IMPROVEMENT OF INVENTORY: A CASE STUDY

of An Air-Conditioning Firm.

By
PATSORNKORN SAWATSRI

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
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Martin de Tours School of Management
Assumption University
Bangkok, Thailand

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Martin de Tours School of Management

Master of Science in Supply Chain Management

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Mr. Patsornkorn Sawatsri

and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in supply chain management.

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Assumption University

Martin de Tours School of Management

Master of Science in Supply Chain Management

Declaration of Authorship Form

Mr.Patsornkorn Sawatsri

declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

Improvement of Inventory: A case study of air-conditioning firm

I confirm that:

1. This work was done wholly or mainly while in candidature for the M.Sc. degree at this University;
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I confirm that this thesis/project has been carried out under my supervision and it represents the original work of the candidate.

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Advisor Dr. Chatchalee Ruktanonchai

Date 29 November 2009

Abstract

The objectives of this research were to study the current status and parameters of raw material inventory, and to analyze and propose method of improving raw material inventory. The study was based on 8-months information of Aircon Mfg. Co., Ltd., one of the air-conditioning manufacturers in Thailand. Aircon had encountered high level of inventory, mainly caused by the lack of analytical tools. This study employed statistical tools and ABC classification to focus on the first 80% value of materials, which were 4 groups of materials; Plastic, Remote, Copper, and Motor. Each group of materials was then subjected to further analysis by using Economic Order Quantity concept, combined with historical data of actual demand and qualitative analyses of purchasing conditions.

The results showed that if using analytical tools for inventory management, Aircon would be able to save a total of 25 millions Baht in the same 8-months period. The results and this analytical approach were subsequently proposed to the Managing Director of the company, who agreed in principle and would seek to apply analytical tools in practice.

Acknowledgement

I would like to express my sincere gratitude to every one for his and her contribution to this research and my master's degree.

Special and deep indebtedness to my advisor Dr. Chatchalee Ruktanonchai, for him in valuable suggestion, patience, understanding, encouragement, inspiration through the completion of this research.

I am grateful to my committee members Dr. Ismail Ali Siad and, Asst. Prof. Dr. Nucharee Supath, for their constructive and recommendation that help improve my research.

Lastly, I would like to give my deepest gratitude to my beloved mother and father as well as my sisters for their encouragement and support.

Mr. Patsornkorn Sawatsri

Table of Contents

Chapter 1
Introduction

1.1 Introduction

Management's role in any organization involves the acquisition, disposition, and control of resources that are necessary for the attainment of organization objectives. These resources typically include labor, capital, equipment, and materials. Every organization either uses, transforms, distributes, or sells materials of one form or another.

Materials management has a tremendous influence on the ultimate cost of a product, because it handles the total flow of materials in an organization. The management of materials concerns their flow to, within, and from the organization. The efficiency and efficacy of the flow can substantially influence costs and revenue generation. The total flow can extend from suppliers to production. Encompassed in the management of the materials flow is the responsibility for the planning, acquisition, storage, movement, and control of materials and final products. The emphasis is primarily on planning and controlling the flow.

Several companies and owners have often emphasized the importance of inventory in one of the major factors that they want to develop and improve performance, such as effective reduction of inventory. These can effectively reduce costs of raw materials, lead-times, and minimize inventory ordering for each batch size. Inventory Management and Inventory Control have to be designed to meet the demands of marketplace, while supporting the organization's strategic plan. Many changes in market demand, new opportunities due to worldwide marketing, global sourcing of materials, and new manufacturing technologies, mean that many companies management system and inventory control process provide information to efficiently manage the flow of materials, effectively utilize people and tooth, coordinate internal activities, and communicate with customers.

Inventory controlling and/or distribution so that ultimately the end user receives any desired level of service (Peterson and Silver, 1979). At the level of the firm, inventory is among the largest investments made and therefore logically deserves to be treated as a major policy variable.

Inventories are common to farms, manufacturers, wholesalers, retailers, hospitals, churches, prisons, zoos, universities, and national, state, and local governments. Indeed, inventories are also relevant to the family unit in relation to food, clothing, medicines, toiletries, and so forth (Tersine, 1994). The term inventory can be used to mean several different things, such as;

- The inventory on hand of materials at a given time (a tangible asset which can be seen, measured, and counted)
- An itemized list of all physical assets
- To determine the quantity of items on hand
- The value of the stock of goods owned by an organization at a particular time

1.2 Background Information of Case Study

Aircon Mfg Company is one of air-conditioner manufacturers in Thailand. The company was established in 1996 to design and manufacture of air-conditioner Hi-wall indoor units for niche market. Product sizes range from 2.6 KW (9,000 Btu / hr) to 12.3 KW (42,000 Btu/hr) for DX or direct expansion system and for chilled water system with built-in 3-way control valve with the capacity ranging from 2.0 KW (7,000 Btu / hr) to 9.37 KW (32,000 Btu / Hr). Both types are for Heating and Cooling, and available for 50 Hz. and 60 Hz. models.

Main customers are in Middle East, Latin America, United States of America, Australia and Europe. Aircon Mfg has gained its reputation through hard work to provide high quality, perfect design, and excellent after-sales services.

In this case study a company has problems of high level of excess inventory which tied up other possibilities of investment, high volume and holding value. It was considered that the problem from insufficient control high inventory, and from directorial attempt to respond quickly to customer demand. The company based its order on subjective judgment, without using any supporting tool or data. Therefore, this research will only focus on company's internal inventory control and propose a feasible recommendation for improving company's inventory management. This would be achieved through examining relevant theory and analysis of company's operational practice.

1.3 Sale Analysis

The air-condition products of the company can be classified into two categories, Completed Built-in Unit (CBU) and Semi Knock-Down unit (SKD). In the 8 months period of 2008, total sale volume was 32,140 sets. Semi Knock-Down unit (SKD) accounted for 61% and Completed Built-in Unit (CBU) accounted for 39% of total sale as illustrated in Figure 1.1

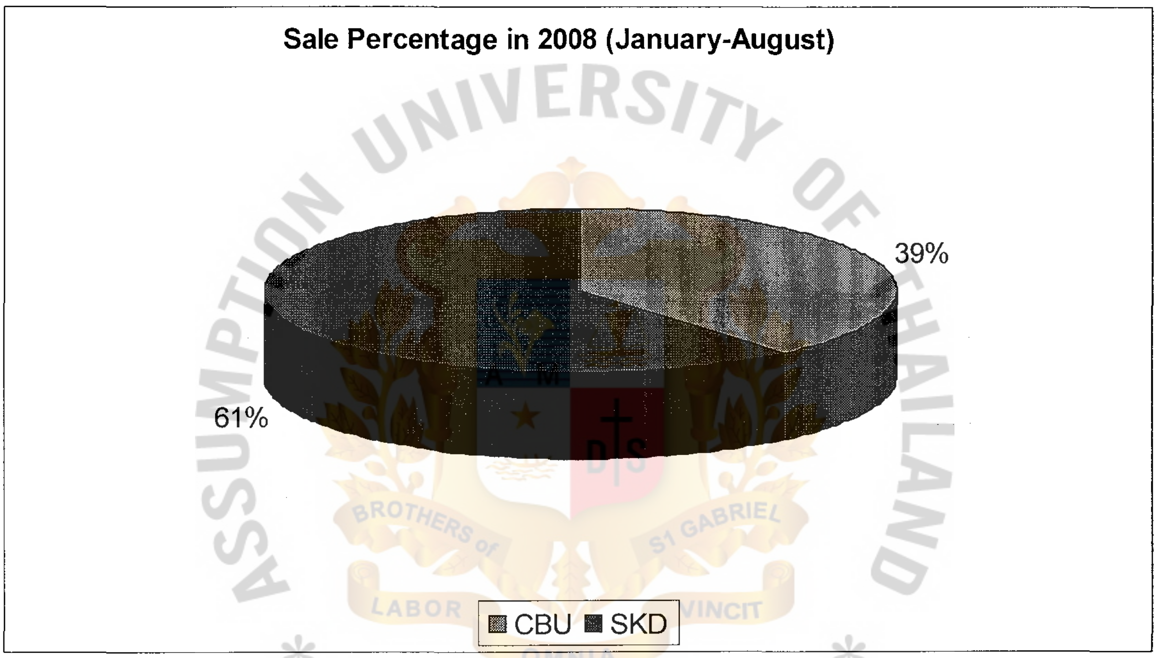


Figure 1.1 Sale percentage of Semi knock-down unit (SKD) and completed built-in unit (CBU)

Based on the sale report of 2008, the maximum sale quantity was 4,457 units in January and minimum sale quantity was 356 units in June, on currently situation sale quantity impact to inventory management for raw material supply.

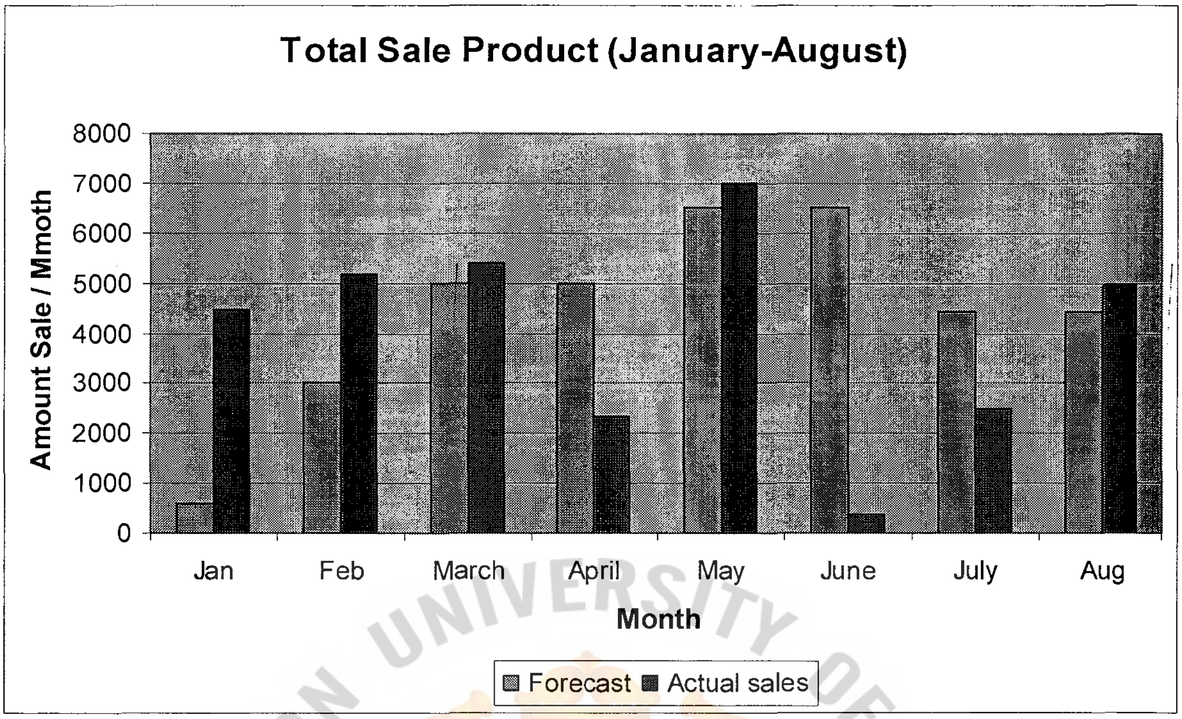


Figure 1.2 Total Sale 2008

From Figure 1.2, it can be seen that quantities varied in each month. For example, in January and February, sales quantities were more than what had been forecasted. However, in April and June, the sales orders were less than forecast value. Therefore, raw materials inventory was then affected from this fluctuation.

1.3 Inventory Analysis

This research focuses on raw materials that are high volume and high value in the inventory. Currently there are many tools for solving problem, and to effectively reduce cost of raw materials, lead-times, minimize inventory ordering for each batch size. The statistical analysis is to be employed as a tool to predict the raw material supply. The data of raw materials supply are shown in Figure 1.3, 1.4, and 1.5.

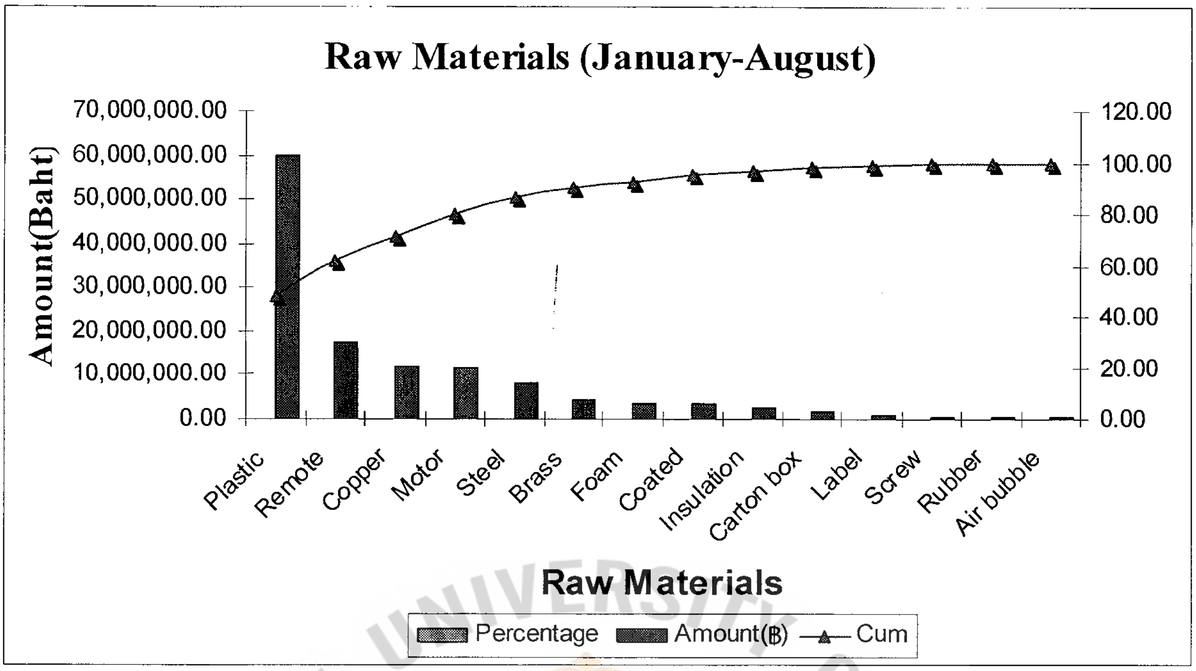
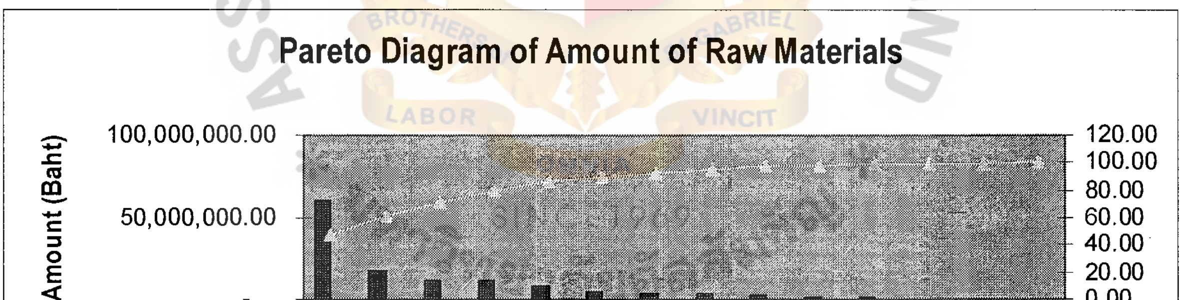


Figure 1.3 Raw materials 2008

Figure 1.3 It is seen that a ranking of raw material by their quantity, from the highest to the lowest group of items. Figure 1.3 shows raw materials are kept inventory, and focuses on raw materials are high 80 % range cover plastic, remote, copper and motor.



	Pla stic	Re mot	Cop per	Mot or	Ste el	Bra ss	Foa m	Coa ted	Insu latio	Cart on	Lab el	Scr ew	Rub ber	Air bub
฿ / 8 months	59,	17,	11,	11,	7,9	4,2	3,3	3,3	2,3	1,6	766	470	455	356
Percentage	47.8	13.7	9.31	9.24	6.30	3.37	2.69	2.65	1.88	1.31	0.61	0.37	0.36	0.28
Cum	47.8	61.6	70.9	80.1	86.4	89.8	92.5	95.1	97.0	98.3	98.9	99.3	99.7	100.

Raw Materials

฿ / 8 months   Percentage   Cum

Figure 1.4 Pareto Diagrams of Inventory Materials

Figure 1.4 shows a classification of raw materials by their value, from the highest to the lowest groups of items. Applying the Pareto concept, Figure 1.4 shows materials from highest to lowest values, and then using accumulative percentage to consider 80:20 concept. It can be seen that the top 80% range covers Plastic, Remote, Copper, and Motor. Therefore, this research will focus only on these 4 types of materials.

Average inventory: Focusing on key raw materials is collection the data of raw materials of Aircon Mfg supply in 8 months are used to analyze the pattern. The data are illustrated in Figure 1.5.

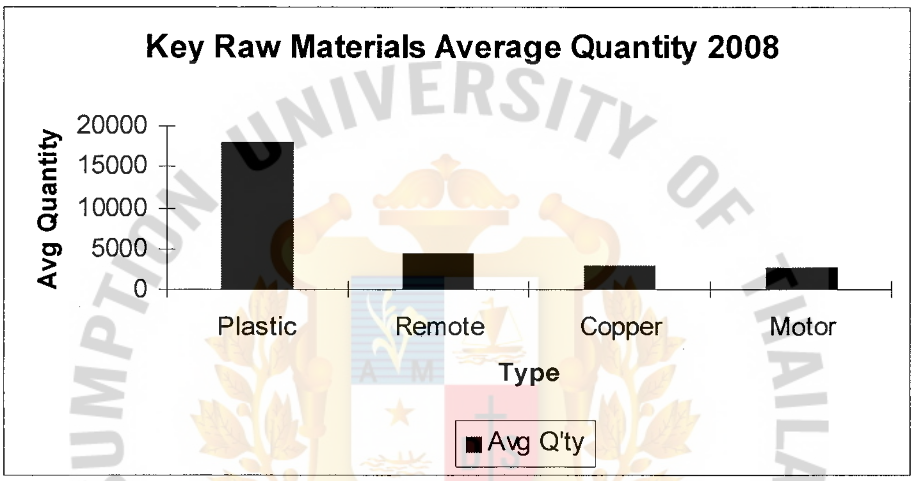


Figure 1.5 Average Raw Materials Quantity (per 8 months)

Figure 1.5 illustrates the quantity of raw materials using per month. It is seen that average quantities of Plastic, Remote, Copper and Motor are high quantity and high value.

