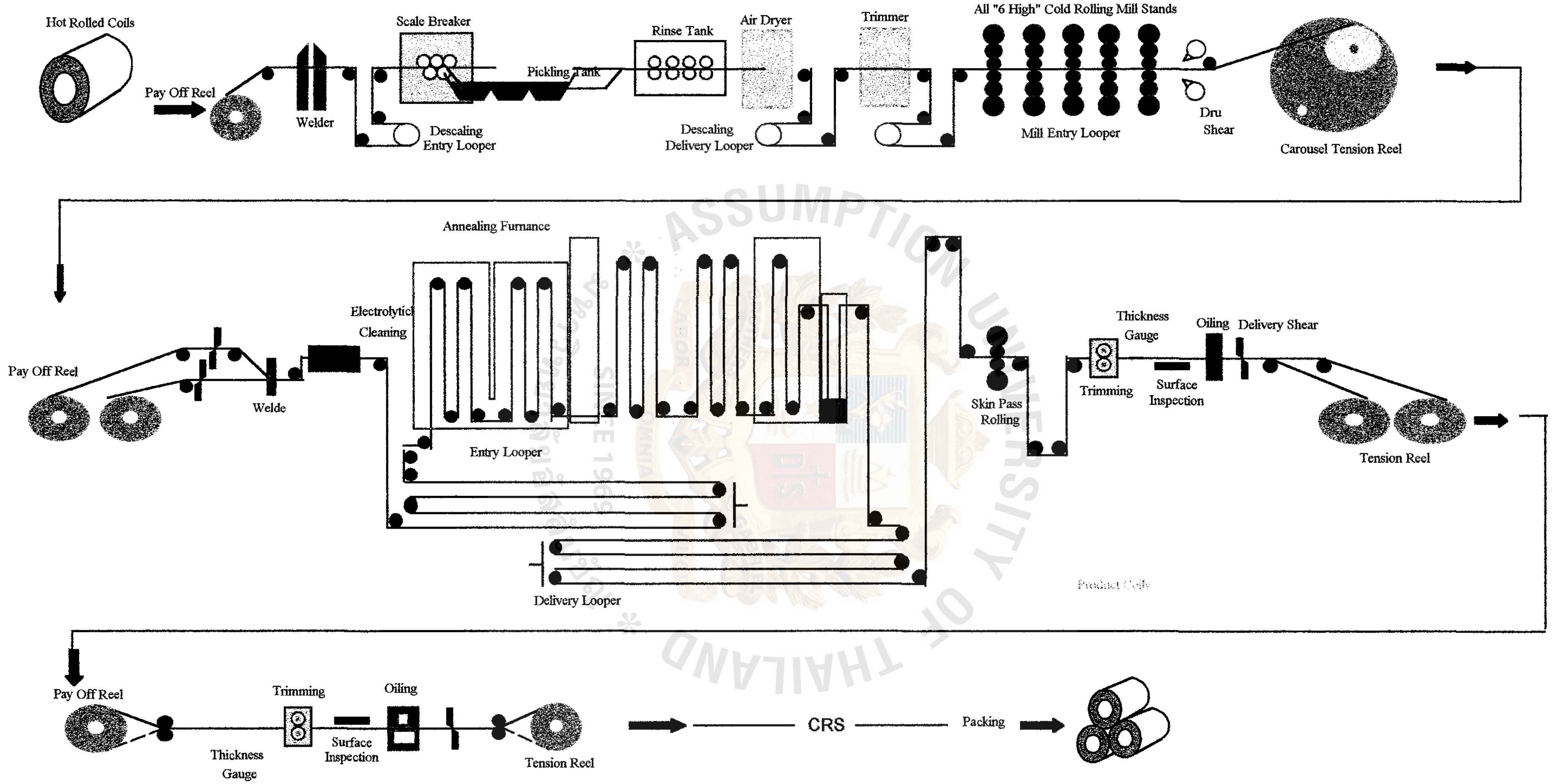

Figure 3.2. Manufacturing Process of CRS Product.

(c) Manufacturing process of TMBP product.

This type of product is in form of Tin-Free plating, applicable for can ends and bodies, battery cases and large-sized container. In this process, it will be separated into three parts.

