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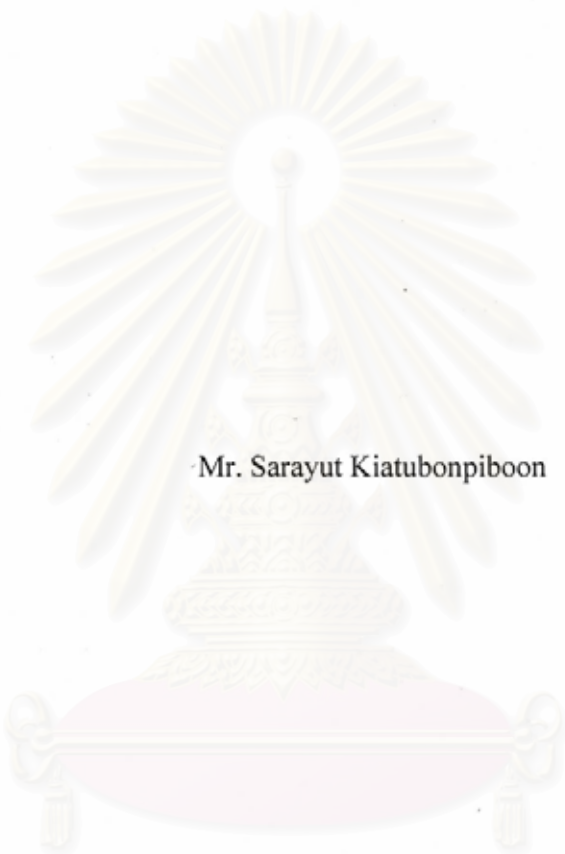
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INVENTORY MANAGEMENT
: A HYDRAULIC CYLINDER FACTORY CASE STUDY



Mr. Sarayut Kiatubonpiboon

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering Program in Engineering Management

The Regional Centre for Manufacturing System Engineering

Faculty of Engineering

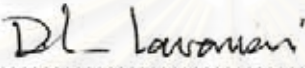
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: A HYDRAULIC CYLINDER FACTORY CASE STUDY)
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ในวิทยานิพนธ์นี้ ได้ให้ความสนใจในเรื่องของการจัดการสินค้าคงคลังใหม่ในโรงงานกระบอกสูบไฮดรอลิกส์โดยมีวัตถุประสงค์ที่จะทำให้มีระดับคงคลังที่เหมาะสม และลดขนาดต้นทุนทางด้านวัตถุดิบให้มากที่สุด โดยมีผลิตภัณฑ์ทั้งหมด เจ็ด ขนาดของกระบอกสูบ หรือ จำนวนชิ้นส่วน 144 ชิ้นส่วน ที่นำมาทำการศึกษา โดยโรงงานนี้ประสบปัญหาทั้งในเรื่องของการขาดชิ้นส่วนในการประกอบในช่วงเวลาที่มีความต้องการสินค้าสูง และพบว่าหลายชิ้นส่วนได้มีการเก็บสต็อกไว้มากกว่าที่วางแผนการผลิตไว้ เนื่องจากการบริหารสินค้าคงคลังที่ไม่เหมาะสม อีกทั้งระบบของผู้ปฏิบัติงานยังไม่มีประสิทธิภาพเพียงพอ

ขั้นตอนแรกของการทำ คือ การวิเคราะห์ความสำคัญของสินค้าคงคลังแบบ ABC โดยวิเคราะห์แบบหลายตัวแปร โดยแยกวัตถุดิบที่สำคัญออกจากวัตถุดิบที่ไม่สำคัญ เพื่อที่จะได้ให้ความสำคัญในส่วนที่สำคัญก่อน โดยใช้มูลค่าของสินค้าที่ใช้คือปี กับช่วงเวลานำ มาวิเคราะห์ในการแบ่งกลุ่ม

การบริหารสินค้าคงคลังเพื่อที่จะมีประสิทธิภาพสูงสุดได้นั้น กลุ่มเองจะใช้ระบบในการควบคุมโดยให้มีการจัดซื้อสินค้าหลายชนิดกับผู้ผลิตเจ้าเดียวกันเพื่อลดค่าใช้จ่าย โดยมีช่วงเวลาในการสั่งซื้อที่คงที่ กลุ่มนี้จะใช้ระบบของคงคลังโดยการกำหนดปริมาณการสั่งซื้อที่ เพื่อที่จะหาการจัดซื้อที่ประหยัด ของคงคลังสำรอง ระดับปริมาณสูงสุด และจุดสั่งใหม่ สำหรับกลุ่มซีได้ใช้ระบบของคงคลังโดยการกำหนดรอบเวลาในการสั่งของคงที่ เพื่อที่จะหาปริมาณของคงคลังสำรองระบบเป้าหมายของคงคลังสำรอง และ ปริมาณการสั่งซื้อ

เพื่อที่จะทำการรักษาระบบใหม่ที่ได้ออกแบบให้ได้มีการปฏิบัติอย่างถูกต้องและเป็นขั้นตอนนั้น กระบวนการปฏิบัติในแต่ละขั้นตอนของแผนกหลักสามแผนกที่เกี่ยวข้องกับคงคลังโดยตรงนั้น ได้ถูกออกแบบและกำหนดหน้าที่ของผู้ปฏิบัติงานขึ้นอย่างละเอียด นอกจากนั้นได้ทำการปรับปรุงแผนผังในคงคลังเพื่อที่จะสามารถใช้ พื้นที่ และอุปกรณ์ ได้อย่างเต็มประสิทธิภาพ ซึ่งจากการปรับปรุงใหม่ สามารถประหยัดพื้นที่ประมาณ 25 เปอร์เซ็นต์

จากการศึกษาพบว่า โรงงานนี้สามารถประหยัดค่าใช้จ่ายทั้งหมดในการเก็บรักษา เป็นจำนวน 2,007,936.28 บาท หรือ 13.38 เปอร์เซ็นต์ ของ ค่าใช้จ่ายสินค้าคงคลังทั้งหมด.

ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต.....ลายมือชื่อนิสิต.....
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SARAYUT KIATUBONPIBOON: INVENTORY MANAGEMENT

: A HYDRAULIC CYLINDER FACTORY CASE STUDY

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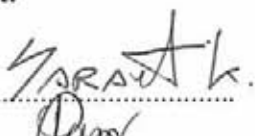
This thesis concerns to inventory management in a case study of a Hydraulic Cylinder factory. It aims to optimal inventory level in minimize cost and improve the inventory process to be high efficiency. This thesis study for all seven models in term of 144 parts. The factory found the shortage problem in high demand season and exceeds inventory stock at the end of the year. Because the inventory system is not suitable and the operator manage the control inventory level by their experience

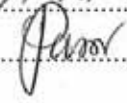
The first step uses ABC analysis for separate the unimportant items out of important items. The consideration of multi criteria makes more accuracy to classify how much they are effective with the cost and lead time period.

To achieve in inventory control, group A use the method of ordering various items with one supplier to save the related ordering cost and Group B use fixed order quantity model to find the economic order quantity, safety stock, and reorder point. In group C, it is used Min-Max model to find the safety stock, target stock level, and order quantity.

In order to maintain the system and to maximize the labor and equipment capacity, the new procedure of three main departments has been designed for each department. The related documents have been created to be more efficiency. For the improvement of inventory layout, that can saver the space than the old lay out about 25 percent.

From the study, a new inventory system for a Hydraulics Cylinder can save 2,007,936.28 Baht or 13.38 percent of total inventory cost.

The regional Centre for Manufacturing Systems Engineering Student's signature..... 

Field of study..... Engineering Management Advisor's signature..... 

Academic year...2006....

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CHAPTER I

INTRODUCTION

1.1 Background of the research

Inventory control is one of the criteria factors that the top management has to consider closely in business, because inventory cost is highly in the asset turnover ratio. Inventory has an impact on both profits and cash flow. If inventory cannot be utilized, it becomes worthless to the business. The excessive stock increase sunk cost and the depreciation rate. If the stock is controlled in the low level, the part shortage may cause the problem in production.