All of above defines to the problem of raw materials keep in inventory; this research aims to solve the problem and defines the objectives as follow.

1.5 Objectives of the Research

- To study the current status and parameters of raw material inventory
- To analyze and propose method of improving raw material inventory

1.6 Scope of study

The case study focused on raw materials high value and volume, as shown in Figure 1.3, 1.4, and 1.5. The data of Aircon Mfg supply in 8 months are used to analyze the quantity and value. The model testing and checking Pareto diagram and Economic Order Quantity (EOQ) are done by using the 8 months of data in 2008. This research aimed to reduce the value and quantities are existing in inventory.

1.7 Problem analysis

- The preliminary review found that key raw materials are of high value and volume in inventory
- The firm based its orders on subjective judgement, without using any supporting tool or data

1.8 Deliverables (Expected Results)

- Proposal of inventory improvement for key raw materials

1.9 Glossary

- Plastic = Raw materials used in the air-conditioner
- Motor = Raw material used in the air-conditioner
- Remote = Raw materials used in the air-conditioner
- Copper = Raw material used in the air-conditioner
- CBU = Completed Built-in Unit
- SKD = Semi Knock-Down unit
- Q'ty = Quantity
- D = Demand
- Avg = Average
- SD = Standard deviation
- PCS = Pieces
- Kgs = Kilograms
- P/O = Purchase order
- UC = Unit cost
- BOM = Bill of material
- CFR = Cost and Freight

- FOB = Free On Board
- LCL = Less than Container Load
- Q = Order quantity
- T= Cycle time
- Qo = Optimal order size
- To = Optimal cycle length
- VC = Variable cost
- TCo = Optimal total cost
- RC = Reordering cost
- HC = Holding cost
- SC = Shortage cost
- EOQ = Economic Order Quantity
- Min = Minimum
- Max = Maximum

Chapter 2
Literature Review

2.1 Introduction of Literature

Many operations management textbooks contain a chapter with a title like "supply chain management" (Simchi-Levi et al., 2003), "Purchasing Management" (Monczka et al., 2005) and Inventory and Warehouse Management. The content associated information to the ongoing provision of items with independent demand, appropriate on-hand quantity, business hold these stocks for various reasons, protection against general shortage or potential problems with suppliers or because unit price increased may be imminent.

This chapter will outline relevant theoretical concepts and tools for applying with the context of the case study.

2.2 Supply Chain Management

Simchi-Levi et al. (2003) state that supply chain management is to efficiently integrate purchasing, manufacturers, suppliers, production, warehouses, and raw material, for support to production line and customers, and transportation to customers at the right quantities, to the right locations and the right time, in order to minimize system-wide costs and customers satisfying service level. Davis (2003) also identified key important areas as follow;

- Inventory control: An inventory of a particular product, customer demand change many times, organization can use only historical data to estimate demands from customers. The point to set some material new batch of the product, and how much to order so as to minimize inventories ordering and holding costs.
- Supply contracts: Relationships between supplier and buyers are made in the form of contract that focus on pricing and volume discount, condition on the contact such as CIF, FOB, terms of payment, lead time, delivery, quantity, quality, return, and replacement.
- Outsourcing and Procurement Strategies: Defines raw materials in the inventory that are kept in large quantity and kept for long time. Companies or owners should use these strategies for solving problems and minimizing holding costs and utilizing space in warehouses.

- Supply Chain Integration and Strategic Partnering: Defines to companies and/or owner and supplier to have clear information sharing and operational planning, which are the key success factor for integrated supply chain.
- Product Design: Organizations want to introduce a new product design to market and attractive to customers. Redesign product may help reduce logistic costs or supply chain lead times.
- Information Technology and Decision Support Systems: Organizations wants to link to information technology and decision support systems.
- Customer Value: Customer value is the measure of a company's contribution to its customer, base on the product, service, and intangibles that constitute the company's policy.
- Distribution Network Configuration: Define to companies or owner must to select and setting location at a warehouse for distributing the goods, merchandise, and high value raw material for supporting customers on time, focusing on production levels for each product at each plant, and setting transportation cost and satisfactory service level agreement.

2.3 Purchasing Management

Monczka et al. (2005) state that; Purchasing must contribute to profitability by focusing on coordination of activities and processes related to the goals and objective of the organization. Purchasing must adopt strategies that help a company complete and expect to win. Purchasing must be able to translate corporate objectives into specific purchasing goals.

Linking Purchasing and Corporate Strategy: The actual processes that occur when developing and implementing corporate or company-wide strategies. A corporate strategy requires a definition of how a company will compete in a changing competitive environment. The strategy of an organization (or of a subunit of a large organization) is a conceptualization of;

- Long-term objectives and purposes of the organization
- Broad constraints and policies that restrict activities
- A current set of action plans (also known as tactic) and near-term goals expected to help achieve an organization's objective

Purchasing management must have a specific plan outlining how the company will differentiate itself from its competitor, achieve growth objective, manage cost, achieve customer satisfaction, and maintain continued profitability, in order to meet or exceed the expectation of company.

The economics associated with corporate strategy are fairly straightforward. A company must take in more revenues than it spends on operating cost in the long term to grow and increase profits. There are two fundamental ways of balancing this equation: increase revenues and decrease costs.

Increase revenue;

- Raise prices
- Increase volume

Decrease costs;

- Reduce cost of employees (downsize)
- Reduce cost of process and waste
- Reduce cost of goods and service

Monczka et al. (2005) state that purchasing to develop strategies that enhance a company's competitive position through supply based management. The term strategic alignment means that purchasing activities are consistent with the nature of the business strategy and make a proactive contribution to business model effectiveness. Purchasing must be able to translate objective into purchasing goals. Goals and objectives are defined in four areas:

1) Timeframe: Time phased and intended to be superseded by subsequent goals.
2) Measurement: Quantified objective are often stated in "relative terms" will be accomplished by a specified date.
3) Specificity: Objective is stated in key raw materials, a target is identified.
4) Focus: Definitions are often stated in some relevant external, and internal, for example, the goal is internally focused on some material in inventory will be reducing

5-10% from previous price and last year. Purchasing must couple each objective with a specific goal that it measures and acts upon. Purchasing goals concerns with various purchasing objectives are defined in 3 areas as shown below.

Cost-Reduction Objectives

- Be the low-cost producer with in a company (for example: reduce material costs by 5-10 % in one year)
- Reduce the levels of inventory required to supply internal customers (for example: reduce raw material inventory to 20 days supply or less)

Technology/New-Product-Development Objectives

- Outsource non-core-competency activities (for example: qualify two new vendor for all major services by end of the one year)
- Reduce product development time (for example: develop a formal supplier integration process manual by the end of the fiscal year)

Supply-based reduction Objectives

- Reduce the number of suppliers used (for example: reduce the total supply base by 20 percent over the end of the year)
- Joint-problem solving with remaining suppliers (for example: identify $ 100,000 in potential cost savings opportunities with key items in inventory by fiscal end)

2.4 Inventory and Warehouse Management

Waters (1992) states that inventory control is to minimize the total costs of holding stock. A result of this has been a trend for companies to hold smaller stocks. Some organization have adopted inventory control systems which idea at eliminating, at least minimizing, stock. Stock consists of all the goods and materials stored by companies.

There should make a clear distinction between "item" and "unit", as follows;

- An item is a single of raw material of product kept in inventory.
- A unit is the stands size or quantity of a stock item.

The operation flow a cycle to consist of;

- Raw material delivery from supplier
- Units are kept in inventory until needed
- Over time customers submit demands for the item
- Units are removed from stock to meet these demands
- Delivery is a relatively large quantity, so it is divided into smaller units

2.5 Inventory and Process Flow

Anupindi et al. (2006) state that inventory is a key lever in managing flow of product / service. Inventory integrates all flow units within the process categories, depending on the inventory is location or length of the process, companies can classify material of inventory into three categories.

1) Input inventory: Defining raw materials, components

2) In-process inventory: Acquiring all works being processed

3) Output inventory: Defining make end-product

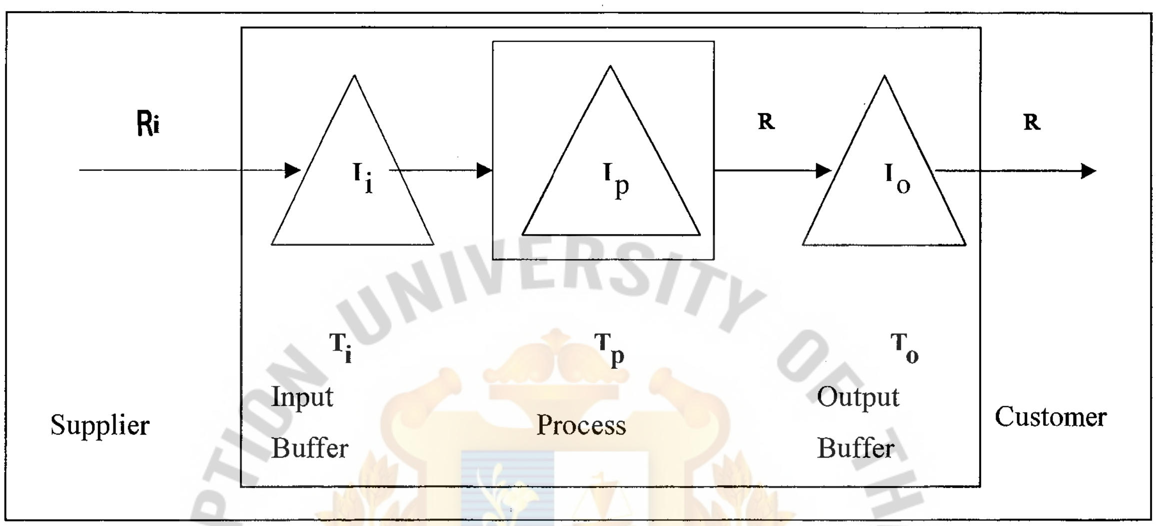


Figure 2.1 Process Flow and Inventories (Source: Anupindi et al., 2006)

Inventories perfectly balance flows: Inflow, processing, and out-flow rate are all equal at every point in time. If there is no flow unit ever waits in a buffer, it remains within the process categories as work in process unit exits the process.

Inventory Benefits: Companies want to reducing inventories and want to solve such problem, protect and kept minimum stock for long lead time, minimum level of in-process inventory. In transportation and logistics, flow units are transported from one location to another location. As a result, the finish goods that are being transported (that are re-routed), pipeline inventory is necessary to allow the functioning of a business process whose activities and responsibility are distributed over locations. Companies usually plan and maintain far in excess of the pipeline inventory.

Economies of Scale: When the average unit cost of output decreases with volume economic of scale may include external or internal, such as purchasing, production, or transportation. Companies refer to the production or order from customer in response to the economies of scale effect as a Baht, such as production setting on going the process a production batch.

2.6 Cost of Carrying Inventory

All inventory holding incur cost. These typically amount to 25% of value held a year, most company view this as a necessary overhead which must be carried to ensure its continued smooth functioning. (Waters, 1992).

Ballou (2004) states that inventories on hand can cost between 20 and 40 percent of their value per year. Therefore, carefully managing inventory levels makes good economic sense. Inventories are most frequently managed as individual items located at single stocking points. Inventory control type has been researched extensively with methods for many specific applications. Inventory control will be viewed as management of inventory in the aggregate.

Chopra and Meindl (2004) state that cost of carrying one unit in inventory for a specified period of time, usually one year. It is a combination of the cost of capital, the cost of physically storing the inventory, and the cost that results from the product becoming obsolete. The holding cost is denoted by H and is measured in \$/unit / year. It may also be obtained as a fraction, h, where h is the cost of holding \$1 in inventory for one year.

- The total holding cost increases with an increase in lot size and cycle inventory.
- The holding cost must be considered in any lot sizing decision are :
  1) Average price per unit purchased, \$$C$ / unit
  2) Fixed ordering cost incurred per lot, \$$S$ / lot
  3) Holding cost incurred per unit per year, \$$H$ / unit / year = hC

Tersine (1994) states that synonymous with carrying cost represents the costs associated with investing in inventory and maintaining the physical investment in storage. It incorporates such as capital cost, taxes, insurance, handling, storage, shrinkage, obsolescence, and deterioration. Capital cost reflects lost earning power or opportunity cost. If the funds were invested elsewhere, a return on the investment would be expected. Capital cost is a charge that accounts for this undeceived return. Insurance coverage requirements and dependent on the amount to be replaced if property is destroyed. Insurance premiums vary with the size of the inventory investment. Obsolescence is the risk that an item will lose value because of shift in styles or consumer preference. Shrinkage is the decrease in inventory quantities over time from loss or theft. Deterioration means a change in properties due to age or environmental degradation. Many items are age –controlled and must be sold or used before an expiration date (e.g. food items, photographic materials, and pharmaceutical). The usual simplifying assumption made in inventory management is that holding costs are proportional to the size of the inventory investment. On an annual basis, they most commonly range between 20 to 40 % of the investment. In line with this assumption is the practice of establishing the holding cost of inventory items as a percentage of their money value.

Peterson and Silver (1979) state that the expenses incurred running a warehouse, the cost of special storage requirements including deterioration of stock, overtime, obsolescence, insurance, and taxes. The cost to carry one dollar of inventory for one year ($/$/year). By for the largest portion of the carrying cost made up of the opportunity costs of the capital tied up that otherwise could be used elsewhere in an organization and the opportunity costs of warehouse space claimed by inventories. Neither of this cost are measured by traditional accounting systems.

Emmett (2005) states that these are caused by many aspects, and the cause of these costs is from many different activities and departments of a company. This can mean that many of the costs may be hidden from view and the following cost items. A large multinational oil company indicates the following percentage costs of its inventory value per year 17-30%.

2.7 ABC Analysis

A useful step to undertaken is to analyse the materials in terms of value by conducting an ABC analysis. This involves the classic Pareto analysis, counted that 80 % of the assets or inventory on hands of 20 % of the population. An alternative name for this type of analysis is the 80 / 20 rule, where a high incidence in one set of variable equates to a smaller incidence in a corresponding set of variables Emmett (2005). Regardless of which, method of categorizing is used, the principle: a high percentage of quantity movement is found from a small number of lines, and the converse that the low value will account for high number of lines for a low percentage of value. Thus, to summarize:

- A items (high value) = high volume
- B items (medium value) = medium volume
- C items (low value)= low volume

In this research focusing an ABC classification and Pareto analysis is to direct attention to those inventory item, and classify raw materials as below;

- A = 80 %
- B = 17 %
- C = 3 %

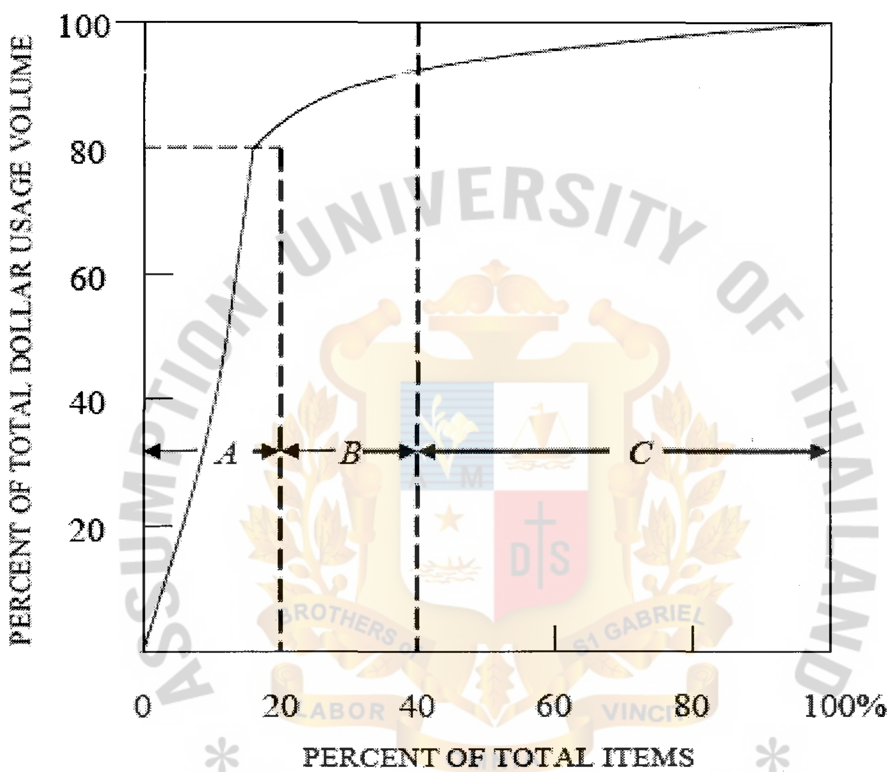


Figure 2.2 Typical ABC inventory analysis (Tersine, 1994)

The same degree of control is not justified for all items. The class *A* items require the greatest attention, and the class *C* item the least attention. Class *C* items need no special calculations, since they represent a low inventory investment. Class *B* items could have EOQ developed with a semiannual review of the variables. Class *A* items could have EOQ developed with a review of the variables each time an order is placed. The major concern of an *ABC* classification is to direct attention to those inventory items that represent the largest 8 months expenditure. If inventory levels can be reduced for class A items, it will result in a significant reduction in inventory investment.

Table 2.1 Comparison of *A, B,* and *C* class (Tersine, 1994)

class	Degree of Control	Type of Records	Lot Sizes	Frequency of Review	Size of Safety Stocks
A	Tight	Accurate and complete	Low	Continuous	Small
B	Moderate	Good	Medium	Occasional	Moderate
C	Loose	Simple	Large	Infrequent	Large

Many articles discuss about *ABC* stock classification for example the top 20 percent account for 80 percent of total usage value in practice the *ABC* classification are fair elastic (Ammer, 1974).

Buxey (2006) commented that the consensus about Q-system should be adopted for expensive items, plus those with an irregular usage pattern or one resulting in infrequent orders. However, qualifications for the P-system are not so clear-cut. The general opinion favors SKUs that are cheap and / or in high demand, but there are still a few contradictions.

2.8 Inventory control system

Waters (1992) states that inventory control systems, there are, however, only a basic questions to answer and the most important of these are:

- What items should be stocked?
- When should an order be placed?
- How many should be ordered?

Some aspects of these questions are discussed below.