(1) C.A.P.L. (Continuous Annealing and Processing line)

This part will start by cleaning the surface of Cold rolled coils from CDCM by using alkali electrolytic process and annealing to improve mechanical properties. Natural gas is used as fuel. Mixture of Nitrogen gas and Hydrogen gas is used in the furnace. On the process of Electrolytic cleaning, it will generate the water waste. This water waste will be transported to water treatment as in GIS Product.

(2) TPM (Temper Mill)

Next it comes into Temper rolling with reduction in the thickness of 1.2-2.0% to improve formability. In this process, the coils are able to be as required surface finish.

(3) Coil Preparation Line

In this part, it will be inspecting pinholes, checking thickness and surface defects, applying rust preventive oil and cutting the coil to the required width and weight. Please see the diagram of manufacturing process of TMBP product in Figure 3.3.

However all the above three manufacturing process for GIS, CRS and TMBP will generate waste at the final stage, After cold rolled steel sheet has been finished. It needs to be left for a while in order to waiting to pack on packing department. During this time, there are some amount of oils will drip from the product. However SUS are able to gain the revenue by selling this oil. The average amount of this oil will be around 36 ton/year. The price of oil are around 500 Baht / Liter.

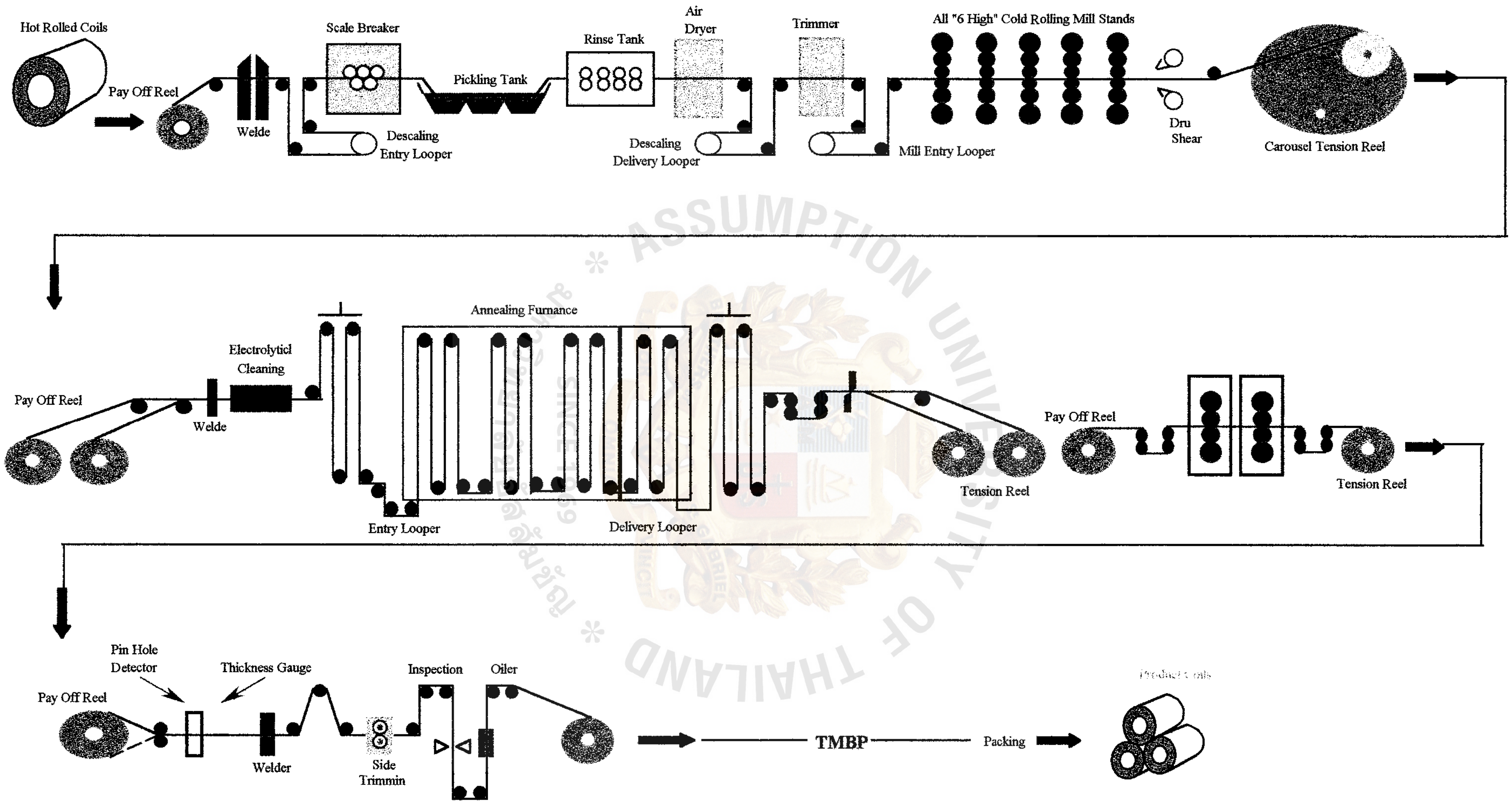

Figure 3.3. Manufacturing Process of TMBP Product.

IV. WASTE MINIMIZATION TECHNIQUE IMPLEMENTATION AND ASSESSMENT OF SUS

In several processes of Siam United Steel have generated a lot of waste as mention earlier such as:

(1) FeO which generated in CDCM process

(2) Hydrochloric Acid which generated in CDCM process

(3) Used oil which generated in CDCM process

(4) Water waste which generated in several processes

These wastes have been disposed and minimize through various waste minimization techniques. Then it comes into the implementation, processes, background, the amount of invest and the assessment of benefits that they gain in various waste minimization techniques.

4.1 The Various Minimization Technique Applied by SUS

(1) Decreasing in garbage quantity of the paper used

Background : Currently, In the factory and office has used a lot of paper (A4 – quantity used around 600 ream/month and A3 – quantity used around 30 ream/month)

Objective : Promote employee to use paper valuably by arrange the box for paper used only one page for reusing again. By these boxes will be available at Xerox and Printer.