Therefore the inventory management is necessary to increase the profit and decrease the expense in business. Basic inventory manage the man, equipment, material and stock area to find out the optimal level in order to save the annual inventory cost. The inventory management concerned with many department in the factory. The efficient management needs the multiple skills of operators and cooperation during the departments such as Production, Sales, inventory, Purchasing and Inventory. All departments have to operate according to the master plan that consists of the production plan, their procedure for each important operation. As the result, each department shares the information to provide the resource and make decision to achieve the high profit.

1.1.1 Company and Product Process

This study involves the inventory control in a Hydraulic cylinder industry, established in 1985 at Rang sit province. This industry is a manufacturing that produce and assembly "Hydraulic cylinder". The employees are about 80 persons with the main five departments. Major customers are domestic companies, especially in the Agriculture field. This industry is quite a small manufacturing. The industry produce Hydraulic cylinder on 7 models and each model are consisted of 22 types of main parts. Then the total inventory parts are 144 items including accessory item. The factory avoid the problem from the suppliers, therefore they select the best three of their suppliers, considered from the factory of price, delivery time and payment term. All parts are supplied by the three suppliers with different items. As the details, most

parts are produced completely from the partnership supplier at Rang sit Province, called code: 1xx. The se-mi machined parts or critical parts are produced by the Factory at Supanburi province, called code:2xx. Another group, the consumption, accessory, equipments items will be supplied from the machinery store at Rang sit area, called code: 3xx.

Part stocking is high investment for over stock or stop production when happening shortage of parts. To make it smooth process and cost saving, the industry have to find out the right planning of demand and stock in order to estimate the right demand that fluctuation through the year. For main process of Hydraulic cylinder and product picture, it is shown as Figure no. 1.1 and 1.2,

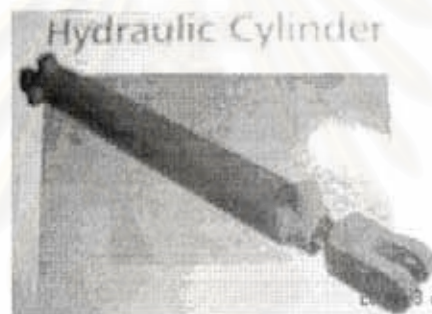


Figure no. 1.1 Hydraulic Cylinder picture

As mentioned above, there are three type of part group that are code 1xx, 2xx and 3xx. The items, code: 1xx and 2xx are the completed items that are ready to be manufacturing. For the parts code: 3xx, they are machined in factory that are Cutting, lathe, Drilling and welding responsively. Then the operator are assembled all the parts code 1xx, 2xx and 3xx together before painting. After that the painted products are sent to Final inspection. The name plates are attached on the cylinder surface, and the goods will be packed before kept into store. The Hydraulic cylinder machining process is shown as below.

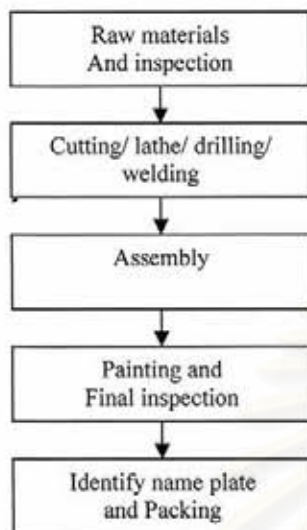


Figure no. 1.2 Process flow chart

1.1.2 Part stock coding

All assembly parts of 7 models consisted of 144 types of raw materials. The item codes help the operator to identify the specification and the supplier. That can save the time to allocate store, pick item on shelves and order them to the correct supplier. However all department have to use the same standard code to work efficiently.

The coding identify simply the definition as below Table 1.1

For M and P code							For C and W code					
M	-	50	32	-	1	14	C	-	6010	-	1	14
Typing code M = Machine P = Part complete							Typing code C = Component W = Ware and tare/ Consumed items					
Typing code C = Component W = Ware and tare/ Consumed items							Shelf position 6010					

Table 1.1 Part stock coding

Bore size 50 mm	Supplier code 1xx → Rangsit Factory 2xx → Normal Store(Rang sit Province) 3xx → Supanburi Factory
Rod size 32 mm. 40 mm. 63 mm. 80 mm. 100 mm. 125 mm.	Position no. From 01 to 100
Supplier code 1xx → Rangsit Factory 2xx → Normal Store (Rang sit Province) 3xx → Supanburi Factory	
Position no. From 01 to 100	

Table 1.1 Part stock coding (cont)

1.2 Statement of problem

This study is to find the efficient solution for inventory management in the industry. In this case study, the problem involves are:

- The existing of inventory plan is not based on theoretical method but it's an independent control. An industrial used the worker experience or intuitive judgment. The worker are lack of knowledge to manage raw material inventory.
- There is no system data recording to monitor and keep usage history and remain quantity. The remained quantity of some item is not identifying in record. They have to check 2 or 3 records to know exactly its quantity. Moreover the information is not good communication

- Checking quantity of received item and finding the items have many error and conflicts occur in this activity, moreover too much time consuming when finding the part in stock.

1.3 Objectives of the research

The objective in this research is to study the development of inventory and determine the appropriate operation for the case study.

- To design the efficiency inventory system
- To minimize the inventory cost
- To maximize effective use of labor, Equipment and Space

1.4 Scope of study

The scope of this study is concentrated on designing appropriate inventory method

- Considering historical data more than 12 months
- Spare part, work in process, and finished goods are not cover in this study.
- Product : Focus on regular product of company
- This thesis does not include implementation of the designed inventory system

1.5 Expected Output

When completed as the developed inventory management system. The inventory operation process goes well and brings the optimal use of new inventory system and operation.

1.6 Expected Benefits

The expectation from this research is that its outcome will implement:

1. To improve the inventory system
2. To eliminate the unnecessary cost such as holding cost
3. To improve workers knowledge and work to standard inventory system

1.7 Research Procedure

1. Survey more literatures and textbooks involving thesis
2. Study and analysis the exist inventory system
3. Collect the historical data and current data
4. Examine and analyze the collecting historical and current data
5. Develop the inventory system and inventory operation process
6. Propose the designed inventory management
7. Evaluate and follow up the feed back to improve
8. Arrange the thesis note presenting the research methodology and the results, Study analysis, conclusion, discussion and recommendation made for a further
9. Thesis examination



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CHAPTER II

LITERATURE SURVEY AND THEORETICAL CONSIDERATION

2.1 Literature Survey

Hebbar and Brani (1976) present the inventory control by using the computer to support in work. The computer helps the operator to issue the inventory reports that are ordering, canceling order and expedition. They also research the inventory control system to balance the inventory level in the optimal cost by mean of lead time requirement planning, order point system, min-max control and physical review control. The efficient inventory management reduces the inventory cost and avoids the hidden problem.

Singh (1983) researched the Economic Order Quantity (EOQ) calculations with limited order cycles that can set the lot sizing, safety stock and inventory monitoring procedure.

EOQ calculation:

$$Q^* = \sqrt{\frac{2AD}{Vr}} \quad T^* = \sqrt{\frac{2A}{D Vr}}$$

Q = lot sizing

T = time between order

D = demand rate in units per time

A = ordering cost per instance

V = unit cost for the item

r = interest rate or cost of inventory per unit time for each inventory dollar

The inventory control with this equation can be more efficient when applying to ABC analysis. It orders separately each group such as every week, every month or every quarter. That depends on how important of each group. The benefit of it is to help the operator constantly ordering, that reduce the shortage problem when ordering the wrong time and quantity.