2.8.1 What items should be stocked

Holding stock is usually expensive so controls are needed to ensure that stock levels remain as low as possible. This means:

- Stock of existing items are kept at reasonable levels
- No unnecessary items are added to the inventory
- All items which are no longer used are removed from the inventory

Stocks should be controlled using rational policies to relate holding to demand. Similarly, analyses should be done, before an item is added to the inventory, to compare the costs and benefits of holding it. Checks should also be made on usage of items already in stock, and if it is cheaper to discontinue stocking them they should also be removed as quickly as possible. Items which have no forecast demand should also be removed from stock, and those which have had no demand over some period (typically few months) should be carefully reviewed.

2.8.2 When should an order be placed?

The system looks more directly at the demand and orders enough stock to meet know demand. Thus the time and quantity ordered depend directly or demand. When an order should be placed depends on a number of factors, including:

- Details of the inventory control system used
- Type of item (materials, finished goods, and so on)
- Type of demand (high or low, constant or erratic, know exactly or estimated)
- Value of the item and associated holding costs
- Cost of placing an order
- Lead time between placing an order and receiving it
- Supplier (location, reliability, etc.)
- A range of order possible factors

2.8.3 How many should be ordered?

Every time an order is placed there are associated costs for administration, delivery and so on, which minimize the overall total cost. The best order quantity would depend on,

- Demand pattern
- Price of the item, including discount for larger orders, impending price rises etc.
- Cost of placing and receiving an order
- Cost of holding stock
- Delivery rates
- Etc

2.9 Economic Order Quantity (EOQ)

Economic Order Quantity (EOQ) is an analytical concept, focused on minimize total costs, relationship between order size, demand for an item and an expression is found for the optimal order quantity (Waters, 1992). Assumption of the analysis: The basic model makes a number of hypotheses, the theme as below;

- Considered a single item
- All costs are known exactly and do not vary
- No shortages
- Lead time is zero

Some other hypotheses are implicit in the model, including

- Purchase price and reorder costs do not vary with the quantity order
- A single delivery is made for each order
- Replenishment is promptly, so that all of an order delivery in stock at the same time and can be used immediately
- Each inventory item is independent

Economic Order Quantity (EOQ) focuses on a relationship between order sizes, demand for an item, and costs. By making a number of hypothesis an maximum order size (EOQ). Variables Used in the Analysis; Objective are defined as 7 important areas.

1) Order Quantity (Q): An order is place and stock is replenished, the quantity is Q. The main objective of this analysis is to find an optimal value for the order quantity.
2) Cycle Time (T): Depend on the order quantity, with big orders related to longer cycle times.
3) Demand (D): Define on planning department issued demand forecast for each month to purchasing department and they will calculate quantity usage by batch size for each model.
4) Unit Cost (UC): The unit price calculated by supplier for one item
5) Reorder cost (RC): Define on fixed cost, variable cost and expense cost in organization
6) Holding cost (HC): The holding cost of items in stock for a period of time, all items usual period for calculating stock costs is a year, a holding cost might be expressed in inventory.
7) Shortage cost (SC): SC does not occur in stock

Derivation of the Economic Order Quantity; EOQ can be used for many inventory control problems. There are three objectives;

- Find the total cost of period time one inventory cycle
- Share this total cost by the cycle length to obtain cost per items
- Minimize the unit cost

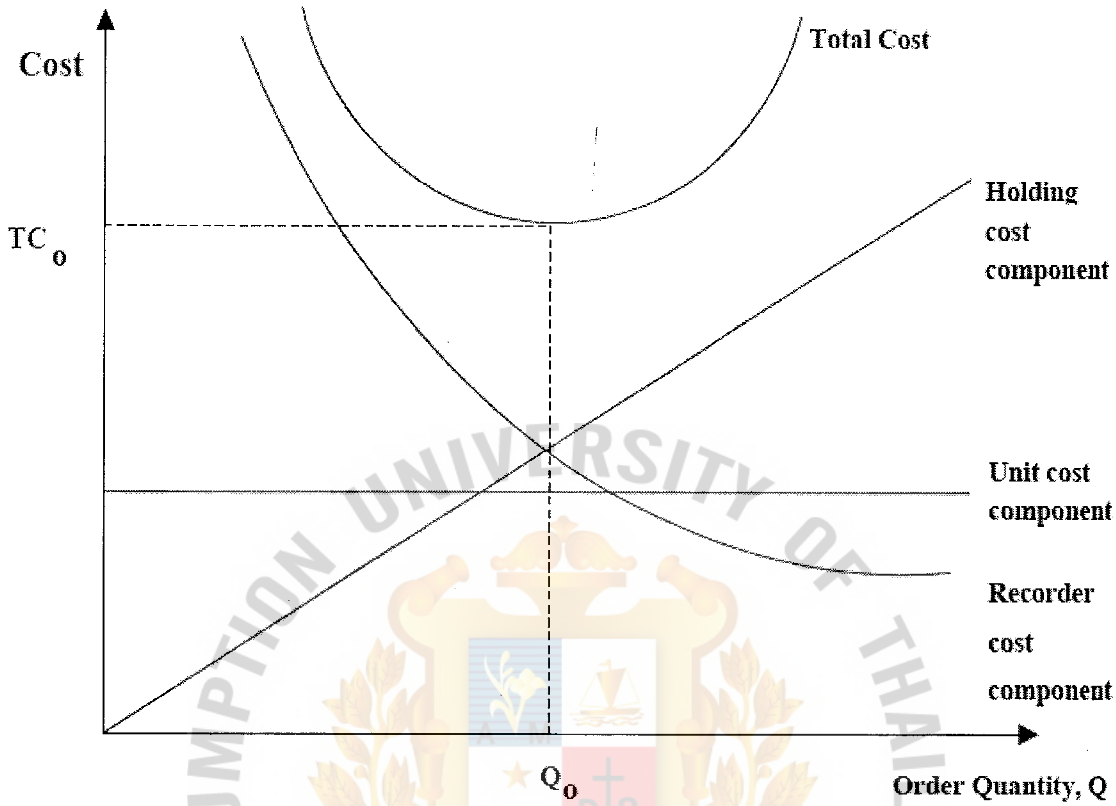


Figure 2.3 Variation of costs with order quantity, *Q* (Waters, 1992)

The holding cost component rises linearly with *Q*, while the re-order cost component fall as *Q* increases. This confirms the observation that costs but high holding costs; small, frequent orders give low holding costs, but high re-order cost.

Adding the three components together gives a total cost curve, which is an asymmetric "*U*" shape with a distinct minimum. This minimum corresponds to the optimal order size, which called the "economic order quantity", EOQ. The best policy is always to place orders of the same size. With smaller orders than this, costs are high because of the reorder cost component, and with larger orders they are high because of the holding cost component.

The minimum value for TC is found by differentiating with respect to *Q* and setting the result equal to zero.

The optimal order size, or economic order quantity (EOQ), which will call *Qo*

- Optimal order size, or economic order quantity (EOQ); $Qo = \sqrt{\dfrac{2 * RC * D}{HC}}$

This is probably the most important part of the analysis and answers the question, "How many should be ordered?". If order are placed with size *Qo,* the total cost per unit time is minimized, but if orders are placed which are either larger or smaller than this the total cost will be higher.

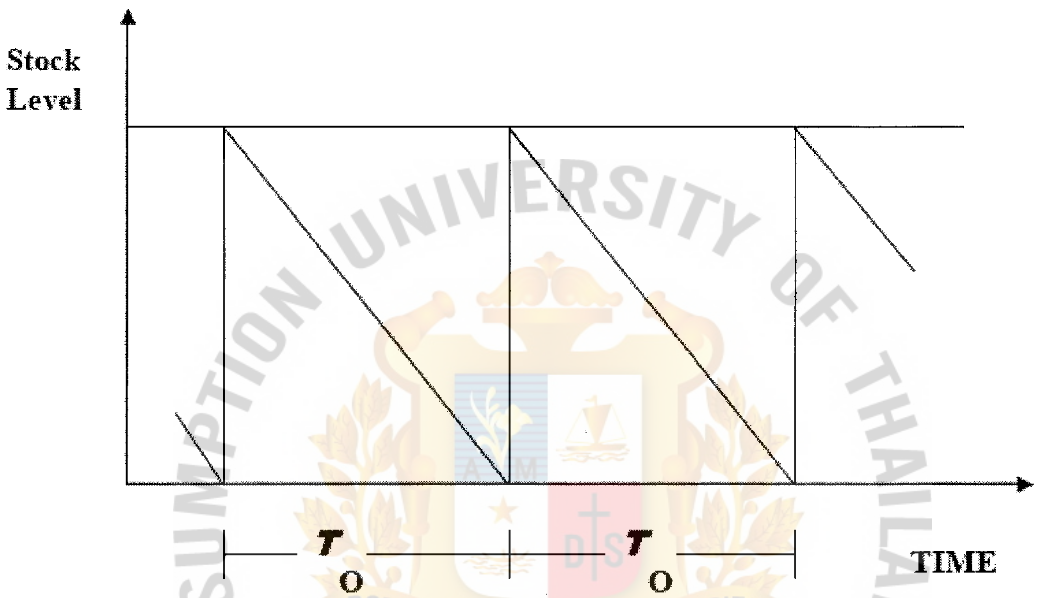


Figure 2.4 Regular pattern of stock level when order of size Qo (Waters, 1992)

The optimal of the stock cycle can be found from the equation $Q = D*T$. If substitute *Qo* for *Q* can find the optimal cycle length, *To.*

- Optimal cycle length; $To = \sqrt{\dfrac{2 * RC}{D * HC}}$

The variable cost can be found reordering cost*holding cost*demand

- Optimal variable cost; $VCo = \sqrt{2 * RC * HC * D}$

Total cost is the sum of variable cost and fixed cost.

- Optimal total cost; $TCo = UC * D + VCo$

The economic order quantity the reorder cost component equals the holding cost component, with both having the value $\sqrt{RC * HC * D} / 2$

Economic Order Quantity (EOQ) focusing on;

- Description of an idealized view of an inventory system
- Building a model of this, relating order size to demand and costs
- Finding an optimal order size which minimizes the total cost per unit time: this is the economic order quantity
- Showing that for large infrequent orders the holding cost component is high, so the total is also high
- Showing that for small frequent orders the reorder cost component is high, so the total cost is also high
- Finding optimal values for the cycle length and cost per unit time.

2.10 Relevant Researches

There have been many attempts to explore and find suitable answers as to how and how much inventory should be fulfilled. Ouyang et al. (2009) study the factors influencing the calculations of Economic Order Quantity, particularly for perishable items like fruits and vegetables. They propose from their mathematical approach that by taking payment conditions into calculations, it would provide results applicable to find appropriate inventory models in those industries.

Teng (2009) proposes a method to calculate EOQ by using arithmetic-geometric-mean-inequality approach to reach global optimum order quantity. He argues that this would be simpler than completing perfect square method discussed by other several authors.

Lau et al. (2008) state that the EOQ policy provided the lowest cost for the supply chain. Sharing information on the future orders plan was shown to be the most effective way for cost and service level improvement.

Gupta (1987) considered an EOQ with all units discounting. A modified procedure is suggested for determining the order quantity, and developed on the total annual relevant costs at various price levels.

Chapter 3
Methodology

3.1 Introduction of Methodology

This chapter describes the methods used to fulfill the purpose of the research. It contains research strategy and research approach. This research uses methodology to study on the objective of inventory improvement. The main methods presented in this research are ABC and EOQ method. The main concept is to find the effectively reduce the cost of materials, lead-times, and minimize inventory ordering for each key raw material. The flow chart of methodology is shown below.

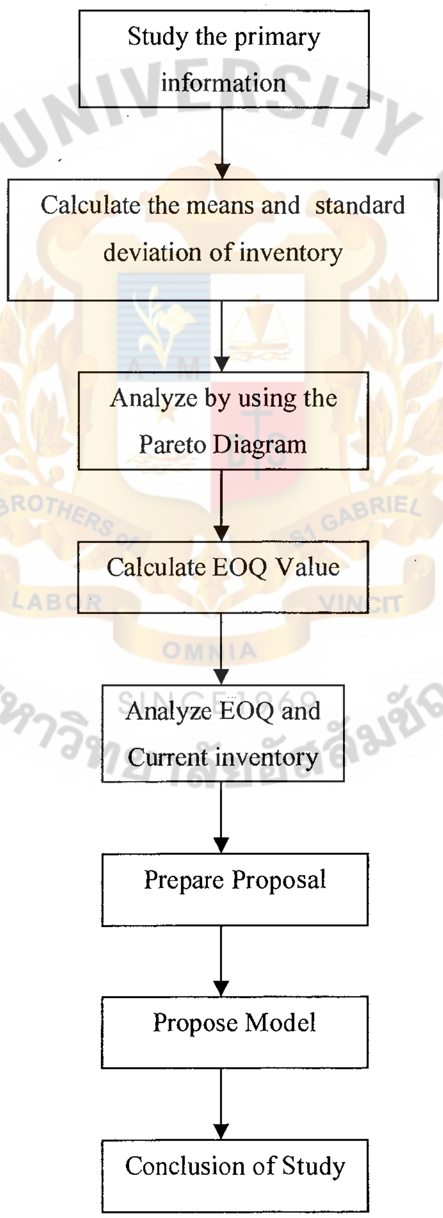


Figure 3.1 Sequential Methodology

The subsequent sections would explain each point of this flowchart.

3.2 Study the Primary Information

Currently, many types of raw materials are kept in large quantity and value, and for long period. The historical provide inventory data, sale report and production report of Aircon Mfg each month starting from January to August 2008. Figure 3.1 is defined as below;

From the historical sale report, it was found that;

- Sale report can be classified into two categories, Completed Built-in unit (CBU) and Semi Knock-Down unit (SKD)
- Quantity of sale can be separated into two regions, export and domestic.
- Demand quantity can be separated each model from BOM (Bill of Materials)
- Demand value can calculated from average demand quantity each model from BOM multiply average quantity each model from sale report.

From the historical inventory report, it was found that;

- Average quantity and average value are classified according to the received raw materials data each month starting from January to August 2008.
- Analyze the received raw materials data and classified in to *A* , *B,* and *C* classes based on the accumulative percentage value.

The historical production report; analyze the quantity of product and separated each model.

3.3 Analysis of Mean and Standard Deviation:

Grant (1996) states that mean is an average value of the data that enable to evaluate the center tendency of a group of value. The mean is a measure of center tendency for roughly symmetric distributions, but can be misunderstood to slope distributions since it can be greatly influenced by scores in the data. Therefore, other statistics such as the median may be more informative for distributions. Nonetheless, mean is the most efficient and therefore the least subject to sample fluctuations of all measures of all measure of central tendency. If any one of the score is zero then the mean is zero. The mean does not make sense it any score are less than zero. The mean is less affected by extreme values and is useful measure of central tendency for some positively to slope distribution.

$$\overline{X} = \frac{\sum X}{n} \qquad \text{---------- (1)}$$

$\overline{X}$ = Sample mean

$\sum X$ = The sum of all the values of the sample

n = Sample size

Grant (1996) states that the standard deviation is useful when comparing the spread of two data sets. Standard deviation usually has comparatively high or low values. So, an item select at random from a data set, when standard deviation is low, has a better chance of being close to the mean.

$$SD = \sqrt{\frac{\sum(X - \overline{X})^2}{n-1}} \qquad \text{---------- (2)}$$

Standard deviation focusing on;

- Standard deviation is only used to measure spread out the mean.
- Standard deviation is never negative
- The greater the spread, the greater the standard deviation
- If the values of all data are the same the standard deviation is zero

Mean and Standard deviation are the statistical measurements of the scatter of data point in a data pattern. Mean and Standard deviation are applied with Pareto diagram and Economic Order Quantity concept.

3.4 Analysis of Pareto Diagram:

The Pareto diagram can be computed by using equation. Figure 1.4 illustrated raw materials each item. Each item may need to be reviewed just to attempt to understand the root cause of the error. The objective of a control group is to find the variations or problems in the transaction processing system, and fix them. Pareto is a selected group of raw materials that are determine, reconcile and eliminate the causes of inventory record in accuracy. It is important to select items / material that representative of the total population of parts / raw materials.

3.5 Analysis of Economic Order Quantity (EOQ) and Average Inventory

Economic Order Quantity (EOQ): EOQ can be used for controlling inventory, takes into consideration the costs of placing an order, and provides a suitable short term approach to minimize the cost of the current materials.

- Optimal order size, or economic order quantity (EOQ); $Qo = \sqrt{\frac{2 * RC * D}{HC}}$
- Optimal cycle length; $To = \sqrt{\frac{2 * RC}{D * HC}}$
- Optimal variable cost; $VCo = \sqrt{2 * RC * HC * D}$
- Optimal total cost; $TCo = UC * D + VCo$

Economic Order Quantity (EOQ) focusing on;

- Described an idealized view of an inventory system
- Flow chart of raw materials, relating order size to demand cost
- Found an optimal order size, cycle length, variable cost, and total cost

Average Inventory: Focusing on key raw materials is a collection the data of raw materials of Aircon Mfg supplied in 8 months are used to analyze the pattern. The model testing and checking are categorized into average quantity. Data are shown in Figure 3.2 below.

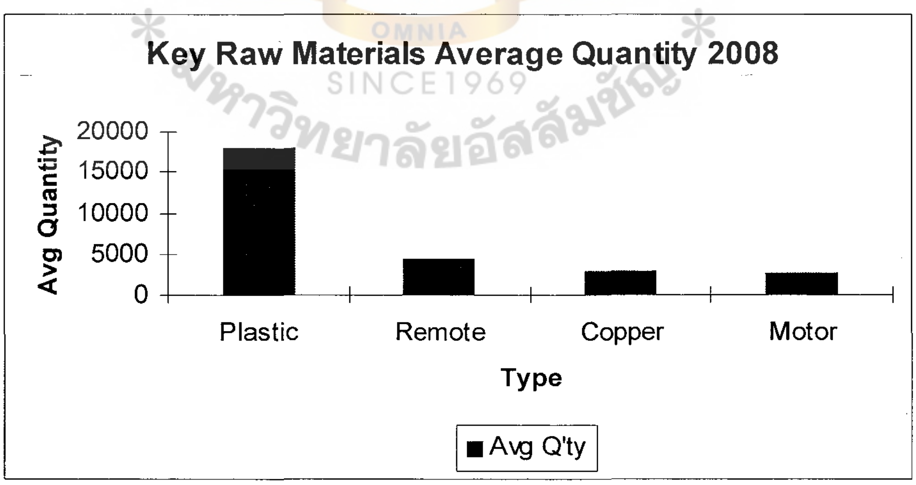


Figure 3.2 Average Raw Materials Quantity (per 8 months)

3.6 Analysis of Economic Order Quantity (EOQ) and Current Inventory

Currently, the firm holds a certain number of inventory. After classifying high value items (first 80%), next the researcher aimed to clarify the order quantity that are suitable for the company. Therefore, the EOQ concept was chosen for analysis. As explained in Chapter 2, EOQ concept is aimed to provide appropriate order quantity for an item, based on the assumption and conditions in the calculation.