Investment : None

Benefit : It can save the paper and reducing the garbage around 50% (A4-saved around 300 ream and A3-saved around 15 ream). Therefore it can decrease the expense for this part 300,000 Baht/ year approximately.

(2) Recycling of used gloves

Background : In working of employee in Maintenance department especially in Maintenance Shop will have one saved equipment which is cloth-glove using for pick up or overhaul all machines everyday. There are a lot of quantities used and disposed which cause the garbage of these gloves are much.

Objective : Recycling of used gloves by separate the gloves with good condition but are dirty for cleaning and reuse again.

Investment : None

Benefit : Decreasing the quantity of gloves to be used around a Thousand of pairs/year. It will reduce the expense for gloves around 4,000 Baht/year.

(3) Setting the inspection system of oil qualities (Hydrolic oil and lubricating oil) to extend the useful life of oil replacing.

Background : SUS used a great deal of lubricating oils which the machine manufacturer always recommend to replace on the specific time.

Objective : SUS will send the sample of oils form Tank to the manufacturer for inspecting quality and record to find out the appropriate time for replacing in order to extending the longer useful life as much as possible.

Investment : None

Benefit : Extend the oil useful life around 25% or 20,000 liter/year

(4) **Recycling of Diesel oil (using for cleaning equipment and component of machine)**

Background : Usually once they overhaul the machine, it will bring out some components for cleaning by Diesel oil.

Objective : It will drop oil from cleaning machine element through filter tank. And then taking some part of oils (which are cleaned) for recycling in cleaning process again.

Investment : None

Benefit : Decreasing the quantity used and disposed Diesel oil around 25,000 liter/year.

(5) **Reuse of Back wash water in factory of water producing.**

Background : In the process of water producing, filter need to use the strainer tank in last stage. Once it was used for a period of time, it needs to be Back washed in order to bring the sludge out of strainer tank which in this process will use a lot of waters and these amount of Back wash waters need to be disposed afterward.

Objective : If water used in this Back wash have been disposed freely, it will lose a huge amount of water. Therefore the company has recycled these waters into the treatment process.