Pattanakritsanun (1981) researched the applying of Replenishment orders system for Department store, he study the stock level of books by Replenishment orders to analyze the maximum stock level, lot size order, reorder point ,in assumption that the constant lead time. This method is suitable for many suppliers and each big order. Then he create the computer program to set the new inventory system, as the result, the inventory cost of new system less about 18.95 percents than the cost of old method.

Riggs (1981) explain the classification of inventory to three group by Dollar usage, called that "ABC analysis". For Group A, it is 70-80% Dollar usage of total material cost, but 20% of total stock items. While the Group B and C are not only less Dollar usage but also more quantity than Group A's. The lot size order and reorder point of Group A is carefully considered. For Group B, he presented the EOQ system to analyze the reorder point and reconsider it every four months or every six months. For Group C, it is very low dollar usage. Then the inventory system is not strictly controlled, but generally it will be ordered once a year.

Ho (1989) studied the inventory control and machine planning for automotive parts factory by theory of Man-Machine Chart. He designed the factory layout, inventory system and machine performance planning. For the inventory system, he presented the new system to control inventory in the optimal cost by using the inventory theory to support his system. To increase the efficiency of inventory system, the production planning, safety stock for inventory has been created to improve the performance

Chitralada Ratanamaethanon (1991) studied about “ Inventory management in consume product factory”. The inventory items are 165 items. The ABC analysis has been applied to separate the important of each item and divide the inventory part to Group A, B and C. as the result, it has been described as following,

Group A, it is 79.51% Dollar usage of total material cost, but 8.48% of total stock items.

Group B, it is 16.39% Dollar usage of total material cost, but 12.12% of total stock items.

Group C, it is 4.10% Dollar usage of total material cost, but 79.39% of total stock items.

Then he designed the purchasing system to order the constant ordering time and amount to manage the inventory system.

Tran (1996) studied “the Inventory management in Shoes factory”. He has divided the inventory by mean of ABC method. As the following, the MRP system (Material Requirement Planning) help the inventory to control the required quantity, the MRP plan about the order lot size, the lead time to receive the ordered materials and the remained quantity according to the manufacturing plan. The benefit of it is to be more efficiency inventory system, reduce the indirect cost and higher productivity

Mulcahy (1994: a 12.50-12.55) explain the item placement system as following

A-B-C categorization of stock-keeping-units: this item placement approach is based on “Pareto’s Law”. The concept stands for the proposition that within any given population of things, approximately 20 percent of them 80 percent of the “value” of all of the items concentrated within them. And that the other 80 percent only have 20 percent of value concentrated within them. If the criterion is usage rate, then 20 percent of all items represent the 80 percent of the items most often used/ sold.

Accordingly, for efficient physical inventory control, using popularity (speed of movement into and through the facility) as the criterion, the most productive overall location for an item is a storage position closet to that item’s point of use. Items are

separated into A-B-C categories, with "A" representing the most popular, fastest moving items, "B" representing the next most active, and "C" the show movers.

In order to separate an inventory into A-B-C categories, it is necessary to create a sorted matrix that presents all items in descending order of important and allow for the calculation of those items representing the greatest concentration of value.

▪ **Operation system**

Chorafas (1974 a: 37-52) *presented the requirement of a warehouse operating system vary. What constitutes the optimum system depends on the special circumstances within each organization. Factors such as organization style, economic needs, and materials characteristics and also influenced by environmental considerations, the above and the other factors are in a state of continuing change. A warehouse operation system must satisfy the operating objectives established by management, of which three are generally accepted for a typical marketing system.*

- 1. Minimize the time required from sales order to its final execution: expediting to customer.*
- 2. Utilize men effectively, as well as mechanism, storage capacity and time resources*
- 3. Provide warehousing management with the information needed to guarantee a timely, orderly and continuous flow of incoming and outgoing goods.*

Apple (1988: a 561 – 565) *presented location addresses and item identified system to keep track where the item has been placed in, the it necessary to: Clearly mark items with an items identifier. Clearly mark items with a unit of measure such as pack size: the item identifier is generally an organization's internal identifying code for the item rather than a manufacturer's or customer's number for that items: Although the item number itself is often adequate for identification purposes, in manufacturing it may be necessary to also include lot ans serial numbers make it possible to track manufacturing batch, date, location, and inspector. Marking related to unit of measure.*

Ackerman (1997 : a 451-471) described that the warehouse has many storage equipment modes. *Products may be floor-stored, solid-stacked, or in racks. Storage are various types such as Pallet, Rack, Shelf and Bin. Detail of some equipment's will be discussed following this:*

Pallet: *Pallet is the storage equipment which is most widely used in general warehouse. It is a portable platform on which goods can be moved, stacked, and worked especially with the aid of a forklift truck. It may be made of wood or plastic. It used for storing a product that is difficult to stack or pile properly. Pallet can carry cartons at one time. There are sizes of pallet but the most widely use is the standard size 40in x 48in. And the models of pallet that are used widely in warehouses, is two-way pallet, four-way pallet and box pallet. The consideration of pallet storage method selection includes:*

- *Ease of storage*
- *Ease of retrieval*
- *Ease of location*
- *Low risk of damage*
- *Good use of cubic space*
- *Cost of handling equipment*
- *Cost of operations*

- **Space planning**

Herbert H. Peckham(1972, p 116) *To establish ware house space requirement, the following factors must be considered:*

- *Estimation of material volumes to be stored*
- *Conversion of volumes to cube requirement*
- *Determination of height to which goods can be stacked*
- *Allowances for inability to tight-stack*
- *Allowances for aisles, staging areas, shipping and receiving docks*
- *Space requirements for offices, locker rooms, lunch rooms, and other services*
- *Tentative expansion plan*

Smith and Peters (1994: 91-100) presented the warehouse space and layout planning. The amount of space available, the physical nature of the space, and the arrangement, or layout, of the space is critical to the operating efficiency and effectiveness of the warehouse. Consequently, proper planning of warehouse space and layout requirements is needed to ensure that all the objectives of the warehouse are adequately met. Space planning is the part of the science of warehousing concerned with making a quantitative assessment of warehouse space requirements. As is true of any science, space planning possesses a very specific methodology, and it consists of the following general steps:

1. Determine what is to be accomplished
2. Determine how to accomplish it
3. Determine space allowances for each element required to accomplish the activity
4. Calculate the total space requirement

2.2 THEORETICAL CONSIDERATION

2.2.1 Basic of inventory control

The normal role for stock control is to meet the required demand at a minimum cost. Long-term profitability has then to be translated into operational and financial targets. The purpose of the inventory control function in supporting the business activities is to achieve the three targets:

1. Inventory costs
2. Operating costs.
3. Customer service

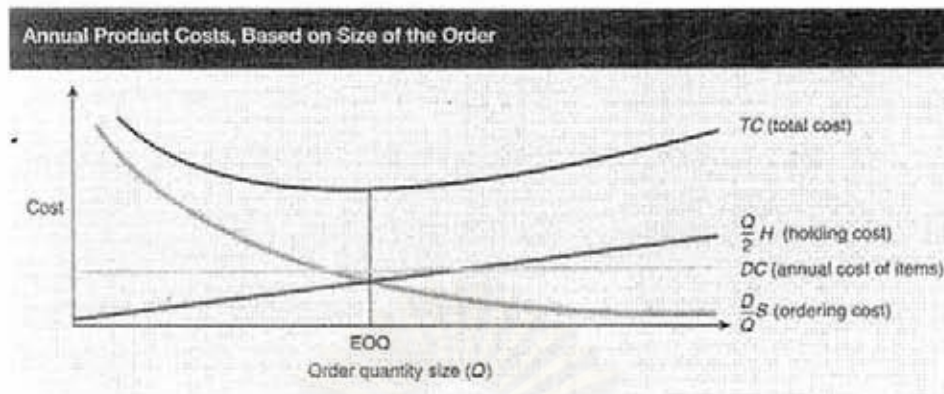
In general, the inventory control helps the operator to manage the material in inventory in the optimal quantity. While inventory costs is required to a minimum of cash in stock. Then each ordering of high cost items are planned in different from the low cost items. The material planning is one of the important factors

to affect the inventory cost. Some factory avoids the shortage cost by mean of ordering the material more than production plan. However the number of exceed stock caused the sunk and obsolesce cost that is the hidden cost. Therefore the stock controller has a fine judgment to identify which material need to be ordered and order for how much. This decision always leads to conflict between holding cost, ordering cost and shortage cost. The holding is also high but the ordering is low. Likewise if the order quantity is low then the holding cost is low but the ordering cost will be high and there is risk that shortage cost might be occurred. It is important to have the order quantity that gives the minimum total cost.