3.7 Prepare Proposal:

The researcher drafted a revised materials-management process that would improve inventory management. There also are other considerations such as customer's request order, improvement supply chain, and ensuring the consistency of internal and external process to be included in this draft and subject.

3.8 Propose Model:

This step is to evaluate the validity of concept. This would be achieved through a submission of the revised process proposal to be considered by the Managing Director of the case study.

3.9 Conclusion of Study:

Summarize key points from the study and conclude the case study.

Chapter 4
Results and Analysis

4.1 Introduction

This chapter will explain the Result and Analysis that were guided by the theoretical framework explained in Chapter 3. The contents of this chapter consist of ABC analysis, EOQ calculations of main types of materials, analysis based on EOQ values and current inventory practice, preparation of inventory-improvement proposal, and the discussion of the proposal with the case study. The research following analysis and result defines each step as below.

4.2 ABC Analysis

The inventory classification was analyzed based on 8-months historical inventory data (between January and August 2008). The step are as follows:

The classical ABC model is based on the following assumptions:

1) The Baht value for each item was determined by multiplying unit cost times the number of unit purchased.
2) Ranking the items on the basis of baht value, from highest to lowest
3) Calculate the percentage of total baht value for each item.
4) Determine cumulative percentage for raw the materials.

According to Figure 1.3 and 1.4 the list of these raw materials are ranked by percentage of value usage and classified raw materials into *A*, *B* and *C* type. As mentioned in theoretical framework (Emmett, 2005), the classification is using a model of percentages of the items. The classification separate to three classes, with the *A* are items accounting approximate 80 percent of baht value, *B* items for 17 percent and *C* items for 3 percent. Table 4.1 displays the materials for their value and percentage. The inventory value for each item is obtained by multiplying the 8 months demand by the unit cost. Eight months demand is used to avoid distortions from seasonal change. The percentages shown are approximate numbers.

Table 4.1 Ranking of Items, using A class (high value)

Raw Materials	Value(Baht)	% of baht value	Cumulative % of baht value	Order	% of items	Class
Plastic	59,993,640.99	47.81%	47.81%	1	7	A
Remote	17,306,365.00	13.79%	61.61%	2	14	A
Copper	11,680,656.25	9.31%	70.92%	3	21	A
Motor	11,594,800.00	9.24%	80.16%	4	29	A
Steel	7,909,484.40	6.30%	86.46%	5	36	B
Brass	4,231,982.75	3.37%	89.83%	6	43	B
Foam	3,381,149.57	2.69%	92.53%	7	50	B
Coated	3,321,328.50	2.65%	95.17%	8	57	B
Insulation	2,359,214.80	1.88%	97.05%	9	64	B
Carton box	1,648,756.00	1.31%	98.37%	10	71	C
Label	766,354.00	0.61%	98.98%	11	79	C
Screw	470,150.00	0.38%	99.35%	12	86	C
Rubber	455,000.00	0.37%	99.72%	13	93	C
Air bubble	356,000.00	0.29%	100.00%	14	100	C
Total		100.00%				

From Table 4.1, it can be seen that Plastic, Remote, Copper, and Motor, are classified as class "*A*", as together they have the highest (80%) of the value. As mentioned earlier, this research would focus only on class *A* items, in order that efforts could be channelled to improve the more important issues. It is also hoped that once the class *A* items could be better controlled, the lessons learnt could be applied to class-*B* and -*C* materials as well.

ABC analysis helps identify those raw materials makes the largest impact on a company's overall inventory cost performance.

4.3 Calculation of Economic Order Quantity (EOQ) value

The inventory classification was analysed based on 8-months inventory historical data (between January-August 2008). The EOQ calculation is one of the most well-known concept of inventory control, as it helps define a relationship between order sizes, demand for an item, and the associated costs. Then by minimizing the total cost, an expression is found for the optimal order quantity. The steps are as follows:

The classical EOQ model is based on the following assumptions:

1) The demand rate is known, constant, and continuous.
2) The lead time is known and constant.
3) The entire lot size is added to inventory at the same time.
4) No stock-outs are permitted; since demand and lead time are known, stock-outs can be avoided.
5) The cost structure is fixed; order / setup cost are the same regardless of lot size, holding cost is a linear function based on average inventory, and unit purchase cost is constant.
6) There is sufficient space, capacity, and capital to procure the desired quantity.
7) The item is a single product; it does not interact with any other inventory items.

4.4 Variables used in the analysis

4.4.1 Reordering Cost (RC): is the cost associated with quantity / lot size. It includes purchased items these would include the cost to enter the Purchase Order and / or Requisition. The cost to process the received, freight charge, shipping service, document fee, lift on / off, transportation terminal handing charge, delivery. If the item is made internally, this becomes a batch set up. Ordering cost is average the unit price / order, define as below; The calculation is shown in Appendix.

Table 4.2 Reordering Cost (RC)

No.	Description	Import	Local	Remark
1	Plastic	16,000.00	1,500.00	Baht/order
2	Remote	25,000.00	1,500.00	Baht/order
3	Copper	24,000.00	1,500.00	Baht/order
4	Motor	24,000.00	1,500.00	Baht/order

4.4.2 Holding Cost (HC): is the cost associated with having inventory on hand. It is primarily made up of the costs relate with the inventory investment and kept raw materials long period. For all items according to *Ballou (2004) states that inventories on hand can cost between 20 and 40 percent of their value per year.* The average holding cost is approximate 20% for key raw materials or item (Baht / piece / month). This research explains to a sample of holding cost of plastic is defines as below: The calculation is shown in Appendix.

Holding cost of imported plastic

$$\text{Imported Plastic} = \frac{\text{Total Value Plastic in 8 months}}{\text{Total Quantity Plastic in 8 months}}$$

$$= \frac{57{,}098{,}405.00 \text{ Baht / 8months}}{1{,}563{,}547.00 \text{ Piece / 8months}}$$

$$= 36.52 \quad \text{Baht/piece/ 8months}$$

$$\text{Holding 20\%} \quad = 7.30 \quad \text{Baht / piece / 8months}$$

$$= 0.91 \quad \text{Baht / piece / month}$$

Table 4.3 Holding Cost (HC)

No.	Description	Import	Local	Remark
1	Plastic	0.91	0.54	Baht/piece/month
2	Remote	3.00	2.00	Baht/piece/month
3	Copper	8.00	8.00	Baht/kgs/month
4	Motor	10.00	7.00	Baht/piece/month

4.4.3 Variable Cost (VC): the unit variable cost of the item. This is not the selling price of the item, in terms of raw materials and value added through processing and assembly operations. The dimensions are Baht / item.

4.4.4 Unit Cost (UC): is average the unit price calculated by one item.

4.4.5 Demand (D): define on average sale report each month multiply to average quantity usage by item each month and got quantity usage by batch size for each model. (the demand rate of the item, in unit / unit time)

- The order quantity need not be an integral number of units.
- The unit variable cost does not depend on the replenishment quantity; in particular, there are no discount in either the unit purchase cost or unit transportation cost.
- The replenishment lead time is of zero duration; extension to a know non-zero duration creates no problem.
- No shortage are allowed.
- The entire order quantity is delivery at the same time.
- The average total inventory cannot exceed a certain baht value.
- The lead time (T) : define on the raw materials each vendor and agreement on the condition with suppliers and buyer their must follow up on the contract.

4.5 EOQ calculation

After ABC analysis was determined, the next step is to analyze the data and identify the most suitable order quantity. The Air-conditions product of the company can be divided into two categories, Completed Built-in Unit (CBU) and Semi Knock-Down unit (SKD). This research focused on key raw materials such as plastic, remote control, copper and motor. The steps are as below;

4.5.1 Calculate import plastic (for Completed Built-in Unit; CBU)

The variables for calculating imported plastic are listed below;

D = 56,000 Units / month

UC = 37 Baht / unit

RC = 16,000 Baht / order

HC = 0.91 Baht/piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2 * RC * D}{HC}}$$

$$Qo = \sqrt{\frac{2 * 16000 * 56000}{0.91}} = 44{,}376 \text{ Units}$$

- Optimal cycle length

$$To = \sqrt{\frac{2 * RC}{D * HC}}$$

$$To = \sqrt{\frac{2 * 16000}{56000 * 0.91}} = 0.79 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2*16000*0.91*56000} \quad = 40{,}382 \text{ Baht / month}$$

- Optimal total cost

$$TCo = UC * D + VCo$$

$$TCo = 37*56000 + 40382 \quad = 2{,}112{,}382 \text{ Baht / month}$$

4.5.2 Calculate domestic plastic (for Completed Built-in Unit; CBU)

The variables for calculating domestic plastic are listed below

D = 1,440 Unit / month

UC = 23 Baht / unit

RC = 1,500 Baht / an order

HC = 0.54 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2*RC*D}{HC}}$$

$$Qo = \sqrt{\frac{2*1500*1440}{0.54}} \quad = 2{,}828 \text{ Units}$$

- Optimal cycle length

$$To = \sqrt{\frac{2*RC}{D*HC}}$$

$$To = \sqrt{\frac{2*1500}{1440*0.54}} \quad = 1.98 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2*RC*HC*D}$$

$$VCo = \sqrt{2*1500*0.54*1440} \quad = 1,527 \text{ Baht / month}$$

- Optimal total cost

$$TCo = UC * D + VCo$$

$$TCo = 23*1440 + 1,527 \quad = 34,647 \text{ Baht / month}$$

4.5.3 Calculation of imported plastic (for Semi Knock-Down unit; SKD)

The variables for calculating imported plastic are listed below;

D = 112,500 Unit / month

UC = 37 Baht / unit

RC = 16,000 Baht / an order

HC = 0.91 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2*RC*D}{HC}}$$

$$Qo = \sqrt{\frac{2*16000*112500}{0.91}} \quad = 62,897 \text{ Units}$$

- Optimal cycle length

$$To = \sqrt{\frac{2*RC}{D*HC}}$$

$$To = \sqrt{\frac{2*16000}{112500*0.91}} \quad = 0.56 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2 * 16000 * 0.91 * 112500} \quad = 57{,}236 \text{ Baht / month}$$

- Optimal total cost

$$TCo = UC * D + VCo$$

$$TCo = 37 * 112500 + 57236 \quad = 4{,}219{,}736 \text{ Baht / month}$$

4.5.4 Calculate Domestic plastic (Semi Knock-Down unit; SKD)

Remark: there are no plastic purchased domestically for SKD products.

4.5.5 Calculate imported remote control (for Completed Built-in Unit; CBU)

The variables for calculating imported remote control are listed below;

D = 5,600 Units / month

UC = 123 Baht / unit

RC = 25,000 Baht / an order

HC =3 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2 * RC * D}{HC}}$$

$$Qo = \sqrt{\frac{2 * 25000 * 5600}{3}} \quad = 9{,}661 \text{ Units}$$

- Optimal cycle length

$$To = \sqrt{\frac{2 * RC}{D * HC}}$$

$$To = \sqrt{\frac{2 * 25000}{5600 * 3}} \quad = 1.73 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2 * 25000 * 3 * 5600} = 28{,}983 \text{ Baht / month}$$

- Optimal total cost

$$TCo = UC * D + VCo$$

$$TCo = 123 * 5600 + 28983 = 717{,}783 \text{ Baht / month}$$

4.5.6 Calculate domestic remote control (for Completed Built-in Unit; CBU)

The variables for calculating domestic remote control are listed below

D = 1,620 Unit / month

UC = 69 Baht / unit

RC = 1,500 Baht / an order

HC = 2 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2 * RC * D}{HC}}$$

$$Qo = \sqrt{\frac{2 * 1500 * 1620}{2}} = 1{,}559 \text{ Units}$$

- Optimal cycle length

$$To = \sqrt{\frac{2 * RC}{D * HC}}$$

$$To = \sqrt{\frac{2 * 1500}{1620 * 2}} = 0.96 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2 * 1500 * 2 * 1620} \quad = 3{,}118 \text{ Baht / month}$$

- Optimal total cost

$$TCo = UC * D + VCo$$

$$TCo = 69 * 1620 + 3118 \quad = 114{,}898 \text{ Baht / month}$$

4.5.7 Calculate import and domestic remote control (Semi Knock-Down unit; SKD)

Remark: there are no remote control purchased domestically for SKD products.

4.5.8 Calculate imported Copper (for Completed Built-in Unit; CBU)

The variables for calculating imported copper are listed below;

D = 2,100 Units / month

UC = 329 Baht / kgs

RC = 24,000 Baht / an order

HC = 8 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2 * RC * D}{HC}}$$

$$Qo = \sqrt{\frac{2 * 24000 * 2100}{8}} \quad = 3{,}550 \text{ Kgs}$$

- Optimal cycle length

$$To = \sqrt{\frac{2 * RC}{D * HC}}$$

$$To = \sqrt{\frac{2 * 24000}{2100 * 8}} \quad = 1.69 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2 * 24000 * 8 * 2100} \quad = 42{,}933 \text{ Baht/month}$$

- Optimal total cost

$$TCo = UC * D + VCo$$

$$TCo = 329 * 2100 + 42933 \quad = 733{,}833 \text{ Baht/month}$$

4.5.9 Calculate domestic copper (Completed Built-in Unit; CBU)

The variables for calculating domestic copper are listed below;

D = 180 Units / month

UC = 308 Baht / kgs

RC = 1,500 Baht / an order

HC = 8 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2 * RC * D}{HC}}$$

$$Qo = \sqrt{\frac{2 * 1500 * 180}{8}} \quad = 260 \text{ kgs}$$

- Optimal cycle length

$$To = \sqrt{\frac{2 * RC}{D * HC}}$$

$$To = \sqrt{\frac{2 * 1500}{180 * 8}} \quad = 1.44 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2 * 1500 * 8 * 180} \quad = 2{,}078 \text{ Baht / month}$$

- Optimal total cost

$$TCo = UC * D + VCo;$$

$$TCo = 308 * 180 + 2078 \quad = 57{,}518 \text{ Baht / month}$$

4.5.10 Calculate import and domestic copper (Semi Knock-Down unit; SKD)

Remark: there are no copper purchased domestically for SKD products.

4.5.11 Calculate import motor (for Completed Built-in Unit; CBU)

The variables for calculating imported motor are listed below;

D = 1,400 Unit / month

UC = 403 Baht / unit

RC = 24,000 Baht / an order

HC = 10 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2 * RC * D}{HC}}$$

$$Qo = \sqrt{\frac{2 * 24000 * 1400}{10}} \quad = 2{,}592 \text{ Units}$$

- Optimal cycle length

$$To = \sqrt{\frac{2 * RC}{D * HC}}$$

$$To = \sqrt{\frac{2 * 24000}{1400 * 10}} \quad = 1.85 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2 * 24000 * 10 * 1400} \quad = 25{,}923 \text{ Baht / month}$$

- Optimal total cost

$$TCo = UC * D + VCo;$$

$$TCo = 403 * 1400 + 25923 \quad = 590{,}123 \text{ Baht / month}$$

4.5.12 Calculate domestic motor (for Completed Built-in Unit; CBU)

The variables for calculating domestic motor are listed below;

D = 180 Unit / month

UC = 286 Baht / unit

RC = 1,500 Baht / an order

HC = 7 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2 * RC * D}{HC}}$$

$$Qo = \sqrt{\frac{2 * 1500 * 180}{7}} \quad = 278 \text{ Units}$$

- Optimal cycle length

$$To = \sqrt{\frac{2 * RC}{D * HC}}$$

$$To = \sqrt{\frac{2 * 1500}{180 * 7}} \quad = 1.54 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2 * 1500 * 7 * 180} \quad = \ 1{,}944 \text{ Baht / month}$$

Optimal total cost

$$TCo = UC * D + VCo$$

$$TCo = 308 * 180 + 1944 \ = \ 53{,}424 \text{ Baht / month}$$

4.5.13 Calculate imported motor (for Semi Knock-Down unit; SKD)

The variables for calculating imported motor are listed below;

D = 2,500 Unit / month

UC = 403 Baht / unit

RC = 24,000 Baht / an order

HC = 10 Baht / piece / month

- Optimal order size, or economic order quantity (EOQ)

$$Qo = \sqrt{\frac{2 * RC * D}{HC}}$$

$$Qo = \sqrt{\frac{2 * 24000 * 2500}{10}} \quad = 3{,}464 \text{ Units}$$

- Optimal cycle length

$$To = \sqrt{\frac{2 * RC}{D * HC}}$$

$$To = \sqrt{\frac{2 * 24000}{2500 * 10}} \quad = 1.39 \text{ Month}$$

- Optimal variable cost

$$VCo = \sqrt{2 * RC * HC * D}$$

$$VCo = \sqrt{2 * 24000 * 10 * 2500} \quad = 34{,}641 \text{ Baht / month}$$

- Optimal total cost

$$TCo = UC * D + VCo;$$

$$TCo = 403 * 2500 + 34641 \quad = 1{,}042{,}141 \text{ Baht / month}$$

4.5.14 Calculate Local motor (for Semi Knock-Down unit; SKD)

Remark: there are no motor purchased domestically for SKD products.

4.6. Analysis key raw material in domestic and imported

4.6.1 Analysis key raw material in domestic: From historical data, we found that Aircon mfg must follow up on the condition in Table 4.4 after commitment in the contract. It would include preparation of raw materials per order, schedule delivery, transportation, lead time, credit term and minimum order per lot size. The purchasing conditions of key raw materials are defined in Table 4.4 below;

Table 4.4 Condition Ordering of Domestic Supplier

No.	Description	Minimum Order	Lead time	Credit term
1	Plastic	500 sets	3 weeks	30 days
2	Remote	1000 sets	7 weeks	60 days
3	Copper	300 kgs	4 weeks	30 days
4	Motor	500 units	4 weeks	30 days

4.6.2 Analysis of imported plastic: From historical data, we found that Aircon mfg ordered plastic parts 3 shipments per month. On the current deal with the plastic supplier in Taiwan, a minimum order is 45,000 pieces / order, or approximately one 40" container. This has an approximate value about 5,000,000 Baht / shipment. The lead time for ordering plastic parts is 4 weeks, including the work in process, shipping time, and transportation of the goods to the company. In addition the credit term is CFR "Cost and Freight" payment term, and shipped by vessels only.

4.6.3 Analysis of import plastic (for Completed Built-in Unit; CBU): From the calculation of imported plastic for Completed Built-in Unit (CBU). EOQ formula identified to the quantity 44,376 pieces / order, and optimal cycle length 0.80 month/cycle. The economic order size, and cycle length approximate quantity are specified with the supplier. Because Aircon mfg deal with the suppliers for long time and, never change suppliers. This is due to many satisfactory factors such as the quality, service, quick response or responsiveness and, etc. The unit price increased or decreased is dependent on the global economic such as the fuel price. The quantity is associated the data demand in each month.