Investment : 120,000 Baht

Benefit : Decreasing the quantity of used water around 300 Cm^3/day or 1,000,000 Baht/year. Decreasing the quantity of disposed water around 300 Cm^3/day or 400,000 Baht/year.

(6) Applying in rotation of Cold melt substance to Temper mill at CDCM

Background : Previously, TCM(Tandem Cold Mill) has only Magnet Separator which installed on Clean Tank in order to remove FeO from Coolant but it cause the disadvantage to lost a lot of Rolling Oil, therefore the Line has to install Electro Magnetic Filter in order to assist to remove FeO and save the Rolling oil.

Objective : In order to use the Rotation system in using oil which effect to decrease the using of Cold oil. They achieve it by installing Electro Magnetic Filter which cost around more than 50,000,000 Baht. Their main function is to use Electro-Magnet system to separate FeO out of the rotated oil so that it is able to extend the useful life of oil.

Investment : 50,000,000 Baht

Benefit : Reducing the used oil by 14% (0.14 Kilogram Roll

Coolant/ 1Ton of steel) which equal to 13.4 Baht/ 1 Ton of steel. SUS has the operating full capacity around 1,000,000 Ton/Year. That means that they can save this oil cost by 13,400,000 Baht per year.

4.2 Implementation of Hydrochloric Acid Recovery System

With hydrochloric acid being used to treat the surfaces of many metals along with many other applications, being able to effectively recover the acid can yield significant financial rewards. Galvanizing, steel pickling, and electronics manufacturing are some of the largest users of hydrochloric acid.

Hydrochloric Acid Recovery system has the following steps which as follows:

Step 1 A centrifugal pump forces the spent hydrochloric acid through a Pre-filter and into the evaporator loop, comprised of the Main Exchanger and the Separator.

Step 2 In the evaporator loop, the spent acid is heated to vaporization. As the solution increases in concentration, the temperature increases in the loop.

Step 3 Forced by expansion, the acid and water vapors are driven from the Separator, through the Acid Condenser, and into the Recovered Acid Tank. The concentration of acid is controlled in these steps to return excellent quality acid to the Pickling Tank.

Step 4 When the proper solution temperature/concentration is reached, a ferrous chloride concentrate is withdrawn slowly from the loop and transferred to a storage tank for sale as a solution or for conversion into a solid crystal.

Step 5 Remaining water vapor continues its journey through the Final Condenser where it is sub-cooled and scrubbed of residual acid vapor. Any final condensate is reused as rinse water in the pickling process or is returned to the pickling tank with the concentrated acid.

The following benefits of hydrochloric acid recovery:

(1) Recycling waste acid for reuse which eliminates disposal of spent acid and neutralized sludge

(2) Reduced demand for virgin HCl

(3) Cost savings by eliminating the transport of waste acids

(4) Generates a salable by-product (iron chloride) that can be used in fertilizer, animal feed, and waste treatment applications

(5) Savings of 81 Million Baht/year with operating at full capacity (1,000,000 ton/year)

(6) It will also save the energy.

In the past, SUS did not applied to the Acid recovery plant. They disregard to the importance of Acid recovery process. They just only get rid of the acid waste and disposal of it normally. In the production process, it takes the waste acid to be burned in the Roaster, and it would get the HCl gas, and then it will use the water to absorb this HCI gas in order to get the HCl acid 18% with the Recovery rate 98% and get the revenue by product as the Iron Oxide which currently they export this material to the Magnet production industry, Anti-rusting Mill through Japan, Korea, Singapore and China.

After SUS has emphasized to the recovery process. They therefore applied to the Acid recovery plant. They decided to invest to build up their own Acid Recovery Plant in order to minimize waste and are able to recover the waste acid (which is called Hydrochloric Acid) to reuse again. It could be seen obviously for cost comparable between before applied to ARP (Acid Recovery Plant) and after applied to ARP. See Table 3.5.

Table 3.5. Cost Comparable between Before ARP and After ARP.