The inventory control can save a number of operating costs that are ordering, holding are shortage costs. In each ordering, the demand of each item must be identify clearly, If ordering huge amount, the inventory cost will increase but other purchasing cost will be decreased. On the other hand, if ordering few amounts, the warehouse cost is small amount but the purchasing cost is high. Because the efficient inventory control support the manufacturing planning to highly performance. The materials are supplied to the production line by just-in-time. The good system can avoid the replicated ordering from shortage part.

The customer expected the delivery on time according to customer requested date. Then the inventory control can manage the production plan to product the goods in time. The customer satisfaction is not able to evaluated the value, but the customer satisfaction strongly effect to the long-term business. Most factories have the main policy to increase the customer satisfaction of each customer every year

The mentioned cost is the criteria factor to make decision. The Economic Order Quantity (EOQ) is the one of solution for the optimal Holding cost and ordering cost. The relation between related cost with ordering and holding cost, has been shown at below Figure 2.1.



1: Mark, M. Davis, Nicholas, J. Aquilano, and Richard, B. Chase, **Fundamentals of Operations Management, 2003: 610.**

Figure 2.1 Annual product cost line graph

Inventory is the item stock or resource to meet customer demand. Normally, manufacturing inventory classified into five sections: raw materials, finished products, component parts, supplier, and work in process. Three principal costs of operating inventory systems are ordering, holding are shortage costs.

- **Holding costs:** Holding costs or carrying costs are the cost of holding one unit of an item in a period of time. These costs are varying with the level of inventory. Holding costs are consisted of capital cost, storage costs (land, and building-own, leased, or rented), service costs (assessments-taxes and insurance, processing-material handling and physical inventory), risk costs (obsolescence costs and shrinkage costs-pilferage, disappearance, damage, spoilage, and devaluation of selling price). These are expressed as Baht per unit per a period of time. Holding costs are those costs that increase with the size of the inventory. Usually most of these costs is a function of the value of the inventory. If the item in inventory is purchased, it will be valued at its purchase price. Holding costs are calculated, in baht per unit per unit time, by the product of the holding costs fraction and the unit costs. Holding cost is the costs of carrying items in inventory that come from the holding cost rate multiply by unit cost.

The holding cost can be estimated from:

1.) **Capital costs:** it is the money that invested in inventory and not available for use in the other areas. This cost is approximately 12% of inventory value.

2.) **Storage costs:** this inventory belongs to the factory, not rented and leased so the storage costs is depended on depreciation, property taxes, insurance, or utilities. These costs are approximately 3% of the inventory value.

▪ **Ordering costs:** it is the processing costs that occur from preparing to purchase order or production order. Ordering costs start from inform order until to receive the items to storage. These are expressed as a Baht amount per order. This cost is always constant. It does not depend on the quantities of items but it changes into the number of orders. Ordering costs are the costs that increase with the number of orders placed. Ordering costs for purchased items includes the costs of some or all of the following :

- Preparation of purchase requisition
- Preparation of purchase order
- Mail
- Expediting, including telephone and telegraph
- Transportation
- Receiving
- Inspection
- Put away
- Updating inventory records
- Paying invoice

▪ **Stock out costs:** when raw materials or finished-goods inventory are not enough for demands, the costs will be occurred. Stock out can also include lost sales and dissatisfied customers. Shortage costs result when demand exceeds the supply of inventory on hand. The costs can include the opportunity cost of not making a sale, loss of customer goodwill, lateness charges, and similar costs. Excess inventory – Where the continued stocking of inventories can no longer be justified for such

reasons as obsolescence or physical deterioration, the inventories are in excess. Possible recourses include sale for scrap or reworking to the specifications of some active item.

2.2.1.1 Inventory factor Definition

- Reorder Point

Reorder point identifies the point of inventory level for reorder again when the inventory level fall to this point. Reorder point equals to the number of units used multiple by the lead time (demand during lead time) plus safety stock. The equation of re order point is:

$$RP = DDLT + SS$$

where

$$DDL T = \text{Demand during lead time} = d * LT$$

$$SS = \text{Safety stock}$$

- Safety Stock with Service Level

Safety stock is the amount of items to protect the uncertainty of demand. If the demand is higher than amount of stock, it is called stockout, safety stock will protect in this reason. Moreover, it protects the stockout when leadtime is uncertainty such as supplier delivery delay and. All of these are the event that effect to the financial risk. The amount of safety stock depends on the service level desired of a company policy. This Service level refers to the probability that a stockout will not occur during leadtime. Inventory control is subject to many uncertainties. Lead times may be longer than expected. The quantity rejected at inspection can only be estimated in advanced.. Safety stocks protect against failure to fill customer orders or satisfy the needs of manufacturing on time due to these uncertainties

In many situations customers do not provide information of their demands far enough in advance. To compensate for this problem there are two tactics. The first is to organize the customer to give more forewarning. more competitive

situations, however, the customer has more power and may not be prepared to wait. This puts the pressure on suppliers to reduce the lead times and better to forecast demand. The second option is to hold sufficient stock to cope with unexpected or excess demand. Safety stock is there to cover our inability to predict demand. The inventory manager has an investment choice. Those who can accurately predict the customer It is very useful to include all goods in the inventory management system as it provides unified records identification and control over all goods, and makes management and analysis easy.

$$SS = z\sigma_L = z\sqrt{LT * \sigma_d^2}$$

Where Z = the deviation in a standardized normal distribution (depends on the risky of stock out that a manager desire)

σ_L = standard deviation of lead-time demand

σ_d = standard deviation of demand per period

Standard deviation of demand per period (σ_d) is equaled to:

$$\sigma_d = \sqrt{\frac{\sum (o - \bar{o})^2}{n}}$$

Where \bar{o} = average demand in a period of time

n = the number of time periods

▪ **Material Cost (TMC)**

Total material cost is the sum cost of holding, ordering, and purchase cost. - Assume the purchase cost is a constant due to no quantity discounts. The equation is:

TMC = ordering cost + holding cost + purchase cost

$$TMC = C_o \left[\frac{D}{Q} \right] + C_h \left[\frac{Q}{2} \right] + pD$$

where p = unit cost

From total material cost, if TMC is regarded on purchase cost, it becomes total stocking cost (TSC).

2.2.2 ABC Classification analysis

Pareto analysis is the technique which forms the basis of inventory control thinking and is an important management principle which can be applied to minimize effort and to obtain best results. To gain best control, effort has to be directed to the most important areas. The Pareto curve (see Figure 2.2) is often called the '80/20 rule', the shape of the Pareto curve arises from the range of volumes and values combined in a statistical distribution. The shape of the curve does not always give exactly an 80/20 relationship, but this does not affect the principles of applying Pareto analysis to inventory management.

The high-value items are normally controlled tightly, whereas the low-value items are not treated as carefully and are issued in bulk in approximate quantities. Most effort should be put into managing items which are most important for achieving. Stores contain items ranging from main products to washers and labels, with a stock record for each. High stock value items need to be closely controlled, whereas minor items need not be treated as carefully. To control the resources of the company most effectively our effort and controls should be biased towards high cost areas. Pareto analysis formalizes our efforts to do this. It states that the majority of the effect is produced by a small proportion of the cause. (80 per cent of the effect is due to 20 per cent of the cause.)