4.6.4 Analysis of domestic plastic (for Completed Built-in Unit; CBU): From the calculation of domestic plastic for Completed Built-in Unit (CBU). The EOQ formula identified to the quantity 2,828 pieces / order, and optimal cycle length 1.98 month / cycle. The economic order size and cycle length approximate quantity are agreed with the supplier. The quantity is associated the data demand in each month, very easy to follow the raw material and quantity after issued Purchase Order (P/O) to them. Because all suppliers in local has to be dealt with them long time periods. The unit price increased or decreased is depend on the global economic such as the fuel price.

4.6.5 Analysis of import plastic (for Semi Knock-Down unit; SKD): From the calculation of imported plastic for Semi Knock-Down unit (SKD). The EOQ formula identified to the quantity 62,897 pieces / order, and optimal cycle length 0.56 month / cycle. The condition similarly imported plastic for Completed Built-in Unit (CBU).

4.6.6 Analysis of domestic plastic (for Semi Knock-Down unit; SKD)
Remark: there are no plastic purchased domestically for SKD products.

4.6.7 Analysis of import Remote control: From historical data, we found that Aircon mfg ordered remote control, on the current contract to the remote control supplier in Malaysia, and we must follow up on the condition as below;

- Aircon mfg ordered remote control 1 shipment per 3 months
- Shipment by Less Container Load(LCL)
- Minimum order quantity 5,000 pieces / shipment
- Maximum order quantity 20,000 pieces / shipment
- Approximate value cost about 2,800,000 Baht / shipment
- The lead time for ordering remote control is 8 weeks, including the work in process, shipping time, and transportation of the goods to the company
- Shipment depend on the Purchase order (P/O) request
- FOB "Free On Board" payment term

4.6.8 Analysis of import Remote Control (for Completed Built-in Unit; CBU): From the calculation of imported remote control for Completed Built-in Unit (CBU). The EOQ formula identified to the quantity 9,661 pieces / order, and optimal cycle length 1.73 month / cycle. The economic order size, and cycle length approximate quantity are agreed with the supplier. Because the remote controls are not heavy, they can be delivered by air freight, and by sea freight, which is more feasible for large order quantity. Aircon mfg are agreed with the supplier for long time and, never change suppliers. This is due to many satisfactory factors such as the quality, service, quickly respond the material has a problem and, etc. The unit price increased or decreased is depend on the global economic such as the fuel price. The quantity is associated the data demand in each month.

4.6.9 Analysis of domestic remote control (for Completed Built-in Unit; CBU): From the calculation of domestic remote control for completed built-in unit (CBU). The EOQ formula identified to the quantity 1,559 pieces / order, and optimal cycle length 0.96 month / cycle. The economic order size, and cycle length shown approximate quantity is deal with to the supplier. The quantity is associated the data demand in each month, and very easy to follow the quantity after issued Purchase Order (P/O) to them. Because all the supplier in local has to be deal with them long time periods. The unit price increased or decreased is depend on the global economic such as the fuel price.

4.6.10 Calculate import and domestic remote control (Semi Knock-Down unit; SKD) Remark: there are no remote control purchased domestically for SKD products.

4.6.11 Analysis of imported Copper: On the current deal with the copper supplier in Malaysia, from historical data, Aircon mfg order copper 1 shipment per 2 months, a minimum ordered is quantity approximate 2,000 kilogram / order and, a maximum ordered is quantity approximate 8,000-10,000 kilograms / order, or approximately one 20' container. This has an approximate value about 2,600,000 Baht / shipment. The lead time for ordering copper is 5 weeks, including the work in process, shipping time, and transportation of the goods to the company. In addition the credit term is FOB "Free On Board" payment term, and shipped by vessels only.

4.6.12 Analysis of import Copper (for Completed Built-in Unit; CBU): From the calculation of imported copper for completed built-in unit (CBU). The EOQ formula identified to the quantity 3,550 kilogram / order, and optimal cycle length 1.69 month / cycle. The economic order size, and cycle length shown approximate quantity is deal with the supplier.

4.6.13 Analysis of domestic copper (for completed built-in unit; CBU): From the calculation of domestic copper for completed built-in unit (CBU). The EOQ formula identified to the quantity 260 kilograms / order, and optimal cycle length 1.44 month / cycle. The economic order size, and cycle length shown approximate quantity are agreed with the supplier. The quantity is associated the data demand in each month, and very easy to follow the quantity after issued Purchase Order (P/O) to them. The quantity of copper dependent on the weight of each roll. The company could manage the quantity from EOQ suggestion, because the agreement and long-term relationship with the supplier allows such change. The unit price increased or decreased is dependent on the global economic such as the fuel price.

4.6.14 Analysis of import and domestic copper (Semi Knock-Down unit; SKD)
Remark: there are no copper purchased domestically for SKD products.

4.6.15 Analysis of import Motor: From historical data, we found that Aircon mfg ordered motor, on the current contract to motor supplier in China, and the company must follow up on the condition as below;

- Aircon mfg ordered motor 1 shipment per 4 months
- Shipment by a container 20"
- Minimum order quantity 2,000 units / shipment
- Maximum order quantity 8,000 units / shipment
- Approximate Value cost about 2,500,000 Baht / shipment
- The lead time for ordering motor is 12 weeks, including the work in process, shipping time, and transportation of the goods to the company
- Shipment depend on the Purchase order (P/O) request.
- FOB "Free On Board" payment term

4.6.16 Analysis of import Motor (for Completed Built-in Unit; CBU): From the calculation of imported Motor for completed built-in unit (CBU). The EOQ formula identified to the quantity 2,592 units / order, and optimal cycle length 1.85 month / cycle. The economic order size, and cycle length shown approximate quantity are agreed with the supplier. Because Aircon mfg deal with the supplier for long time period and, never change suppliers. For the many reasons Aircon mfg never change the vendor such as the quality, service, quickly respond the material has a problem and, etc. The unit price increased or decreased is dependent on the global economic such as the fuel price. The quantity is associated the data demand in each month.

4.6.17 Analysis of imported motor (for semi knock-down unit; SKD): From the calculation of imported Motor for completed built-in unit (CBU). The EOQ formula identified to the quantity 3,464 units / order, and optimal cycle length 1.39 month / cycle. The economic order size, and cycle length shown approximate quantity are agreed with to the supplier. Because Aircon mfg deal with the supplier for long time period and, never change suppliers. For the many reasons Aircon mfg never change the vendor such as the quality, service, quickly respond the material has a problem and, etc. The unit price increased or decreased is dependent on the global economic such as the fuel price. The quantity is associated the data demand in each month.

4.6.18 Analysis of domestic motor (for semi knock-down unit; SKD): From the calculation of imported Motor for completed built-in unit (CBU). The EOQ formula identified to the quantity 278 units / order, and optimal cycle length 1.54 month / cycle. The economic order size, and cycle length shown approximate quantity. From EOQ data it is recommend that the quantity per lot size is less than the quantity in the condition (Table 4.4). At this point Aircon mfg have to issue a purchase order 500 pieces / lot size because the quantity per lot size dependent on the contract.

Table 4.5 EOQ calculation of Key raw materials

Description	Imported Domestic	EOQ (PCS/Kgs)	To (Month)	VC (Baht / month)	TCo (Baht / Month)
Plastic (CBU)	Imported	44,376.00	0.80	40,382.00	2,112,382.00
Remote (CBU)	Imported	9,661.00	1.73	28,983.00	717,783.00
Copper (CBU)	Imported	3,550.00	1.69	42,933.00	733,833.00
Motor (CBU)	Imported	2,592.00	1.85	25,923.00	590,123.00
Plastic (CBU)	Domestic	2,828.00	1.98	1,527.00	34,647.00
Remote (CBU)	Domestic	1,559.00	0.96	3,118.00	114,898.00
Copper (CBU)	Domestic	260.00	1.44	2,078.00	57,518.00
Motor (CBU)	Domestic	278.00	1.54	1,944.00	53,424.00
Plastic (SKD)	Imported	62,897.00	0.56	57,236.00	4,219,736.00
Motor (SKD)	Imported	3,464.00	1.39	34,641.00	1,042,141.00

Remark; To = Optimal cycle length

VC = Variable cost

TCo = Optimal total cost

Table 4.5 summarizes EOQ calculations of key raw materials. It can be seen that, from the calculations, these materials should be procured at different quantities, and different frequencies. For example, imported plastic for Completed Built-in Unit (CBU) can be ordered for the quantity of 44,376 pieces / order, and the company can place an order once every 0.80 month.

4.7 Analysis of Economic Order Quantity (EOQ) and Current Inventory

Based on the *ABC* (class *A*) and EOQ analysis after implementing proposed inventory ordering policy continuous review inventory for class- *A* is identify to plastic, remote control, copper and motor. It is worth noting that the *ABC* (class *A*) and EOQ are favorably considered an improvement on quantity and value in the inventory and cost reduction in the inventory. It is hoped that they may be used as a guideline for key raw materials inventory management. 8-months inventory data of the 4 key materials are calculated for their monthly average values. These numbers are then compared with the EOQ values, which have been adjusted to monthly values. The results are compared in Figure 4.1 below.

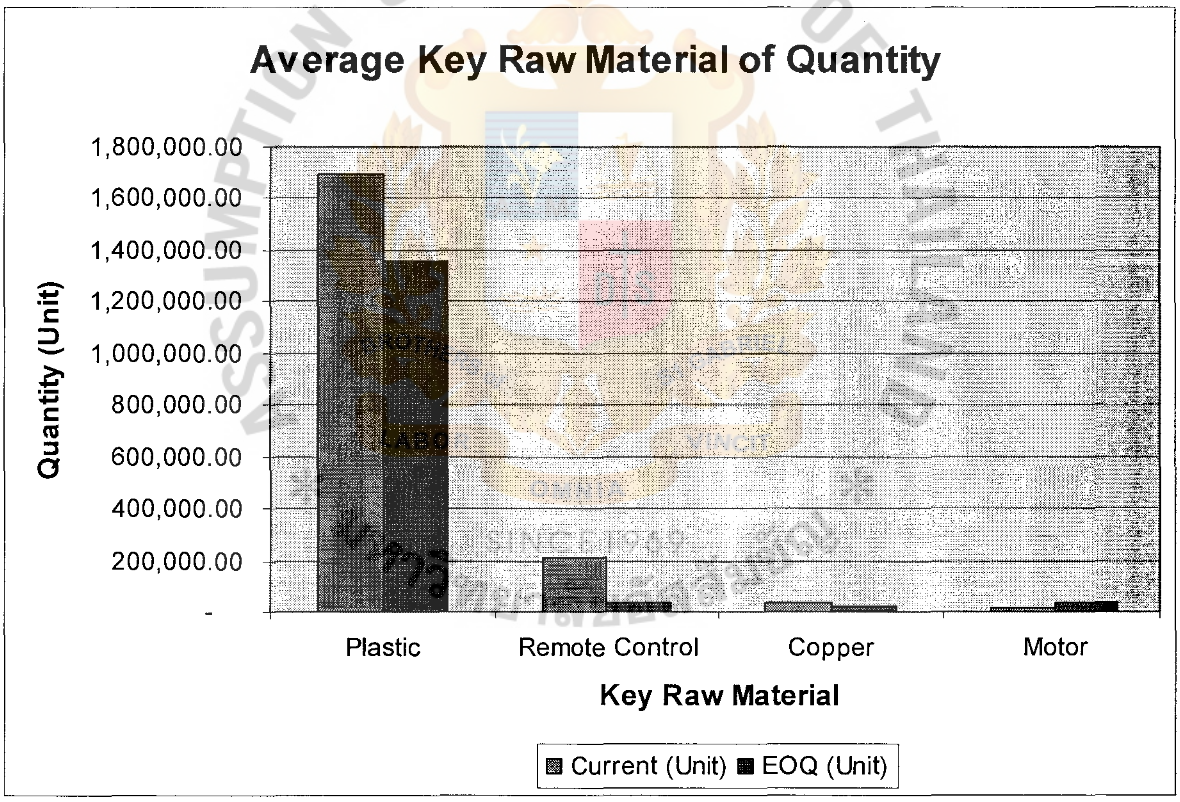


Figure 4.1 Average Key Material of Quantity 2008 Comparison

Table 4.6 Average Key Material of Quantity 2008 Comparison

No.	Description	Current (Unit)	EOQ (Unit)	Difference (Unit)
1	Plastic	1,697,333.00	1,353,823.00	-343,510.00
2	Remote	212,950.00	35,388.00	-177,562.00
3	Copper	36,493.00	18,248.00	-18,245.00
4	Motor	12,242.00	32,588.00	20,346.00

Figure 4.1,and Table 4.6, it can be seen that the total EOQ quantity of key raw materials is lower than actual orders from 8 months, but the quantity of motor is higher than plastic, motor and copper. At this point the total ordering quantity from EOQ data is higher than the total quantity of motor in Figure 4.1, and Table 4.6. After further enquiries with the company, the explanations are that the company is aware of its high inventory, and starting to react by ordering lower quantities. However, this reaction was again based on the subjective judgment, without any fact or supporting analysis. Thus, only Motor received lower ordering quantity, but not the other three main materials.

Figure 4.1, and Table 4.6 illustrates key raw materials kept in inventory, these may be considered as "AS IS" and "TO BE" of key raw materials, based on EOQ analysis and result. The parameter involved in a control policy are the interval between orders and the quantity lot size. EOQ identifies as the most suitable order quantity. This research EOQ can solve problem key raw materials for improved are minimized cost, reduce lot size, minimized order quantity, such as total plastic can reduce the quantity approximately 343,510 Pieces / 8 months after implement the proposed inventory quantity system.

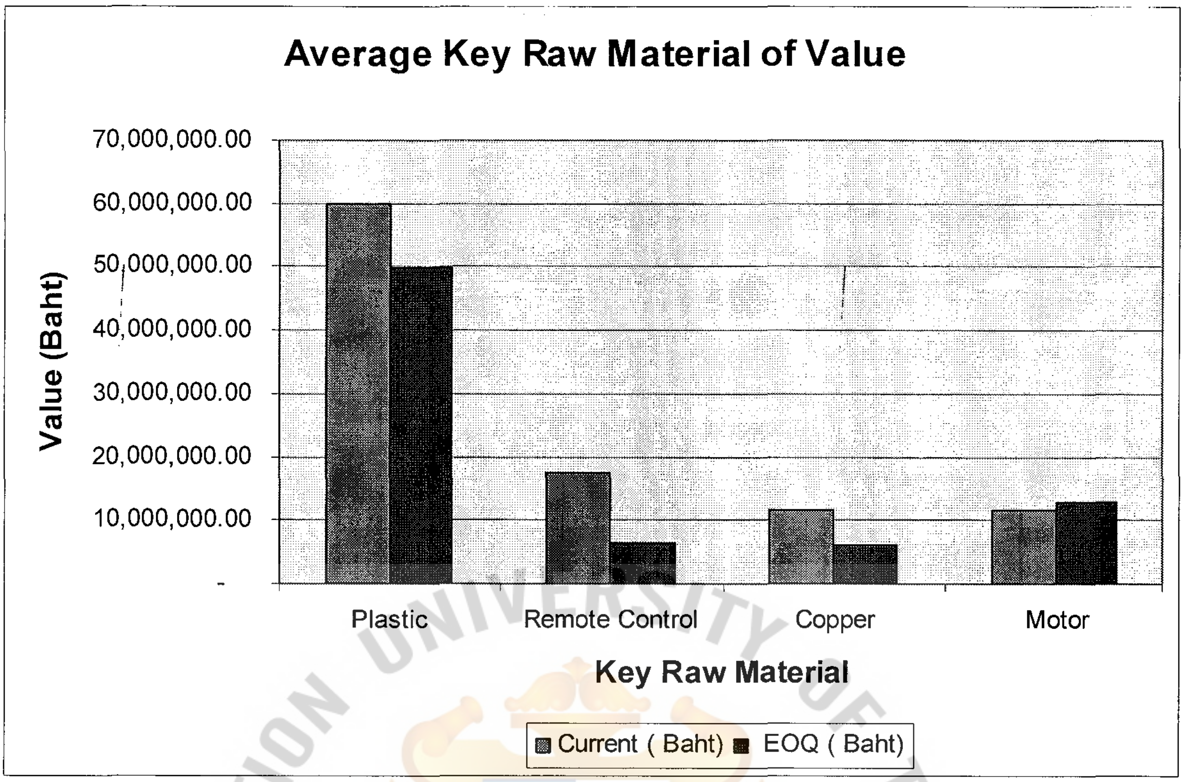


Figure 4.2 Average Key Raw Materials of Value 2008 Comparison

Table 4.7 Average Key Raw Materials of Value 2008 Comparison

No.	Description	Current (Baht)	EOQ (Baht)	Difference (Baht)
1	Plastic	59,993,640.00	49,929,990.00	-10,063,650.00
2	Remote	17,306,365.00	6,391,467.00	-10,914,898.00
3	Copper	11,680,659.00	5,973,645.00	-5,707,014.00
4	Motor	11,594,799.00	12,964,599.00	1,369,800.00

Figure 4.2, and Table 4.7 shown that motor is high Baht value after analysis of key raw materials. The reason similarly with motor of quantity is shown in figure 4.1.

Figure 4.2, and Table 4.7 illustrates key raw materials kept in inventory, it shown to "AS IS" and "TO BE" of key raw materials are based on EOQ analysis and result. The analysis of description suggests key raw materials of inventory suitable order quantity and lot size. In this research, EOQ can be applied to the key raw materials of control used for an item and the developed, improvement in performance likely to be achieved. It is seen that the total plastic can reduce the value approximately 10 millions Baht / pieces / 8 months after implement the proposed inventory value system.

4.8 Implications from the case study

From the results above, ABC (Class *A*), and Economic order quantity (EOQ) concepts are considered as a major part of inventory-improvement proposal, for the Managing Director of Aircon mfg Co., Ltd. To improve high inventory value of key items, by using the ABC (Class *A*), and EOQ concept, the steps are defined as below;

- ABC analysis
    1) Determine cumulative percentage for raw materials and based on the total number of raw materials and Baht value respectively.
    2) Usually based on the total purchase expenditure or usage value for each item long period.
    3) If inventory levels can be reduced for class *A* item, it will result in a significant reduction in inventory.

- EOQ analysis
    1) Derive and use an economic order quantity (EOQ)
    2) Demonstrated that an optimal order size could be calculated to minimize associated costs.
    3) Describe some limitations of the EOQ

In this study, ABC (Class *A*) and Economic order quantity (EOQ) concept can developed an improvement quantity and value. It is shown the efficiency and efficacy of the raw materials flow can substantially influence cost and revenue generation.