Description	Before ARP Baht / year	After ARP Baht / year
HCl cost	34 Million	5 Million
Disposal and operating cost	67 Million	18 Million
Remedy and treatment cost	-	2 Million
Total Cost	101 Million	25 Million
Revenue by Product	-	(5) Million

As a result of the Table 3.5, SUS are able to save cost for purchasing HCl and remedy cost by 81 Million Baht / year which full production capacity of 1 Million ton / year. Pay-back period 6 years. Noted:- Cost of Investment is 500 Million Baht / year approximately

4.3 Energy Conservation of SUS

SUS has applied the energy conservation into their company also in order to gain any benefits from these following method:

(1) Decreasing in utilization of steam by install valve in order to turn off some part of unusable steam.

Background : Maintenance shop has set the steam pipe around the factory in order to use in shop. But due to the necessary in using steam is not much, therefore the opening of steam in pipe with unuse, it will lost a lot of thermal energy useless.

Objective : Installation valve and turn off the unused steam and turn on only once it need to be used.

Invest : 2,000 Baht

Benefit : Save cost of losing steam around 120,000 Baht/year

(2) Install the insulator on the Sub Tank of Line ECL in order to reduce losing Thermal energy.

Background : Line ECL will have the Tank to warm NaOH solution and water in order to use in production process which arise the losing of thermal in the side of tank made by metal.

Objective : Installation of insulator to prevent the losing of thermal.

Invest : 50,000 Baht

Benefit : Reducing steam consumption around 3,000 ton/year or around 1,800,000 Baht/year

(3) **Decreasing in utilization of steam by using the remaining thermal left from burning at Line of CAPL and CAL**

Background : Exhaust gas remained from the burning in Production process will have a high temperature (Line CAPL 270 °C, Line CAL 459 °C)

Objectives : Taking the remaining thermal pass through thermopile in order to recycle thermal energy. It can cause reducing the quantity used of steam.

Invest : Line CAPL 10,600,000 Baht, Line CAL 7,000,000 Baht

Benefit : Reducing the using of steam in Line CAPL, CAL around 24,000 Ton/year or around 14,400,000 Baht/year

(4) **Reducing electrical energy by using fluorescent thin light (36 watt) instead of fluorescent fat light (40 watt)**

Background : Previously , company office used the fluorescent fat light (40 watt)

Objective : Convert to use fluorescent thin light (36 watt) which can give the same level of light with the fat one (40 watt) . It cause reducing using electrical energy.

Invest : 60,000 Baht

Benefit : It can save the electrical cost by 10% or around 360,000 Baht/year

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In Waste Minimization technique, there are several techniques as aforesaid which the management of the organization can choose to implement to its organization in order to serve the environment issue which is now a major concern for doing business. The better environmental management the company implements, the more advantage it gains beyond its competitors either in terms of money or image, which Siam United Steel Co., Ltd. proved this sentence and this research is trying to present.

SUS has applied several Waste Minimization techniques in order to achieve in their environmental policy which are as follows:

(1) Acid Recovery Plant

   (a) This plant was constructed to recover the Hydrochloric acid which used in manufacturing process.

   (b) It can save cost by 81,000,000 Baht/year which full production capacity of 1 Million ton/year.

(2) Decreasing in garbage quantity of paper used

   (a) Promoting the employee to use paper valuably.

   (b) It can save the paper expense by 300,000 Baht/year

(3) Recycling of used glove

   (a) Recycling of used gloves by separate the gloves with good condition to reuse again.

   (b) It can save the glove expense by 4,000 Baht/year.

(4) Setting the inspection system of oil quality

   (a) Inspecting the oil quality and records in order to extend the oil useful life

(b) It can save cost in extending the oil useful life by 20,000 liter/year pr around 200,000 Baht/year

(5) Recycling of Diesel oil

(a) Recycling of Diesel oil in cleaning process again.

(b) It can save the quantity used and disposed Diesel oil by 25,000 liter/year or around 340,000 Baht/year.

(6) Reuse of water in the factory

(a) It is the water recycling through treatment process.

(b) It can save cost by 1,400,000 Baht/year.

(7) Applying in rotation of cold melt substance.

(a) Using Electro Magnet System to separate Feo out of the rotated oil for extending oil useful life.

(b) It can save cost by 13,400,000 Baht/year

From the above techniques, it can save cost by 97,000,000 Baht/year approximately which equal to 0.6% when comparing with total revenue of full capacity of 1 million ton/year (15,000,000,000 Baht/year)

5.2 Recommendations

At present it is urgently necessary to solve various environmental problems, especially the problem of waste, which is rapidly increasing in quantity. The government realizes this problem, therefore, various work plans were set up in order to solve the problem. However, the collection practice and problem solving measures implemented were successful only at limited level.