The application of this to a stores stock control means that 80 per cent of the total stock value is made up from 20 per cent of the total stock items as stated. The other 80 per cent of stock items contribute only 20 per cent to the total inventory value. In a stock reduction exercise the majority of our cost saving will be gained by decreasing stocks of those few major items.

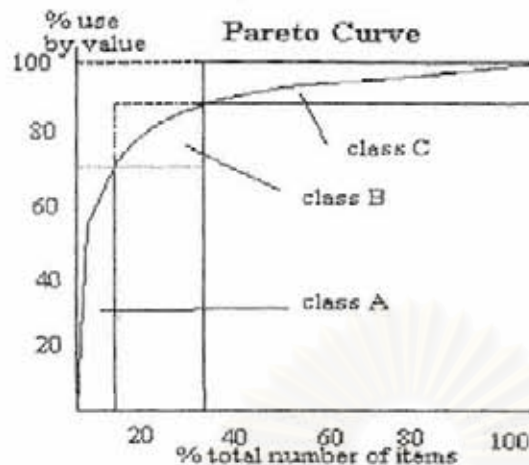


Figure 2.2 Pareto curve

As the above, we can briefly conclude as below,

A class

Category A, have to be controlled tightly using systems in conjunction with market expertise and product knowledge to maintain stock at the lowest appropriate level.

B class

For category B, it is lower values. it makes a waste of time to use specialist skill which could be working on category A. Then the inventory system should be applied on it such as EOQ system.

C class

For category C, should be controlled by a simple system which enables supply to be obtained with a minimum of administration. However, the control system for C items must be reliable and not result in stock outs or large excesses. An investment in extra stock of C class items is inexpensive but can greatly simplify the problems of controlling large numbers of stock lines. There are many inventory system that suitable to control this group such as Min-Max and two bin method.

In practice the stocks could have control limits to avoid extremes of Inventory and an allowable stock cover range can therefore be set by the ABC inventory classes. Acceptable ranges for category A, B and C items are shown as:

- A class: between one and four weeks.
- B class: between two and eight weeks.
- C class: between three and twenty weeks.

2.2.2.1 Checking The demand rate whether fit with EOQ (Pipop Lalitaporn: 2543. 49-50)

Normally, EOQ formula is assumed that the consumption rate is in constant. But the real demand rate is Variance depend on seasonal. Therefore we have to prove whether the demand is proper to apply with EOQ by Peterson and Silver theory. They present the procedure step by step as below

(a) Calculate the estimated \bar{d} average demand per period

$$\bar{d} = \frac{1}{n} \sum_{i=1}^n d_i$$

(b) Calculate the estimated variance per the demand period as below formula

$$Est\sigma^2 D = \frac{1}{n} \sum_{i=1}^n d_i^2 - \bar{d}^2$$

When $Est\sigma^2 D$ = the estimated of variance D

(c) Calculate the estimate of relation of demand variance called that VC as below formula

$$VC = \frac{Est\sigma^2 n}{(\bar{d})^2}$$

It can be seen that \bar{d} average is constant and the estimated variance of D equal zero, then the VC value is zero. When VC value is going to close zero that mean the

constant demand is reasonable according to the assumption. SO the EOQ formula is proper to apply with these data.

When the VC value less than 0.2, the data can be apply with EOQ formula.

When the VC value more than 0.2, the data can not be apply with EOQ formula.

Then other formula like Dynamic Programming or random logic method of Silver-Meal is other solution.

2.2.2.2 Definition

Inventory is defined as a stock of goods. More generally, inventory can be regarded as an resource that has economic value. An inventory is made up of one or more items where each item is a unique supply item, raw material, purchased or manufactured part, assembly, or final product.

1. A stock point is a location at which an item can be stored. Generally, a warehouse will have many stock points, one for each item.

2. A stock-keeping unit (SKU) is an item held at a particular stock point. So three items, for example, each stocked in three warehouses would result in nine SKUs.

3. An allocation is a quantity on a requisition sent to the stockroom but not yet filled.

4. Net inventory is on-hand inventory less back orders and allocation. Inventory position is on-hand plus on-order inventory less back orders and allocation.

5. C = Unit price (baht per unit)

6. D = Usage rate (unit per year)

7. Dm = Average usage rate (unit/ month)

8. I = warehouse cost rate (% of inventory value)

9. I = warehouse cost (baht/unit/year)

10. K = Total cost (baht/ year)

11. P = Purchasing cost (baht/ times)

12. Q = Quantity demand (units)

13. R = Recording time (year)

14. R_m = Recording time (month)
15. SS = Safty stock (unit)
16. S_{max} = Inventory amount in highest level
17. S_{rop} =Reorder point
18. T = Lead time
19. TC = Total cost (Baht/ unit)
20. T_m = Purchasing lead time (month)
21. T_v = Lead time (years)
22. $T_v(m)$ = Lead time (month)
23. w = Warehouse cost (% of inventory value)
24. W = Warehouse cost (baht/ unit/ year)
25. σ = Standard deviation

2.2.2.3 ABC analysis by multi criteria

Analysing by Classical ABC is wide using, because it is simple and able to adapt for many situations. However the analyzing for annual usage is not enough, the main of Group C factor is leadtime, Therefore there are many methods to consider multiple criteria. One of the useful method is presented as below.

Flores and Whybark (1986) introduce the ABC analyzing by Multiple Criteria (Multi-criteria inventory classification : MCIC) such as Lead time, Part criticality, Commonality, Obsolescence and Substitutability. As a result, we can manage more efficient than the single criteria analysis(classical ABC)

At first, the data is analyzed by considering Annual Dollar usage.

The sample ABC analysis of MCIC method by sampling 100 parts as shown below
Table 2.1 Classify group by Baht usage,

	Manufacturing Firm	
Dollar- Usage Category	% of Item	% of Dollar Usage
A	5	80
B	15	15
C	80	5
Totals	100	100

Table 2.1 Classify group by Baht usage,

After that, the analyzing by lead time is the secondary step. The data is classified by the period of leadtime as Table 2.2 Criteria factor by Lead time.

	Manufacturing Firm
Criticality Category	Lead time
I	$L > 14$
II	$7 \geq L \leq 14$
III	$L < 7$

Table 2.2 Criteria factor by Lead time.

	Lead time				Totals
		I	II	III	
Baht Usage	A	14	2	5	21
	B	5	4	13	22
	C	49	25	113	187
Total		68	31	131	230

Table 2.3 Classification the parts by 2 criteria in Matrix model

For the above, there are re group as below,

$$AA = AI + AII + BI$$

$$BB = BII + AIII + CI$$

$$CC = CII + BIII + CIII$$

The sample result of MCIC method as below Table 2.4

Combined Category	Manufacturing Firm	
	% of Item	% of Dollar Usage
A	11	60
B	23	24
C	66	16
Totals	100	100

Table 2.4 The sample result of MCIC method

Constrain: this analyzing is invalid for analyzing more than 2 criteria and the equal important of each group.

2.2.2.4 GROUP AA

To minimize the purchasing cost, the ordering group the part produced with the same supplier into the one purchasing order. To save the involved cost, The inventory in this class is high value and purchasing cost, therefore the strictly control system is needed. Ordering multi parts in the same supplier with constant purchasing period, and the Purchasing period is considered by service level. The Formula has been shown as below.

Ordering various items with one supplier

$$T = \sqrt{\frac{2P}{\sum[(I+W)D_i]}}$$

$$Q_i = TD_i$$

$$SS_i = Z_i \sigma_{(M)_i} \sqrt{T_{V(M)_i} + T_{(M)_i}}$$

$$S_{(MAX)_i} = SS_i + Q_i$$

$$K = \sum[C_i D_i] + \frac{P}{I} + \sum\left[\frac{(I_i + W_i)Q_i}{2}\right] + \sum[(I_i + W_i)SS_i]$$

Spencer B. Smith: Computer based Production and inventory control 1989

2.2.2.5 GROUP BB

This group is the moderate unit price. Each part is ordering independently and the control system is also in strictly. Moreover the recording the usage history need accuracy, because this group have to define the ordering size, reorder point by EOQ (Economic Order Quantity) that manage continuously the stock level . When the stock reduced in the reorder point, the purchasing will order the constant quantity by considered service level.