- Quantity Improvement

From EOQ analyses and result of key raw materials such as total plastic before proposed model is approximately 1.7 millions pieces / 8 months, it can minimize approximately 1.4 millions pieces / months.

- Value Improvement

Inventory value of key raw materials such as total plastic before implement the proposed model is 60 millions Baht / 8 months, it can reduce approximately to 50 millions Baht / months.

This research has sought to present the managing director of Aircon mfg Co.,Ltd appreciation of way in which savings can be achieved through inventory management based on parameter in the methodology used in this case study. The emphasis has been on inventory control designed to take account of relevant analytical procedures. The analysis which has been outlined, and in some instances developed an improvement quantity and value in the inventory.

After this research has been agree by the managing director of Aircon mfg Co.,Ltd. This research suggested at the beginning of these notes that inventory was kept for long period, therefore there is a need to develop procedures for reviewing important inventory items, in order to achieve optimal level. In this study, *ABC* (class *A*) analysis and EOQ methods involving a mix of analysis and judgment. Based on the result, after implementing proposed inventory ordering policy continuous review system of key raw materials for *ABC* (Class *A*) and EOQ, the inventory level of key raw materials active items shown in Figure 4.1, 4.2 and Table 4.5, 4.6.

The proposed model is favorably considered an improvement on inventory level and cost reduction in studied case. It is enabled to use as a guideline for improving purchasing system, demand analysis, demand forecasting, delivery lead time for the case study inventory management.

Chapter 5
Conclusion

5.1 Introduction

This research attempted to address the inventory management issue by a case study of an air-conditioning manufacturer in Thailand. The preliminary study showed that the company held many items in the warehouse, and thus might be carrying an unnecessary high value of cash-equivalent assets. The preliminary study also revealed that the company often based its purchasing quantities by using subjective judgement, not corresponding to actual production requirements. All of these led to carrying inventory much higher than required. Therefore, the researcher attempted to use analytical tools, such as statistical analyses, ABC analysis, EOQ, cycle time, together with qualitative description of practical operating conditions. The subsequent sections will address key conclusions.

5.2 Quantity and Value Improvement

The results show that inventory of this case study could be improved in many ways. By considering the approach of ABC classification and subsequently EOQ calculations, the quantities of key materials can be managed more appropriately. Also taking into consideration practical conditions such as contract agreements with existing suppliers and transportation, this research attempts to provide a practical guideline for improvement, which could save this company a lot of money. For example, Plastic quantity can be reduced from 1.70 million pieces in 8 months, down to 1.40 millions pieces for the same period, without affecting the ability to respond to customers. If the average cost per plastic is 10.06 million Baht, this is an equivalent to about 10.00 million Baht in saving.

5.3 Validity and Practicality of Results

The researcher presented a practical proposal for inventory improvement, which was agreed by the Managing Director of Aircon Mfg Co., Ltd.. ABC and EOQ analyses can help in reducing unnecessary quantities and thus the value of the inventory. These tools could be integrated into the inventory management process, as well as the procurement process. In addition, the results of this research could be used to guide a systematic reduction of current unnecessary inventory.

5.4 Limitation to the study

This research framework developed a comparison between key actual raw materials and estimated quantity of raw materials. The assumptions are related to estimations and the result confirmed the objective of the research, scope of study, and problem analysis.

5.5 Conclusion

This research explains key raw materials in the company by the application of *ABC* (class *A*) and EOQ. It has considered the parameters for the minimum quantity required for replenishing raw materials, responding to the customer demand, and which sufficiently support the production line. In fact, this research approach can be considered a common practice among many companies, where some of their inventory items are purchased according to *ABC* and EOQ. These results are based on the analysis of direct and variable inventory costs associated with the two inventory-management concepts. In addition, the benefits associated with the proposed inventory implementation of *ABC* and EOQ concepts may exceed the benefits of saving in inventory costs.

5.6 Recommendation for Future Research

This study of the ABC and EOQ classification system in the research, shows that it can reduce inventory costs. Other interesting techniques which should be studied include demand forecasting and Min-Max inventory for implementation. This technique means the company will set up the ordering demand each month from the customer as the guideline to make a forecast and set up min–max in inventory management. The purchasing department can issue accurate quantities to suppliers and meet the time line of the production plan. However a just-in-time concept could be a future plan for the company to study and implement for a more effective cost reduction concept.

Bibliography

Anupindi, R., Chopra, S., Deshmukh, S.D., Van Mieghem, J.A., and Zemel, E. (2006) "Managing Business Process Flows" (2nd edition), Pearson, New Jersey.

Ballou, R. H., (2004) "Business/Logistics and Supply Chain Management, Planning, Organizing, and Controlling the Supply Chain" (5th edition), Pearson, New Jersey.

Buxey, Geoff., (2006) "Reconstructing inventory management theory" International Journal of Operation & Production Management, Vol. 26, no. 9, pp. 996-1012.

Cohen, S. and Roussel, J. (2005) "Strategic Supply Chain Management, The five Disciplines for Top Performance", McGraw-Hill, New York.

Emmett, S., (2005) "Excellence in Warehouse Management", John Wiley & Sons, England

Grant, L. and Leavenworth, S. (1996) "Statistical Quality Control", (7th edition), United States

Gupta, O.K., (1987) " an improved procedure for economic order quantity with all unit price discounts discount", Indian Institute of Management, pp. 79-83

Howard, K., (2007) "Inventory Management", University of Bradford Management Centre., pp. 81-116, Emerald

Lau, R.S.M., Xie, J., and Zhao, X., (2008) "effects of inventory policy on supply chain performance: a simulation study of critical decision parameters", Computer & industrial engineering, pp. 620-633, Elsevier

Monczka, R., Trent, R., and Handfield, R. (2005) "Purchasing and Supply Chain Management", (3rd edition), Thomson, South-Western.

Ouyang, L. Y., Teng, J. T., Goyal S. K., and Yang, C. T., (2009) "an economic order quantity model for deteriorating items with partially permissible delay in payments linked to order quantity", European Journal of Operational Research, Vol. 194, pp. 418-431, Elsevier

Peterson, R., and Silver, E. (1979) "Decision Systems for Inventory Management and Production Planning", John Wiley & Sons, New York.

Render, B., Stair Jr., R.M., and Hanna, M.E. (2006) "Quantitative analysis for management", Pearson, New Jersey.

Sheldon, D. H. (2004). Achieving Inventory Accuracy: A Guide to Sustainable Class *A* Excellence in 120 days, J. Ross, Florida.

Silver, E., Pyke, D., and Peterson, R. (1998) Inventory Management and Production Planning and Scheduling, (3^{td} edition), John Wiley & Son, New York.

Simchi-levi, D., Kaminsky, P., and Simchi-levi, E. (2003) Designing & Managing The Supply Chain, (2^{nd} edition), McGraw-Hill, New York.

Teng, J. T., (2008) A simple method to compute economic order quantities, European Journal of Operational Research, article in press, Elsevier

Tersine, R.J. (1994). Principles of Inventory and Materials Management, (4^{th} edition), Englewood Cliffs, New Jersey

Waters, C.D.J., (1992). Inventory Control and Management, John Wiley & Sons.

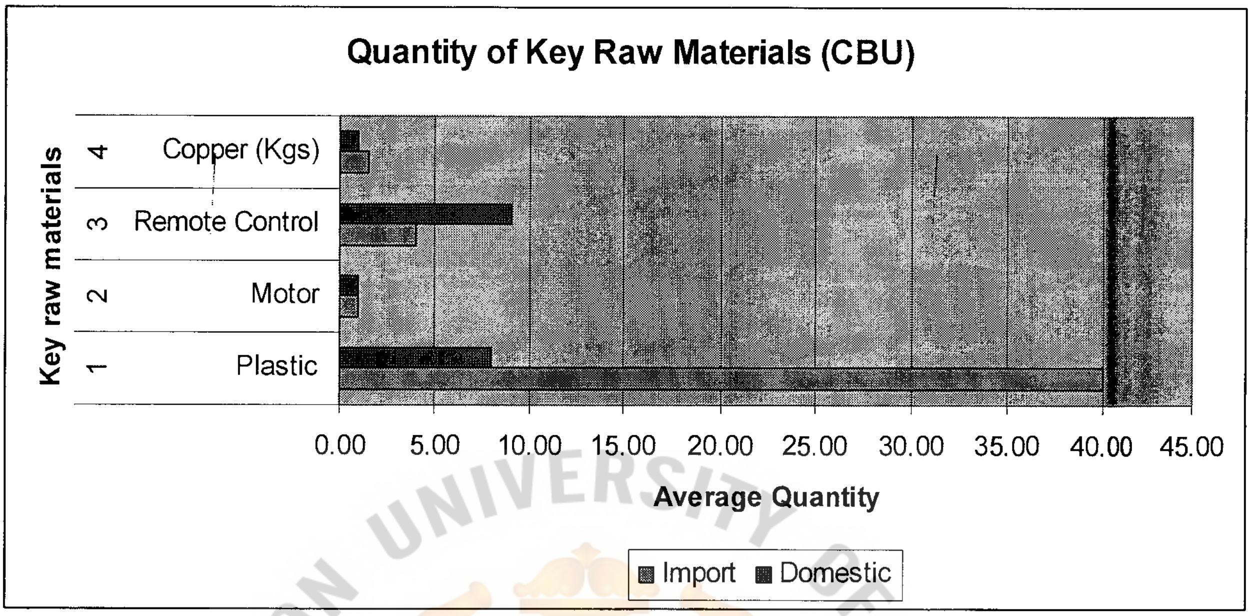
Appendices

Appendix 1: Sale quantity of Air-conditioners in 8 months (January-August 2008)

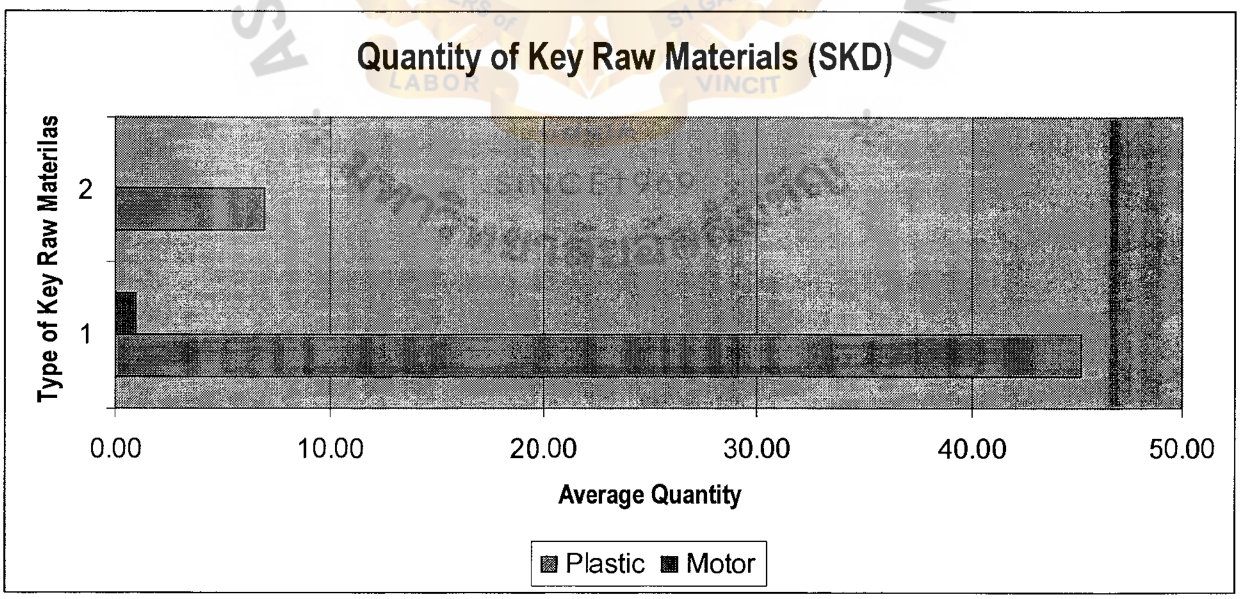
No.	Month	Sale Quantity 2008			Remark
		CBU	SKD	Total	
1	Jan	646.00	3,811.00	4,457.00	Exported & Domestic
2	Feb	1,897.00	3,260.00	5,157.00	Exported & Domestic
3	March	2,210.00	3,196.00	5,406.00	Exported & Domestic
4	April	1,374.00	961.00	2,335.00	Exported & Domestic
5	May	1,880.00	5,110.00	6,990.00	Exported & Domestic
6	June	23.00	333.00	356.00	Exported & Domestic
7	July	1,793.00	709.00	2,502.00	Exported & Domestic
8	Aug	2,654.00	2,283.00	4,937.00	Exported & Domestic
Total		12,477.00	19,663.00	32,140.00	Exported & Domestic

Appendix 2: Quantity of Key Raw Materials

Quantity of Key Raw Materials of Completed Built-in Units (CBU)

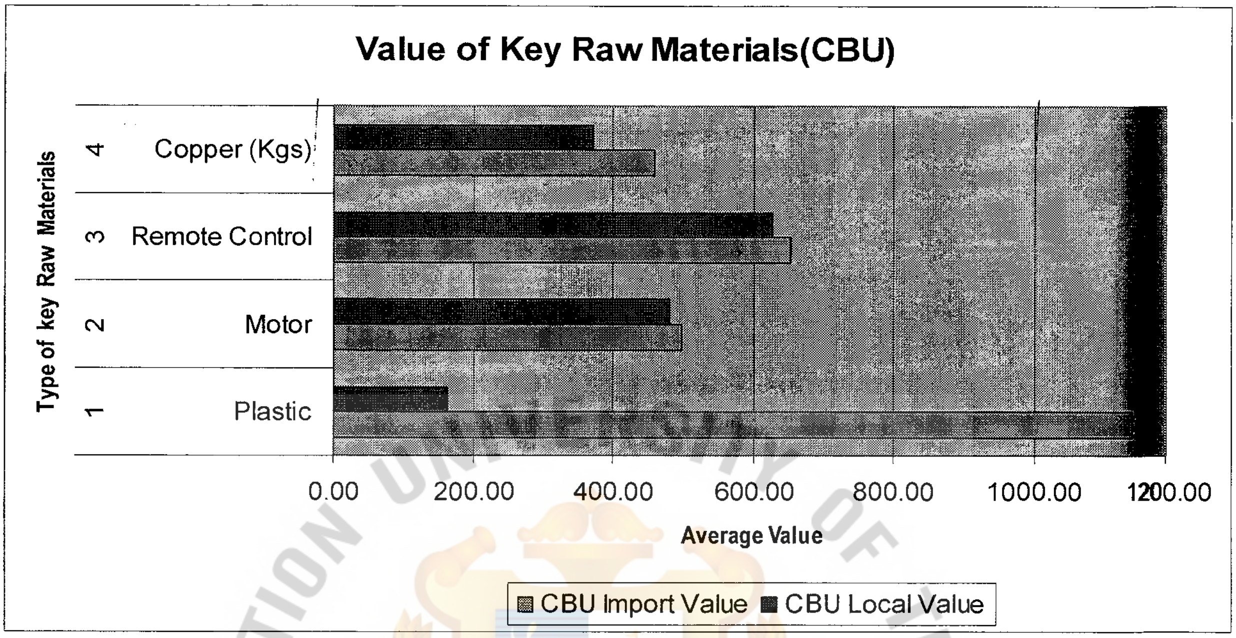


Quantity of Key Raw Material of Semi Knock Units (SKD)

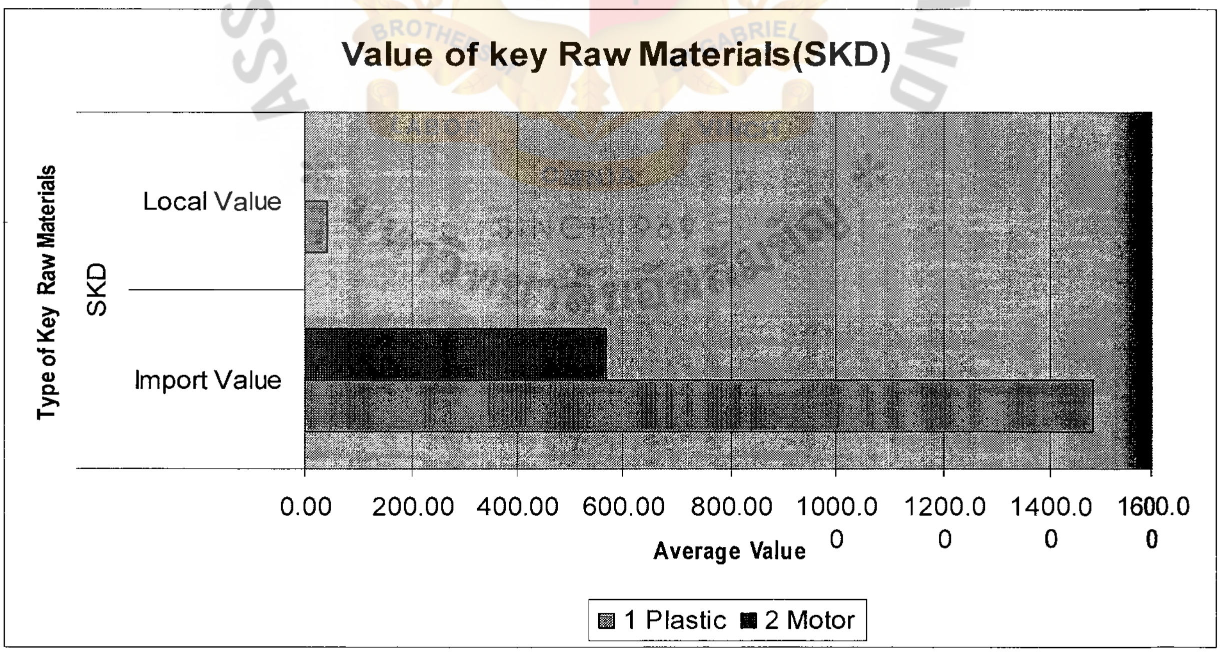


Appendix 3: Value of Key Raw Materials

Value of Key Raw Material of Completed Built-in Units (CBU)



Value of Key Raw Material of Semi Knock Units (SKD)