For most organizations, the ultimate aim of zero negative impact on the environment, widely defined, simply are not able to be met. The only way to ensure such a position would be to have virtually no industry at all. What we can expect is improved environmental performance overtime and therefore a never-ending or continuous cycle of improvement is an achievable goal.

The environmental Management System has to be firmly tied to a regular assessment of company performance and audit of environmental damage. The central importance of commitment must not be lost, if it is, the system will collapse. The never-ending improvement cycle will mean that the organization learns from its success and failures and improves operations and outputs. This has to be done in a planned systematic and documented way in order to create an organizational culture which protects the environment and the reputation of the company, that intervene through the whole organization.

APPENDIX A

INDUSTRIAL EFFLUENT STANDARDS

Table A.1. Industrial Effluent Standards.

Parameters	Units	Standard Values
1. pH	-	5.5-9.0
2. Total Dissolved Solids (TDS)	mg/l	• not more than 3,000 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 5,000 mg/l • not more than 5,000 mg/l exceed TDS of receiving water having salinity of more than 2,000 mg/l or TDS of sea if discharge to sea
3. Suspended solids (SS)	mg/l	not more than 50 mg/l depending on receiving water or type of industry or wastewater treatment system under consideration of PCC but not exceed 150 mg/l
4. Temperature	°C	not more than 40
5. Color and Odor	-	not objectionable
6. Sulphide (as H_2S)	mg/l	not more than 1.0
7. Cyanide (as HCN)	mg/l	not more than 0.2

Table A.1. Industrial Effluent Standards. (Continued)

Parameters	Units	Standard Values
8. Fat, Oil & Grease (FOG)	mg/l	not more than 5.0 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 15.0 mg/l
9. Formaldehyde	mg/l	not more than 1.0
10. Phenols	mg/l	not more than 1.0
11. Free Chlorine	mg/l	not more than 1.0
12. Pesticides	mg/l	not detectable
13. Biochemical Oxygen Demand (BOD)	mg/l	not more than 20 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 60 mg/l
14. Total Kjedahl Nitrogen (TKN)	mg/l	not more than 100 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 200 mg/l
15. Chemical Oxygen Demand (COD)	mg/l	not more than 120 mg/l depending on receiving water of type of industry under consideration of PCC but not exceed 400 mg/l
16. Heavy metals		
1. Zinc (Zn)	mg/l	not more than 5.0

Table A.1. Industrial Effluent Standards. (Continued)

Parameters	Units	Standard Values
2. Chromium (Hexavalent)	mg/l	not more than 0.25
3. Chromium (Trivalent)	mg/l	not more than 0.75
4. Copper (Cu)	mg/l	not more than 2.0
5. Cadmium (Cd)	mg/l	not more than 0.03
6. Barium (Ba)	mg/l	not more than 1.0
7. Lead (Pb)	mg/l	not more than 0.2
8. Nickel (Ni)	mg/l	not more than 1.0
9. Manganese (Mn)	mg/l	not more than 5.0
10. Arsenic (As)	mg/l	not more than 0.25
11. Selenium (Se)	mg/l	not more than 0.02
12. Mercury (Hg)	mg/l	not more than 0.005

Remark: (1) PCC stands for Pollution Control Committee

(2) The standards were summarized from the Notification of the Ministry of Science, Technology and Environment, No. 3, B.E. 2539 (1996) and it specifies that pollution sources that the above standards are to be applied are factories group II and III issues under the Factory Act B.E.2535 (1992) and every kind of industrial estates.