EOQ (Economic Order Quantity)

$$Q = \sqrt{\frac{2DP}{(I+W)}}$$

$$SS = \frac{Z\sigma_{(M)}\sqrt{T_{V(M)}}}{\sqrt{R_{(M)}}}$$

$$= Z\sigma_{(M)}\sqrt{T_{V(M)}} \text{ when } R_{(M)} = 1$$

$$S_{(SOP)} = SS + D_{(M)}T_{V(M)}$$

$$S_{(MAX)} = SS + Q$$

$$K = CD + \frac{PD}{Q} + \frac{(I+W)Q}{2} + (I+W)SS$$

Pipop Lalitaphon , Planning and Production control system, 2539

2.2.2.6 GROUP CC

To control technique that based on head of worker, for example, the worker used own experience to estimate reorder point and order quantity. The inevitable effect of this technical is stock outs and excessive inventory. It is the most informal system. To achieve this problem, he offered Min-Max technique as explain below,

Min-Max technique

$Q = D*(3/12)$ The quantity order for 3 months

$SS = (0.1 \text{ or } 0.2) \times D$ The safety stock keep for 10 or 20 percents of annual usage.

$$K = CD + \frac{PD}{Q} + \frac{(I+W)Q}{2} + (I+W)SS$$

In addition, there are other methods to be properly control for Group CC. **Swann (1984)** researched the key to success of any system for management material flow control. He focused on improvement of inventory planning and control, then he present the comparison the visual review technique and principle techniques with Order point and Order quantity as below table.

Method	Order Point	Order Quantity
visual Review	Judgment	Judgment
Two - bin	Zero free stock	Bin size
Min/Max	Minimum	Max - Min
Statistical	Forecast of demand during replenishment lead time + safety stock	

Table 2.5 The comparison between visual view technique and principle technique

2.2.3 Improvement

2.2.3.1 Kanban

Kanban is an operational method, which achieves a pull system from within the company or from a supplier. When an item is demanded a request must be passed back to the source to provide another. This information can be a kanban card or a simple signaling system. The card will identify the item, the quantity required (ideally one, but possibly more) and where it is required. It will also state times so that performance can be monitored. This ticket or traveler has to be provided to the source very rapidly if the supply is to be prompt.

The ticket is held with the physical goods and is an easily maintained and simple method of informing the previous stage of supply. Using the principle of the ticket, there are other trigger mechanisms which can be used instead, such as colored lights or sound. The way information is transferred is immaterial so long as the process is instantaneous, completely reliable and accurate. Before the card system can

be put into place, substantial physical revision of the equipment and plant layout are necessary. Routings must be defined and fixed so that each part has a clear path through production, and so that in each plant there is only one source location for each part.

Each work center must be defined and organized so that inventory held only at the work centers and not in stockrooms. Each work center has an inbound stock point and an outbound stock point. Assembly lines have one or more inbound stock points that serve as staging areas, where material is organized for positioning in exactly the right location for easy access during assembly work. In effect, the entire plant becomes organized something like a stockroom. That is necessary if all active inventory is to be kept on the plant floor without confusion.

Move card. This card (Figure 2.3) authorizes the movement of the part number between a single pair of work centers. The card circulates between the outbound stock point of the supplying work center (where the part is made) and the inbound stock point of the center. The card is always attached to a standard container, parts when it is moved to the using work center. The information on a move card includes.

Production card. This card (Figure 2.4) authorizes the production of a standard container of parts to replace one just taken from an outbound stock point. These cards are used only at the supplying work center and its outbound stock point. Information on a production card.

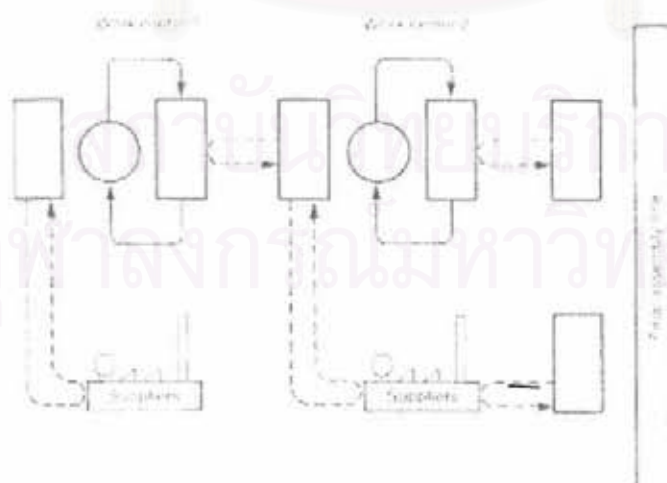


Figure 2.3 Move card

----- Move cards. These circulate between work centers as signals to advance standard containers of parts.

—— Production cards. These circulate at the producing work center to signal the need to replenish the outbound stockpoint with a standard container of parts.

When a container of parts is selected for use from the inbound stockpoint, the move card is detached and placed in a collection box. It will then be picked up and taken back to the supplying work center as authorization to get another container of parts. Move cards, therefore, circulate between only two work centers. Each designates only one part number

When a move card is brought to an outbound stockpoint to get parts, the production card is removed from the standard container selected. The move card is attached to the standard container, and it is transported back to the inbound stockpoint of the using work center ready for use.

Typical move card

FROM SUPPLYING WORK CENTER #52 PAINT	PART NO. A575 GAS TANK MOUNT	TO USING WORK CENTER #0 ASSEMBLY
OUTBOUND STOCKPOINT NO. 524	CONTAINER TYPE 7 (RED) NO. IN EACH CONTAINER 20 CARD NO. 3 NO. CARDS ISSUED 5	INBOUND STOCKPOINT NO. 2-1

Figure 2.4 Production card.

An outbound stockpoint supplying several parts might be organized by marking the spot on the floor or table on which each part number may be found. For many parts, the standard containers can be stacked on the floor at the designated spot.

Numbers may be painted on the floor. More likely they are painted on signs that rise above the floor.

The production card which was removed is placed in a collection box at the supplying work center. From time to time workers there collect these cards. Each production card collected is authorization to make another standard container full of parts to replace one that was just taken.

- All workers in the system have the obligation to provide parts to those who need them. Everyone must be able to come get what they need when they need it. This is most important because it overcomes the psychology that one must hoard parts to protect against the vagaries of the unreliable people who provide them. Therefore, the running of a schedule that is very near to that originally planned is important, and all workers must produce what is required to be produced. Only then does the system hold together.

In the inventory control term, Kanban are a lot of objective points as following

- Indicate process information and operation ordering

It monitor process information to show how many items in process. Moreover it is a tool to fix procedure and how many additional manufacturing.

- ▪ Eliminate the over stock

It control to manufacture as same as the customer order. The system can check and more manufacturing from the shortage Kanban, because it pull from the previous process. In the same way, this kind of manufacturing produce according to customer's requirement or "Pull manufacturing system".

2.2.3.2 Physical inventory

The operations that are needed to perform these functions efficiently are identified and establish standards for the tasks to be performed and the procedure.

The purpose of this operation is to count the real quantity of stock keeping units and compare it to the number in the report. The other benefit of this operation is to check the quality of stock keeping units then; both quantity and quality of stock keeping units in storage area are supported to be checked at this operation.

There are 2 methods to operate physical inventory:

- Periodic physical Inventory, Usually, this method has been done once a year and its main purpose is to check quantity of stock keeping units. To do this operation, most of other functions in warehouse should be stopped until it is finished.