Appendix 4: Domestic of Key Raw Materials 2008

4.1) Domestic of Copper

Domestic Copper			
Code No.	Description	'Q'ty Received	Unit
CT16	COPPER TUBE 3/16 x 0.60 x 6M (H)	367.39	Kgs
CT01	COPPER TUBE 5/16 x 0.50 x 6M (H)	301.40	Kgs
CT04	COPPER TUBE PLAIN 3/8 x0.30mm (9.52mm) (RoHS)	10,025.30	Kgs
CT06	COPPER TUBE (LWC) 3/16 x 0.61 mm. THK (RoHS)	576.70	Kgs
CT0678	COPPER TUBE DIA 1 foot foot X 1.02MM.	300.70	Kgs
CT092	COPPER TUBE 5/8 x 0.61 mm x 0.25KG (RoHS)	746.10	Kgs
CT096	COPPER TUBE 3/8 x 0.61 mm (LWC) (RoHS)	999.70	Kgs
CT098	COPPER TUBE 5/16 x 0.61 mm (LWC) (RoHS)	200.00	Kgs
CT099	COPPER TUBE 1/2 x 0.61 mm (LWC) (RoHS)	246.30	Kgs
CT14	COPPER TUBE(STRAIGTH)3/4 X1.02mmX6m (RoHS)	1,206.00	Kgs
CT15	COPPER TUBE(STRAIGTH)7/8 X1.02mmX6m (RoHS)	603.30	Kgs
	Total Quantity	15,572.89	Kgs

4.2) Domestic of Motor

Domestic Motor			
Code No.	Description	Q'ty Received	Unit
EX0501	MOTOR (FASCO) 6755EVS-A13 W/RUBBER FOR AERMEC	1,400.00	PCS
	Total Quantity	1,400.00	PCS

4.3) Domestic of Plastic

Domestic Plastic			
Code No.	Description	Q'ty Received	Unit
P210	CONTROL BOX (STD) WQ-09/12/18S (RoHS)	4,000.00	PCS
P230	DECOR PANEL WQ-09/12S (RoHS)	1,000.00	PCS
P502	DECOR PANEL WJ-09/12S (RoHS)	1,970.00	PCS
P503	FRAME GRILL WQ-09/12S (RoHS)	2,940.00	PCS
P504-1	AIR FILTER WQ-09/12S ANTI BACTRIA	5,857.00	PCS
P506	DRAIN PAN WQ-09/12S (RoHS)	2,800.00	PCS
P507	HORIZONTAL LOUVER WQ-09/12S (RoHS)	3,050.00	PCS
P508	BASE PAN WQ-09/12S (RoHS)	2,950.00	PCS
P71	CONNECTOR DRAIN HOSE	22,400.00	PCS
P205	DRAIN PAN STRIP (RoHS)	1,300.00	PCS
P652	DRAIN PAN STRIP 1160 mm (RoHS)	8,200.00	PCS
P70	DRAIN HOSE FOR WQ18/24/30/36/42	26,300.00	PCS
PP0218	DRAIN HOSE ID16 mm x L 785 mm,	3,300.00	PCS
PP0501	DRAIN PAN STRIP MODEL 16V/REV. A	1,000.00	PCS
P398	RAIL FILTER RH CHARCOAL FILTER WN/WQ (RoHS)	6,000.00	PCS
P399	RAIL FILTER LH CHARCOAL FILTER WN/WQ (RoHS)	6,000.00	PCS
P682	PLASTIC SPACER /REV.B	7,500.00	PCS
PP0648	CLIP- UV LAMP HOLDER-2 WN-36 (RoHS) /Rev.C	18,000.00	PCS
PP0666	IR PLATE COVER	1,000.00	PCS
PP0667	LAMP PLATE COVER	1,000.00	PCS
P204	DRAIN PAN (RoHS)	1,450.00	PCS
P209	HORIZONTAL LOUVER WQ-12/18S (RoHS)	1,690.00	PCS
P211	FRAME GRILLE WQ,WJ-12/18S (RAW) (RoHS)	2,080.00	PCS
P215	DECOR PANEL WQ12/18S (RoHS)	500.00	PCS
P501	DECOR PANEL WJ-12/18S (RoHS)	1,500.00	PCS
Total Quantity		133,787.00	PCS

4.4) Domestic of Remote

Domestic Remote			
Code No.	Description	Q'ty Received	Unit
ET0005	REMOTE HANDSET COOL LCD5.3 HOTPOIN	500.00	PCS
ET0006	REMOTE HANSET H/P LCD5.3 HOTPOINT	500.00	PCS
ET0010	WIRE HARNESS FOR DISPLAY BOARD	420.00	PCS
ET0011	WIRE HARNESS FOR DISPLAY BOARD	420.00	PCS
ET0012	ROM WQ-SERIES, WIRELESS, INTRONICS #720264-060	13,700.00	PCS
ET0013	ROM WN/WR, WIRELESS, INTRONICS # 720264-062	800.00	PCS
ET0014	ROM WQR/WNR/WRR/WRM , WIRELESS,	420.00	PCS
ET0017	Display 7-Segment , WQ/WN-36, No UV# A810070-130	300.00	PCS
ET0021	ROM WQ-SERIES, WIRED REMOTE	150.00	PCS
ET080002	Main PCB Common Board LCD6 WQ/WN/WR	250.00	PCS
ET080003	REMOTE HAND SET LCD6 COOL INTRONICS	250.00	PCS
ET080008	DISPLAY BOARD WITH MODULE W/ OUT UV LED	420.00	PCS
ET080013	REMOTE HANDSET COOL, LCD6 V6, INTRONICS	370.00	PCS
ET080017	DISPLAY BOARD 7-SEGMENT WQ/WN-36, NO UV	2,000.00	PCS
ET103	THERMOSTAT SENSOR INTRONIC #C00682-203A	14,800.00	PCS
ET104	WIRE HARNESS FOR LAMP BOARD INTRO	50.00	PCS
ET105	WIRE CONNECT FOR LAMP BOARD TO PCB	50.00	PCS
ET106	FREEZE SENSOR INTRONIC #C00682-508B	14,800.00	PCS
ET108	REMOTE HANDSET COOL W/HOLDER INTRONICS	4,500.00	PCS
ET110	LAMP BOARD WQ18/24 INTRONICS #A810265-100	1,000.00	PCS
ET111	AUXILARY SWITCH INTRONIC # A810266-000	14,750.00	PCS
ET112	WIRE HARNESS FOR LAMPBOARD INTRONICS	16,550.00	PCS
ET113	WIRE HARNESS FOR AUXILARY SWITCH #C00111-002A	14,750.00	PCS
ET133	LAMP BOARD WQ - 36 #A810265-110	13,300.00	PCS
ET134	LAMP BOARD COOL LCD5 INTRONICS	50.00	PCS
ET138	REMOTE HANDSET COOL INTRONIC , LCD5.1	3,900.00	PCS
ET140	REMOTE HANDSET COOL INTRONIC	100.00	PCS
ET142	LAMP BOARD WN-36 INTRONICS #A810265-310	250.00	PCS
ET202	DEICE, EXTENSION WIRE 8M. INTRONICS	5,550.00	PCS
ET203	DEICE SENSOR WIRE PCB SIDE 30 cm. INTRONIC	7,050.00	PCS
ET204	DEICE SENSOR 1 M INTRONICS #C00022-100A	7,250.00	PCS
ET206	REMOTE HANDSET H/C W/HOLDER INTRONICS	5,830.00	PCS
ET221	REMOTE HANDSET H/P INTRONIC LOGO COOLINE	520.00	PCS
ET222	REMOTE HANDSET H/P INTRONIC , LCD5.1	2,200.00	PCS
ET700	Main PCB Common Board H/C & Cool only A810264-130	14,500.00	PCS
ET703	REMOTE HANDSET COOL ONLY LCD 5.1 INTRONIC	300.00	PCS
Total Quantity		162,550.00	PCS

Appendix 5: Imported of Key Raw Materials 2008

5.1) Imported of Motor

Imported Motor			
Code No.	Item Description	Q'ty Received	Unit
E137	MOTOR YDK-45C-4	2,000.00	PCS
E55	MOTOR 35W YDK-35L-4	500.00	PCS
E95	MOTOR	1,000.00	PCS
E57	STEP MOTOR MODEL ST-35 130 OHM	1,000.00	PCS
E71	MOTOR RPS 16C 50/60HZ 12K	2,500.00	PCS
EX0006	MOTOR RPS 16C-1 W/RUBBER FOR AERMEC	2,700.00	PCS
EX0007	MOTOR RPS 16C-2 W/RUBBER FOR AERMEC	2,000.00	PCS
E606	MOTOR LC-14558,50/60Hz	15,000.00	PCS
EX0001	MOTOR LC 14558T-1	1,100.00	PCS
	Total Quantity	27,800.00	PCS

5.2) Imported of Plastic

Imported Plastic			
Code No.	Item Description	Q'ty Received	Unit
P164	BASE PAN 18/24/30-RAW	4,500.00	PCS
P166	EVAP SUPPORT LH	1,800.00	PCS
P167	EVAP SUPPORT RH	1,800.00	PCS
P168	DRAIN PAN	4,536.00	PCS
P169	DEFLECTOR W/ARM /REV.C	12,320.00	PCS
P170	DEFLECTOR @ 12 /REV.C	36,960.00	PCS
P171	BAR GANG /REV. B	12,320.00	PCS
P172	HORIZONTAL LOUVER WQ-18/24	4,092.00	PCS
P173	BUSHING /REV. C	213,960.00	PCS
P176	WIRE RETAINER /Rev B	9,000.00	PCS
P177	FRAME GRILLE WQ,WJ-18/24/30 (RAW)	3,480.00	PCS
P178	HINGE SUPPORT LH /Rev D	34,500.00	PCS
P179	HINGE SUPPORT RH /Rev D	34,500.00	PCS
P180	HINGE LH /Rev E	34,500.00	PCS
P181	HINGE RH /Rev E	34,500.00	PCS
P182	LOCK	4,500.00	PCS
P183	AIR FILTER WQ-18/24	6,000.00	PCS
P183-1	AIR FILTER WQ-24 ANTI BACTERIA	100.00	PCS
P184	DECOR PANEL WQ-18/24/30	1,490.00	PCS
P185	SCREW COVER / REV. A	35,000.00	PCS
P206	DEFLECTOR W/HANDLE /REV. A	18,220.00	PCS
P207	DEFLECTOR /REV. A	54,660.00	PCS
P208	BARGANG /REV. A	18,420.00	PCS
P221	STRAP EVAP	21,000.00	PCS
P378	LOCK PIN HOLDER WN-24	34,000.00	PCS
P384	IR PLATE WN-24	5,560.00	PCS

P390	ILLUMINANT PLAST WN-24	6,000.00	PCS
P500	DECOR PANEL WJ-18/24/30	4,010.00	PCS
P536	CONTROL BOX WQ-24/30/36 (FIRE RTD)	11,200.00	PCS
P537	CONTROL BOX COVER WQ-24/30/36,FIRE	10,360.00	PCS
P600	BASE PAN 36/42 (RAW)	24,783.00	PCS
P601	FRAME GRILL WQ,WJ,MSL-36/42 (RAW)	18,150.00	PCS
P602	TERMINAL COVER (FRAME GRILL-RH)	14,980.00	PCS
P603	DECOR PANEL WQ-36	9,027.00	PCS
P604	DRAIN PAN WQ-36	24,399.00	PCS
P605	DEFLECTOR W/ARM WQ-36	86,500.00	PCS
P606	DEFLECTOR WQ-36 /REV.A	356,800.00	PCS
P607	BAR GANG WQ-36	88,500.00	PCS
P608	HORIZONTAL LOUVER WQ-36 / REV.A	13,032.00	PCS
P609	CENTER BARING HOLDER WQ-36	14,980.00	PCS
P610	EVAP SUPPORT LHS WQ-36	20,115.00	PCS
P611	EVAP SUPPORT RHS WQ-36	20,115.00	PCS
P614-1	ANTI BACTERIA FILTER WQ-36	43,920.00	PCS
P615	CHARCOAL HOLDER (optional) WQ-36	15,600.00	PCS
P624	FRAME GRILL WN-36	3,000.00	PCS
P625	TERMINAL COVER WN-36 /REV. A	3,000.00	PCS
P628-1	AIR FILTER WN-36 (GREEN)	6,000.00	PCS
P644	DECOR PANEL WJ-36 (DOVE WHITE)	3,015.00	PCS
P645	BASE PAN 36/42 RAW (DOVE WHITE COLOR)	2,988.00	PCS
P646	FRAME GRILLE WJ-36 DOVE WHITE COLOR	3,005.00	PCS
P647	HORIZONTAL LOUVER WJ-36 DOVE WHITE COLOR	3,528.00	PCS
P653	TERMINAL COVER DOVE WHITE COLOUR	3,185.00	PCS
P654	SCREW COVER DOVE WHITE COLOUR	10,000.00	PCS
P662-1	FILTER FRAME DOVE WHITE COLOUR	6,000.00	PCS
P663	LOCK PIN HOLDER DOVE WHITE COLOUR	6,000.00	PCS
P664	EVAP SUPPORT RH DOVE WHITE COLOUR	3,060.00	PCS
P665	EVAP SUPPORT LH DOVE WHITE COLOUR	3,060.00	PCS
P666	BEARING HOLDER DOVE WHITE COLOUR	3,185.00	PCS
P674	DECOR PANEL MSL36 /REV. A	3,888.00	PCS
P675	DRAIN PAN WN-36 REVERSE LOUVER (WRM/WS)	2,964.00	PCS
P676	LOUVER WN-36 REVERSE FUNCTION / REV.A	2,574.00	PCS
P678	HORIZONTAL LOUVER WQ-36 REVERSE	3,240.00	PCS
PP0602	DECOR PANEL WRM -36/42(RAW)	2,700.00	PCS
PP0668	Decor Panel WS-36	3,006.00	PCS
P165	CROSS FLOW FAN 106.50DIA X 899MM	1,200.00	PCS
P194	CROSS FLOW FAN 107.90DIA X 899MM.	5,550.00	PCS
P5	NYLON PIVOT W/RUBBER SEAT	25,210.00	PCS
P612	CROSS FLOW FAN 107.9mm. x 572mm. LH	15,000.00	PCS
P613	CROSS FLOW FAN 107.9mm. x 572mm. RH	15,000.00	PCS
Total Quantity		1,563,547.00	PCS

5.3) Imported of Remote

Imported Remote			
Code No.	Item Description	Q'ty Received	Unit
E001	CONTROLLER IC WITH SSPJL131B (ONLY IC)	500.00	PCS
E0001	MAIN PCB COOLBIZ H/P MCT- AC - 502 (IC# SSPJL103B)	1,000.00	PCS
E0032	EPCOS SENSOR,NTC THERMISTER TYPE B57020 FOR	5,000.00	PCS
E0033	EPCOS SENSOR,NTC THERMISTER TYPE B57020 FOR	5,000.00	PCS
E0201	LAMP BOARD WQ12, SB003 (Ro)	4,500.00	PCS
E0501	LAMP BOARD WQ24, SB004 (Ro)	2,600.00	PCS
E0601	LAMP BOARD WQ36, SB005 (Ro)	900.00	PCS
E209	INDOOR COIL SENSOR COOLBIZ	500.00	PCS
E51	WIRE HARNESS FOR IR RECEIVER COOLBIZ WIR-004	3,000.00	PCS
E65	AUXILIARY SWITCH BOARD, SB002 (RoHS)	12,400.00	PCS
EW0002	MAIN PCB MB004 (Ro) CHILLED WATER G2 H/C PROGRAM	4,500.00	PCS
EW11	REMOTE HANDSET EPSILON HS002 (RoHS) HEAT/COOL	7,500.00	PCS
EW17	MAIN PCB CHILLED H/P COOLBIZ SINGLE MCT-AC-539	3,000.00	PCS
Total Quantity		50,400.00	PCS

5.4) Imported of Copper

Imported Copper			
Code No.	Description	Q'ty Received	Unit
CT03	COPPER TUBE GROOVE 3/8	6,000.00	Kgs
CT631	COPPER TUBE	14,920.00	Kgs
Total Q'TY		20,920.00	Kgs

Appendix 6: Average quantity Bill of Materials for SKD

6.1) Average quantity BOM of Plastic for SKD

NO.	Customer	Model	Group	Quantity					
				BOM Plastic					
				Total	STDEV	Local	STDEV	Imported	STDEV
1	AWAL GULF	WN-36	SKD	55.00		6.00		49.00	
2	AWAL GULF	WQ-36	SKD	59.00		8.00		51.00	
3	AWAL GULF	WQ-30	SKD	56.00		11.00		45.00	
4	AWAL GULF	WRM-24	SKD	55.00		15.00		40.00	
5	GE/ZAMIL	WJ-36	SKD	48.00		0.00		48.00	
6	PANABISHI	WQ-24	SKD	40.00		5.00		35.00	
7	PETRA	WN-24	SKD	50.00		9.00		41.00	
8	ZAMIL	MSL-36	SKD	43.00		0.00		43.00	
9	ZAMIL CLASSIC	WJ-36	SKD	57.00		6.00		51.00	
Average				51.44	6.62	6.67	4.85	44.78	5.49
Round up				52	7	7	5	45	6

6.1) Average quantity BOM of Motor for SKD

NO.	Customer	Model	Group	Quantity					
				BOM Motor					
				Total	STDEV	Local	STDEV	Imported	STDEV
1	AWAL GULF	WN-36	SKD	1.00		0.00		1.00	
2	AWAL GULF	WQ-36	SKD	1.00		0.00		1.00	
3	AWAL GULF	WQ-30	SKD	1.00		0.00		1.00	
4	AWAL GULF	WRM-24	SKD	1.00		0.00		1.00	
5	GE/ZAMIL	WJ-36	SKD	1.00		0.00		1.00	
6	PANABISHI	WQ-24	SKD	1.00		0.00		1.00	
7	PETRA	WN-24	SKD	1.00		0.00		1.00	
8	ZAMIL	MSL-36	SKD	1.00		0.00		1.00	
9	ZAMIL CLASSIC	WJ-36	SKD	1.00		0.00		1.00	
Average				1.00	0.00	0.00	0.00	1.00	0.00
Round up				1	0	0	0	1	0