(3) Notification of the Pollution Control Committee, No. 3, B.E. 2539

(1996) dated August 20, B.E. 2539 (1996) has issued types of factories (category of factories issued under the Factory Act B.E.2535 (1992) that are allowed to discharge effluent having different standards from the Ministerial Notification No. 3 above as follows:

(a) BOD up to 60 mg/l

(1) animal furnishing factories (category 4 (1))

(2) starch factories (category 9 (2))

(3) food from starch factories (category 10)

(4) textile factories (category 15)

(5) tanning factories (category 22)

(6) pulp and paper factories (category 29)

(7) chemical factories (category 42)

(8) pharmaceutical factories(category 46)

(9) frozen food factories (category 92)

(b) COD up to 400 mg/l

(1) food furnishing factories (category 13 (2))

(2) animal food factories (category 15 (1))

(3) textile factories (category 22)

(4) pulp and paper factories (category 38)

(c) TKN

(1) 100 mg/l - effective after 1 year from the date published in the Royal Government Gazette of the Ministerial Notification No. 4

(2) 200 mg/l - effective after 2 year from the date published in the Royal Government Gazette of the Ministerial Notification No. 4 for the following factories:

1. food furnishing factories (category 13 (2))
2. animal food factories (category 15 (1))

Sources: (1) Notification the Ministry of Science, Technology and Environment, No. 3, B.E.2539 (1996) issued under the Enhancement and Conservation of the National Environmental Quality Act B.E.2535 (1992), published in the Royal Government Gazette, Vol. 113 Part 13 D, dated February 13, B.E.2539 (1996)

(2) Notification the Ministry of Science, Technology and Environment, No. 4, B.E.2539 (1996) issued under the Enhancement and Conservation of the National Environmental Quality Act B.E.2535 (1992), published in the Royal Government Gazette, Vol. 113 Part 13 D, dated February 13, B.E.2539 (1996)

(3) Notification of the Pollution Control Committee, No. 3, B.E. 2539 (1996) dated August 20, B.E. 2539 (1996) issued under Factory Act B.E.2535 (1996), published in the Royal Gazette, Vol. 113, Part 75 D, dated September 17, B.E. 2539 (1996)

APPENDIX B

GOOD OPERATING PRACTICES

Table B.1. Good Operating Practices.

Practice	Program elements
Waste Minimization Assessment	1. Form a team of qualified individuals 2. Establish practical short-term and long-term goals 3. Allocate resources and budget , Establish assessment targets 4. Identify and select options to minimize waste 5. Periodically monitor the program's effectiveness
Environmental Audits/reviews	1. Asssemble pertinent documents 2. Conduct environmental process reviews 3. Carry out a site inspection 4. Report on and follow up on the findings
Loss prevention programs	1. Establish Spill Prevention, Control, and 2. Countermeasures (SPCC) plans 3. Conduct hazard assessment in the design and operation phases
Waste segregation	1. Prevent mixing of hazardous wastes with non-hazardous wastes 2. Isolate hazardous wastes by contaminant 3. Isolate liquid wastes from solid wastes
Preventative maintenance	1. Use equipment data cards on equipment location, 2. Characteristics, and maintenance 3. Master preventive maintenance (PM) schedule

Table B.1. Good Operating Practices. (Continued)

Practice	Program elements
Training/awareness-building	Provide training for: 1. Safe operation of the equipment, Proper materials handling 2. Detecting releases of hazardous materials, and Emergency procedure
Employee participation	"Quality circles" (free forums between employees and supervisors) to identify ways to reduce waste Solicit employee suggestions for waste reduction ideas
Production Scheduling / planning	Maximize batch size Dedicate equipment to a single product Schedule production to minimize cleaning frequency
Cost accounting/allocation	Cost accounting done for all waste streams leaving the facilities Allocate waste treatment and disposal costs to the operations that generate the waste

APPENDIX C

ENGINEERING CLASSIFICATION SYSTEM FOR HAZARDOUS WASTE

Table C.1. Engineering Classification System for Hazardous Waste. (Continued)

Major category	**Characteristics**	**Examples**
Oils	Liquid wastes comprised primarily of petroleum-derived oils	- Used lubricating oils from internal Combustion engines - Used hydraulic and turbine oils from heavy equipment operations - Used cutting oils from machinery Manufacture - Contaminated fuel oils
Inorganic Sludges/solids	Sludges, dusts, solids and other non-liquid waste containing inorganic hazardous substances.	- Wastewater treatment sludge from Mercury cell process of chlorine production - Emission control dust from steel Manufacture and smelters - Waste sand from coking operations - Lime sludge from coking operations

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