Many errors in warehouse operation that have been overlooked for a whole year will be unveiled by this operation. It means that it is difficult to identify the causes of these errors.

- Cycle counting. This method can overcome disadvantages of periodic physical inventory. It need operators who have to do this operation regularly as their routine job. It can find errors immediately so it is easy to track back to the root cause of the errors.

2.2.3. 4 Reporting

The last activity of storage function is a paper work or record keeping of all activities in warehouse. In the modern day, most ware houses operate this activity through computer system and warehouse software.

2.2.3.5 Aggregate Inventory Measurement

The evaluation of inventory performance **Susan Thomas and Michael Kilpatrick(2001: B1 – B5)** have many type of KPI (Key Performance Indicator) to identify how much the system can be improve after implement the new inventory system

Inventory Turnover.

Inventory turnover is the number of times the total inventory dollars is used by inventory customers in a given period of time. The average total dollar value of items held in inventory for the year can be calculated by taking the average of total dollar inventory. it measured at different times during the year (for example, at the end of each month, or the beginning and ending levels for the year). Turnover can be calculated for any time period.

Inventory Turnover Ratio = Annual Sale / Average Inventory

Total Inventory Dollars

Total inventory dollars is the total cost to the transit agency of all items held in inventory at a given point in time. It is calculated by multiplying the number of units for each item times the item's unit cost, and summing across all items. This indicator measures the size of inventory in terms of the dollars that the transit agency has tied-

up in inventory assets. It is best used to monitor changes in the size of inventory (increases and/or decreases) by examining the value at different points in time.

Months on Hand

Months on hand is the number of months that a transit agency's inventory will last if no additional items are added to inventory. Months on hand is the inverse of monthly inventory turnover. It is another way to measure the size of inventory relative to the demand for inventory over a specific time period. It is calculated by dividing the average total inventory dollars for a month by the total dollars used from inventory during the month. The fewer months that a transit agency must keep on hand to support the demand for inventory items, the better the performance relative to minimizing inventory levels. This indicator can also be calculated for different time periods, such as days on hand or years.

Percent Inventory Carrying Cost

The percent inventory carrying cost is the cost of maintaining inventory divided by the total dollar value of the inventory. The cost of maintaining inventory includes the following components:

- *Storage cost, the cost of storage space and equipment*
- *Insurance cost, the cost, if any, of insuring inventory*
- *Obsolescence, the cost of items that become obsolete*

Percent Obsolete Inventory

The percent obsolete inventory is the cost of obsolete inventory items divided by the total dollar inventory value. Although this indicator is also a component of carrying cost, many organizations track it separately. Items may become obsolete due to changes in the mix of vehicle series in the fleet, changes in parts design, changes in part quality specifications, etc. If these items remain in inventory, the transit agency will incur the cost of carrying items that it cannot use. This indicator assists in measuring the degree to which inventory management anticipates and reacts to changes in fleet mix and part storage requirements.

CHAPTER III

THE SYSTEM BEFORE IMPROVEMENT AND PROBLEM

3.1 The system before improvement and Problem

The current process has been shown as below Figure 3.1. The order will be sent by Fax from Sales to Engineering department, then the order are broken down in to Bill of material(BOM). All of the part list will be sent to Inventory department, they will be provided to production Dept if available. In case of shortage, Inventory will send Purchase requisition to Purchasing department. The following that the Purchasing side will issue Purchasing order and submit it to Supplier. The goods are sent directly to inventory. The inventory part will be divided to 2 portions that are the completed parts and machined parts.

The parts for 7 models are the total 144 items as below list

No	Item	Code	No	Item	Code
1	CYLINDER HEAD	P-5032-102	39	PISTON	P-50100-107
2	CYLINDER HEAD	P-5040-103	40	PISTON	P-50125-107
3	PISTON	P-5032-107	41	STOP TUBE	P-5040-118
4	PISTON	P-5040-108	42	PISTON ROD	P-5080-114
5	CYLINDER HEAD	P-5050-102	43	Cutter for cutting machine	W-6010-107
6	BARREL	P-5040-110	44	BUSH IN ROD BUSHING	P-5050-101
7	CYLINDER HEAD	P-5063-102	45	Sticker on box for 5032	C-6010-216
8	PISTON ROD	P-5032-114	46	Metal BELT	C-6010-102
9	PISTON ROD	P-5040-115	47	WIPER	P-5032-213
10	CYLINDER HEAD	P-5080-102	48	BUSH IN ROD BUSHING	P-5063-101
11	BUSH IN ROD BUSHING	P-5032-101	49	Pneumatic pipe for 5062 Size	C-6010-138
12	Pneumatic pipe for 5032 Size	C-6010-135	50	ROD SEAL	P-5050-111
13	PISTON	P-5050-107	51	Sticker on box for 5040	C-6010-217
14	Glue	W-6010-105	52	ROD SEAL	P-5063-111
15	BUSH IN ROD BUSHING	P-5040-102	53	U-RING	P-5032-212
16	BARREL	P-5032-109	54	REAR COVER	P-5050-105
17	Pneumatic pipe for 5040 Size	C-6010-136	55	BUSH IN ROD BUSHING	P-5080-101
18	ROD SEAL	P-5032-111	56	WIPER	P-5040-214
19	PISTON	P-5063-107	57	BARREL	P-50125-109
20	REAR COVER	P-5032-105	58	Pneumatic pipe for 5080 Size	C-6010-139
21	BACK UP WASHER	P-5040-101	59	BARREL	P-50100-109
22	ROD SEAL	P-5040-112	60	U-RING	P-5040-213
23	PISTON	P-5080-107	61	PISTON SEAL	P-5032-206
24	BARREL	P-5050-109	62	TUBE	P-5040-117
25	Operation suit	C-6010-101	63	Instruction book for 5032	C-6010-226
26	CYLINDER HEAD	P-60100-102	64	PLUG	W-6010-214
27	CYLINDER HEAD	P-50125-102	65	REAR COVER	P-5063-105
28	REAR COVER	P-5040-106	66	ROD SEAL	P-5080-111
29	EYE MOUNTING	P-6040-104	67	PISTON SEAL	P-5040-207
30	BARREL	P-5063-109	68	Instruction book for 5040	C-6010-227
31	PISTON ROD	P-5050-114	69	PISTON ROD	P-60125-114
32	Coaling water	W-6010-106	70	O-RING PISTON ROD	P-5032-106
33	Lubricant	W-6010-109	71	PISTON ROD	P-50100-114
34	BARREL	P-5080-108	72	O-RING COVER	P-5032-210
35	WELDING SET	W-6010-104	73	Protection foam	C-6010-234
36	PISTON ROD	P-5083-114	74	REAR COVER	P-5080-106
37	STOP TUBE	P-5032-103	75	NUT M 8	C-6010-203
38	Pneumatic pipe for 5050 Size	C-6010-137	76	PORT OIL SQUARE ELBOW(1)	P-5040-110