Appendix 7: Average quantity Bill of Materials for CBU

7.1) Average quantity BOM of Plastic for CBU

NO.	Customer	Model	Group	Quantity					
				BOM Plastic					
				Total	STDEV	Local	STDEV	Imported	STDEV
1	AERMEC	WJW-07V	CBU	39.00		39.00		30.00	
2	AERMEC	WJW-10V	CBU	39.00		9.00		30.00	
3	AERMEC	WJW-16V	CBU	41.00		5.00		36.00	
4	AIR SYSTEMS	WRM-42	CBU	57.00		9.00		48.00	
5	AIRRI	WRM-36	CBU	52.00		4.00		48.00	
6	AIR SYSTEMS	WN-30	CBU	49.00		9.00		40.00	
7	MULTIAQUA	WQ-18	CBU	45.00		7.00		38.00	
8	PANSIAM	WQ-42	CBU	52.00		4.00		48.00	
9	DAIKOOL	WQ-32	CBU	54.00		3.00		51.00	
10	DAIKOOL	WQ-30	CBU	39.00		5.00		34.00	
11	C-AIR CON	WQ-36	CBU	59.00		7.00		52.00	
12	SETPOINT	WQ-24	CBU	43.00		6.00		37.00	
13	SETPOINT	WQ-12S	CBU	41.00		9.00		32.00	
14	EFATAR	WQW-18	CBU	41.00		5.00		36.00	
15	MULTIAQUA	WQW-12	CBU	48.00		12.00		36.00	
16	EFATAR	WQW-09	CBU	40.00		12.00		28.00	
17	MULTIAQUA	WQW-24H	CBU	43.00		5.00		38.00	
18	SETPOINT	WQW-32V	CBU	56.00		5.00		51.00	
19	SETPOINT	WQW-26V	CBU	55.00		5.00		50.00	
20	SETPOINT	WQW-21V	CBU	42.00		5.00		37.00	
21	SETPOINT	WQW-16V	CBU	43.00		6.00		37.00	
22	SETPOINT	WQW-10V	CBU	40.00		10.00		30.00	
23	SETPOINT	WQW-07V	CBU	40.00		10.00		30.00	
24	SNC FORMER	WN-42	CBU	53.00		4.00		49.00	
25	TEKLIMA LTD	WJW-21V	CBU	42.00		4.00		38.00	
26	TRANE EXPORT	WRM-30	CBU	56.00		11.00		45.00	
27	TRANE (DUBAI)	WJ-30	CBU	40.00		4.00		36.00	
28	TRANE (SAUDI)	WJ-36	CBU	54.00		6.00		48.00	
29	ZAMIL	WJW-32V	CBU	56.00		30.00		26.00	
30	ZAMIL	WJW-26V	CBU	56.00		9.00		47.00	
31	ZAMIL	WJW-16V	CBU	42.00		5.00		37.00	
32	ZAMIL COOLINE	MSL-42	CBU	55.00		4.00		51.00	
33	ZAMIL COOLINE	MSL-36	CBU	55.00		5.00		50.00	
34	GENERAL CUSTOMER	WQ-09	CBU	36.00		6.00		30.00	
Average				47.15	7.16	8.21	8.21	39.82	8.11
Round up				47	7	8	8	40	8

7.2) Average quantity BOM of Motor for CBU

NO.	Customer	Model	Group	Quantity					
				BOM Motor					
				Total	STDEV	Local	STDEV	Imported	STDEV
1	AERMEC	WJW-07V	CBU	1.00				1.00	
2	AERMEC	WJW-10V	CBU	1.00				1.00	
3	AERMEC	WJW-16V	CBU	1.00		1.00			
4	AIR SYSTEMS	WRM-42	CBU	1.00				1.00	
5	AIRRI	WRM-36	CBU	1.00				1.00	
6	AIR SYSTEMS	WN-30	CBU	1.00				1.00	
7	MULTIAQUA	WQ-18	CBU	1.00				1.00	
8	PANSIAM	WQ-42	CBU	1.00				1.00	
9	DAIKOOL	WQ-32	CBU	1.00				1.00	
10	DAIKOOL	WQ-30	CBU	1.00				1.00	
11	C-AIR CON	WQ-36	CBU	1.00				1.00	
12	SETPOINT	WQ-24	CBU	1.00				1.00	
13	SETPOINT	WQ-12S	CBU	1.00				1.00	
14	EFATAR	WQW-18	CBU	1.00				1.00	
15	MULTIAQUA	WQW-12	CBU	1.00				1.00	
16	EFATAR	WQW-09	CBU	1.00				1.00	
17	MULTIAQUA	WQW-24H	CBU	1.00				1.00	
18	SETPOINT	WQW-32V	CBU	1.00				1.00	
19	SETPOINT	WQW-26V	CBU	1.00				1.00	
20	SETPOINT	WQW-21V	CBU	1.00				1.00	
21	SETPOINT	WQW-16V	CBU	1.00				1.00	
22	SETPOINT	WQW-10V	CBU	1.00				1.00	
23	SETPOINT	WQW-07V	CBU	1.00				1.00	
24	SNC FORMER	WN-42	CBU	1.00				1.00	
25	TEKLIMA LTD	WJW-21V	CBU	1.00				1.00	
26	TRANE EXPORT	WRM-30	CBU	1.00				1.00	
27	TRANE (DUBAI)	WJ-30	CBU	1.00				1.00	
28	TRANE (SAUDI)	WJ-36	CBU	1.00				1.00	
29	ZAMIL	WJW-32V	CBU	1.00				1.00	
30	ZAMIL	WJW-26V	CBU	1.00				1.00	
31	ZAMIL	WJW-16V	CBU	1.00				1.00	
32	ZAMIL COOLINE	MSL-42	CBU	1.00				1.00	
33	ZAMIL COOLINE	MSL-36	CBU	1.00				1.00	
34	GENERAL CUSTOMER	WQ-09	CBU	1.00				1.00	
Average				1.00	0.00	1.00	0.00	1.00	0.00
Round up				1	0	1	0	1	0

7.3) Average quantity BOM of Remote for CBU

NO.	Customer	Model	Group	Quantity					
				BOM Remote					
				Total	STDEV	Local	STDEV	Imported	STDEV
1	AERMEC	WJW-07V	CBU	6.00				5.00	
2	AERMEC	WJW-10V	CBU	4.00				4.00	
3	AERMEC	WJW-16V	CBU	6.00				4.00	
4	AIR SYSTEMS	WRM-42	CBU	11.00		11.00			
5	AIRRI	WRM-36	CBU	8.00		8.00			
6	AIR SYSTEMS	WN-30	CBU	9.00		9.00			
7	MULTIAQUA	WQ-18	CBU	5.00				4.00	
8	PANSIAM	WQ-42	CBU	2.00		2.00			
9	DAIKOOL	WQ-32	CBU	5.00				4.00	
10	DAIKOOL	WQ-30	CBU	4.00				4.00	
11	C-AIR CON	WQ-36	CBU	8.00		8.00			
12	SETPOINT	WQ-24	CBU	5.00				4.00	
13	SETPOINT	WQ-12S	CBU	5.00				4.00	
14	EFATAR	WQW-18	CBU	3.00				4.00	
15	MULTIAQUA	WQW-12	CBU	4.00				4.00	
16	EFATAR	WQW-09	CBU	5.00				4.00	
17	MULTIAQUA	WQW-24H	CBU	6.00				4.00	
18	SETPOINT	WQW-32V	CBU	4.00				4.00	
19	SETPOINT	WQW-26V	CBU	4.00				4.00	
20	SETPOINT	WQW-21V	CBU	5.00				4.00	
21	SETPOINT	WQW-16V	CBU	4.00				4.00	
22	SETPOINT	WQW-10V	CBU	4.00				4.00	
23	SETPOINT	WQW-07V	CBU	4.00				4.00	
24	SNC FORMER	WN-42	CBU	8.00		8.00			
25	TEKLIMA LTD	WJW-21V	CBU	5.00				4.00	
26	TRANE EXPORT	WRM-30	CBU	13.00		13.00			
27	TRANE (DUBAI)	WJ-30	CBU	11.00		11.00			
28	TRANE (SAUDI)	WJ-36	CBU	11.00		11.00			
29	ZAMIL	WJW-32V	CBU	8.00		8.00			
30	ZAMIL	WJW-26V	CBU	8.00		8.00			
31	ZAMIL	WJW-16V	CBU	8.00		8.00			
32	ZAMIL COOLINE	MSL-42	CBU	8.00		8.00			
33	ZAMIL COOLINE	MSL-36	CBU	8.00		8.00			
34	GENERAL CUSTOMER	WQ-09	CBU	5.00				5.00	
Average				6.29	2.62	8.64	2.53	4.10	0.31
Round up				6	3	9	3	4	1

7.4) Average quantity BOM of Copper for CBU

NO.	Customer	Model	Group	Quantity					
				BOM Copper					
				Total	STDEV	Local	STDEV	Imported	STDEV
1	AERMEC	WJW-07V	CBU	0.98		0.98		0.00	
2	AERMEC	WJW-10V	CBU	1.11		1.11		0.00	
3	AERMEC	WJW-16V	CBU	2.22		2.22		0.00	
4	AIR SYSTEMS	WRM-42	CBU	4.77		0.89		3.88	
5	AIRRI	WRM-36	CBU	3.76		0.38		3.38	
6	AIR SYSTEMS	WN-30	CBU	3.45		0.69		2.76	
7	MULTIAQUA	WQ-18	CBU	1.93		0.44		1.49	
8	PANSIAM	WQ-42	CBU	4.77		0.90		3.88	
9	DAIKOOL	WQ-32	CBU	3.03		0.55		2.48	
10	DAIKOOL	WQ-30	CBU	3.48		0.72		2.76	
11	C-AIR CON	WQ-36	CBU	4.01		0.64		3.38	
12	SETPOINT	WQ-24	CBU	2.60		0.51		2.09	
13	SETPOINT	WQ-12S	CBU	3.45		0.69		2.76	
14	EFATAR	WQW-18	CBU	1.86		1.86		0.00	
15	MULTIAQUA	WQW-12	CBU	1.28		1.28		0.00	
16	EFATAR	WQW-09	CBU	1.13		1.13		0.00	
17	MULTIAQUA	WQW-24H	CBU	2.47		2.47		0.00	
18	SETPOINT	WQW-32V	CBU	3.31		3.31		0.00	
19	SETPOINT	WQW-26V	CBU	2.63		2.63		0.00	
20	SETPOINT	WQW-21V	CBU	2.08		2.08		0.00	
21	SETPOINT	WQW-16V	CBU	1.65		1.65		0.00	
22	SETPOINT	WQW-10V	CBU	0.94		0.94		0.00	
23	SETPOINT	WQW-07V	CBU	0.86		0.86		0.00	
24	SNC FORMER	WN-42	CBU	4.77		0.90		3.88	
25	TEKLIMA LTD	WJW-21V	CBU	2.20		2.20		0.00	
26	TRANE EXPORT	WRM-30	CBU	3.28		0.52		2.76	
27	TRANE (DUBAI)	WJ-30	CBU	3.45		0.69		2.76	
28	TRANE(SAUDI)	WJ-36	CBU	4.01		0.64		3.38	
29	ZAMIL	WJW-32V	CBU	3.07		3.07		0.00	
30	ZAMIL	WJW-26V	CBU	2.42		2.42		0.00	
31	ZAMIL	WJW-16V	CBU	1.66		1.66		0.00	
32	ZAMIL COOLINE	MSL-42	CBU	4.77		0.90		3.88	
33	ZAMIL COOLINE	MSL-36	CBU	3.72		0.77		2.95	
34	GENERAL CUSTOMER	WQ-09	CBU	1.16		1.16		0.00	
Average				2.71	1.22	1.29	0.81	1.42	1.60
Round up				3	1	1	1	2	2

Appendix 8: Calculation of Reordering Cost

8.1) Reordering cost of imported plastic

No.	Description	Shipment	Credit	Region	Operating cost
1	Shipping service	Container 40"/Shipment	CFR	Taiwan	2,200.00
2	Document Fee	Container 40"/Shipment	CFR	Taiwan	200.00
3	Lift on (Thai port)	Container 40"/Shipment	CFR	Taiwan	3,350.00
4	Transportation 40"	Container 40"/Shipment	CFR	Taiwan	4,400.00
5	Terminal Handing Charge(THC)	Container 40"/Shipment	CFR	Taiwan	3,900.00
6	Delivery order (D/O)	Container 40"/Shipment	CFR	Taiwan	500.00
7	Insurance	Container 40"/Shipment	CFR	Taiwan	994.00
Total					15,544.00
Approximate Price (Baht)					16,000.00

8.2) Reordering cost of imported motor

No.	Description	Shipment	Credit	Region	Operating cost
1	Freight Charge	Container 20"/Shipment	FOB	China	10,121.00
2	Shipping service	Container 20"/Shipment	FOB	China	2,200.00
3	Document Fee	Container 20"/Shipment	FOB	China	100.00
4	Lift on (Thai port)	Container 20"/Shipment	FOB	China	1,550.00
5	Transportation 20"	Container 20"/Shipment	FOB	China	3,900.00
6	Terminal Handing Charge(THC)	Container 20"/Shipment	FOB	China	2,600.00
7	Delivery order (D/O)	Container 20"/Shipment	FOB	China	500.00
8	Insurance	Container 20"/Shipment	FOB	China	2,200.00
Total					23,171.00
Approximate Price (Baht)					24,000.00

8.3) Reordering cost of imported copper

No.	Description	Shipment	Credit	Region	Operating cost
1	Freight Charge	Container 20"/Shipment	FOB	China	10,121.00
2	Shipping service	Container 20"/Shipment	FOB	China	2,200.00
3	Document Fee	Container 20"/Shipment	FOB	China	100.00
4	Lift on (Thai port)	Container 20"/Shipment	FOB	China	1,550.00
5	Transportation 20"	Container 20"/Shipment	FOB	China	3,900.00
6	Terminal Handing Charge(THC)	Container 20"/Shipment	FOB	China	2,600.00
7	Delivery order (D/O)	Container 20"/Shipment	FOB	China	500.00
8	Insurance	Container 20"/Shipment	FOB	China	2,200.00
Total					23,171.00
Approximate Price (Baht)					24,000.00

8.4) Reordering cost of imported remote

No.	Description	Shipment	Credit	Region	Operating cost
1	Freight Charge	LCL/Shipment	FOB	Malaysia	16,657.00
2	Shipping service	LCL/Shipment	FOB	Malaysia	4,200.00
3	Document Fee	LCL/Shipment	FOB	Malaysia	100.00
4	Transportation (by truck)	LCL/Shipment	FOB	Malaysia	2,300.00
5	Terminal Handing Charge(THC)	LCL/Shipment	FOB	Malaysia	6,612.00
6	Delivery order (D/O)	LCL/Shipment	FOB	Malaysia	850.00
7	Carrier Freight Service(CFS)	LCL/Shipment	FOB	Malaysia	7,439.00
8	Wharfage Charge	LCL/Shipment	FOB	Malaysia	2,479.00
9	Handing Charge	LCL/Shipment	FOB	Malaysia	250.00
Total					24,230.00
Approximate Price (Baht)					25,000.00

8.5) Reordering cost Domestic of key raw materilas

No.	Description	Shipment	Credit	Region	Operating cost
1	Computer time cost	Truck	30 Days	Local	84.00
2	Telephone cost	Truck	30 Days	Local	500.00
3	Fax	Truck	30 Days	Local	60.00
4	Correspondence	Truck	30 Days	Local	200.00
5	Use of equipment	Truck	30 Days	Local	200.00
6	Quality Check	Truck	30 Days	Local	300.00
7	Operating cost	Truck	30 Days	Local	150.00
Total					1,494.00
Approximate Price (Baht)					1,500.00

Appendix 9: Calculation of Holding Cost

9.1) Holding cost of imported plastic

Imported Plastic = $\frac{\text{Total Value Plastic in 8 months}}{\text{Total Quantity Plastic in 8 months}}$

= $\frac{57{,}098{,}405.00 \text{ Baht / 8 months}}{1{,}563{,}547.00 \text{ Piece / 8 months}}$

= 36.52 Baht / piece / 8 months

Holding 20% = 7.30 Baht / piece / 8 months

= 0.91 Baht / piece / month

9.2) Holding cost of domestic plastic

Imported Plastic = $\frac{\text{Total Value Plastic in 8 months}}{\text{Total Quantity Plastic in 8 months}}$

= $\frac{2{,}895{,}236.00 \text{ Baht / 8 months}}{133{,}787.00 \text{ Piece / 8 months}}$

= 27.64 Baht / piece / 8 months

Holding 20% = 4.33 Baht / piece / 8 months

= 0.54 Baht / piece / month

9.3) Holding cost of imported remote

Imported Remote = $\frac{\text{Total Value Remote in 8 months}}{\text{Total Quantity Remote in 8 months}}$

= $\frac{6,162,905.00 \text{ Baht / 8 months}}{50,400.00 \text{ Pieces / 8months}}$

= 122.28 Baht / pieces / 8 months

Holding 20% = 24.46 Baht / pieces / 8 months

= 3.06 Baht / pieces / month

Round up = 3.00 Baht / pieces / month

9.4) Holding cost of domestic remote

Domestic Remote = $\frac{\text{Total Value Remote in 8 months}}{\text{Total Quantity Remote in 8 months}}$

= $\frac{11,143,460.00 \text{ Baht / 8 months}}{162,550.00 \text{ Pieces / 8 months}}$

= 68.55 Baht / pieces / 8 months

Holding 20% = 13.71 Baht / pieces / 8 months

= 1.71 Baht / pieces / month

Round up = 2.00 Baht / pieces / month

9.5) Holding cost of imported copper

Imported Copper = $\frac{\text{Total Value Copper in 8 months}}{\text{Total Quantity Copper in 8 months}}$

= $\frac{6,882,400.00 \text{ Baht / 8 months}}{20,920.00 \text{ Kgs / 8 months}}$

= 328.99 Baht / kgs / 8 months

Holding 20% = 65.80 Baht / kgs / 8 months

= 8.22 Baht / kgs / month

Round up = 8.00 Baht / kgs / month

9.6) Holding cost of domestic copper

Domestic Copper = $\frac{\text{Total Value Motor in 8 months}}{\text{Total Quantity Motor in 8 months}}$

= $\frac{4,798,260.00 \text{ Baht / 8 months}}{15,573.00 \text{ Kgs / 8 months}}$

= 308.11 Baht / kgs / 8 months

Holding 20 = 61.62 Baht / kgs / 8 months

= 7.70 Baht / kgs / month

Round up = 8.00 Baht / kgs / month

9.7) Holding cost of imported motor

Imported Motor = Total Value Motor in 8 months / Total Quantity Motor in 8 months

= 11,195,450.00 Baht / 8 months / 27,800.00 Pieces / 8 months

= 402.71 Baht / pieces / 8 months

Holding 20% = 80.54 Baht / pieces / 8 months

= 10.07 Baht / pieces / month

Round up = 10.00 Baht / pieces / month

9.8) Holding cost of domestic motor

Domestic Remote = Total Value Motor in 8 months / Total Quantity Motor in 8 months

= 399,350.00 Baht / 8 months / 1,400.00 Pieces / 8 months

= 285.25 Baht / pieces / 8 months

Holding 20% = 57.05 Baht / pieces / 8 months

= 7.13 Baht / pieces / month

Round up = 7.00 Baht / pieces / month