Table 3.1 all part lists for 7 model

No	Item	Code	No	Item	Code
77	PORT OIL SQUARE ELBOW(2)	P-5040-119	115	PORT OIL	P-5063-104
78	O-RING PISTON ROD	P-5040-209	116	O-RING PISTON ROD	P-5063-108
79	PORT OIL	P-5040-117	117	STOP TUBE	P-50100-103
80	STOP TUBE	P-5050-103	118	EYR PROTECTION for welding	W-6010-212
81	O-RING COVER	P-5040-211	119	Small box	C-6010-223
82	An-ti dust Powder	C-6010-225	120	Instruction book for 5080	C-6010-230
83	STOP TUBE	P-5063-103	121	O-RING PISTON ROD	P-5080-108
84	BUSH IN ROD BUSHING	P-50100-101	122	O-RING COVER	P-5063-110
85	BUSH IN ROD BUSHING	P-50125-101	123	PORT OIL	P-5080-104
86	Cap for Operator	W-6010-210	124	O-RING COVER	P-5080-110
87	Pneumatic pipe for 50100 Size	C-6010-140	125	WIPER	P-50125-213
88	Pneumatic pipe for 50125 Size	C-6010-141	126	U- RING	P-50125-212
89	PORT OIL	P-5032-104	127	WIPER	P-50100-213
90	Sticker on box for 5050	C-6010-218	128	Glove for operator	W-6010-208
91	ROD SEAL	P-50125-111	129	Sticker on box for 50100	C-6010-221
92	ROD SEAL	P-50100-111	130	Sticker on box for 50125	C-6010-222
93	STOP TUBE	P-5080-103	131	U- RING	P-50100-212
94	wire	W-6010-213	132	PISTON SEAL	P-50125-206
95	U- RING	P-5050-212	133	Robe for packing	C-6010-233
96	WIPER	P-5050-213	134	PISTON SEAL	P-50100-206
97	Sticker on box for 5062	C-6010-219	135	Plastic bag	W-6010-215
98	REAR COVER	P-50125-105	136	O-RING PISTON ROD	P-50125-108
99	REAR COVER	P-50100-105	137	Instruction book for 50100	C-6010-231
100	Ear protection	W-6010-211	138	Instruction book for 50125	C-6010-232
101	WIPER	P-5063-213	139	O-RING PISTON ROD	P-50100-108
102	U- RING	P-5063-212	140	PORT OIL	P-50125-104
103	PISTON SEAL	P-5050-206	141	PORT OIL	P-50100-104
104	Sticker on box for 5080	C-6010-220	142	O-RING COVER	P-50125-110
105	Instruction book for 5050	C-6010-228	143	O-RING COVER	P-50100-110
106	U- RING	P-5080-212	144	Big Box 12x	C-6010-224
107	WIPER	P-5080-213			
108	PISTON SEAL	P-5063-206			
109	O-RING PISTON ROD	P-5050-108			
110	PORT OIL	P-5050-104			
111	Instruction book for 5062	C-6010-229			
112	PISTON SEAL	P-5080-206			
113	STOP TUBE	P-50125-103			
114	O-RING COVER	P-5050-110			

Table 3.1 all part lists for 7 models (Cont.)

The limit for Inventory is set in Min-Max, that is possible to over stock and shortage. Because the Inventory do not consider Inventory cost and suitable safety stock. The ordering amount and period is decided by the operator's experience.

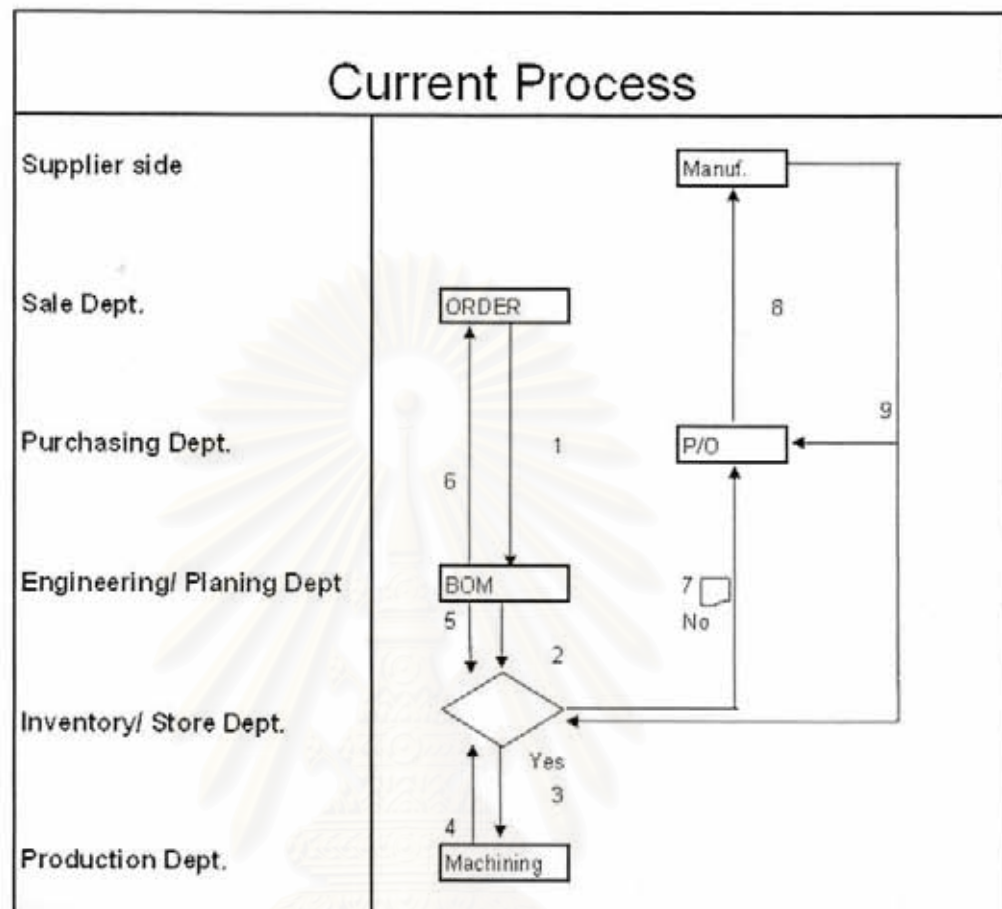


Figure 3.1. The current process

- **Organization system**

The organized structure is flat level, because the few employees operate. I would like to describe the structure of function as following.

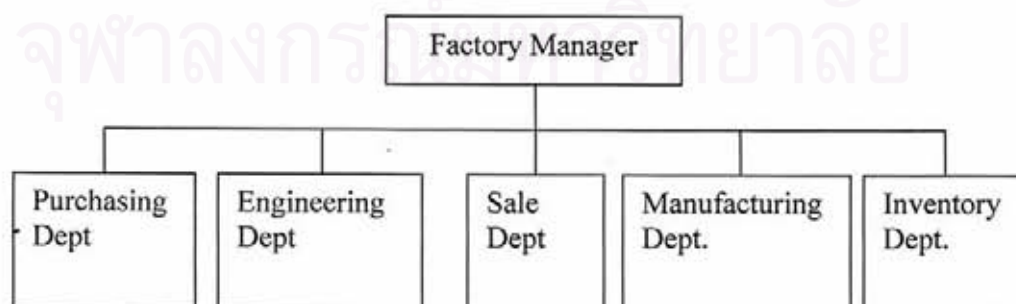


Figure 3.2 Organization chart

Inventory control is the activity which organizes the availability of items to the customers. It co-ordinates the purchasing, manufacturing and distribution functions to meet the marketing needs. The responsibility of each main position in factory has been described as below,

- **Factory Manager**

The Factory manager take care all concerned main activity in factory, the inventory control is one of his main responsibility because the higher stock mean the higher sunk cost in factory,

So the optimal stock level is the best solution. He designs the inventory system by MIN-MAX method with safety stock 20 percent of annual usage. However the person who direct involve and responsibility is Purchasing department. The proper system in inventory has not been created from this side.

- **Purchasing department**

They consider that stock control provides the opportunity for goods to be purchased so that optimum prices can be obtained. Buying items in bulk often reduces the purchase price and it improves the efficiency within the purchasing department. The ordering is set for 2 times per month from Manager Factory. For ordering, they use their experience without consideration Min-Max method. That has been seen from the total stock amount at the end of the year is more the Maximum stock than 300 % for some item. Moreover the shortage part often happen during a year.

- **Engineering department**

The department take care about the planning for production and make Bill of material when getting the order from Sale department to issue the part requirement form to Inventory. The another main duty is the crating the drawing of new part to order to Suphanburi province.

- **Sale Department**

The department has responsibility for selling the product for external area, and for the inter, they have to follow up the order status about finish date and the related document to Finance Dept.

- **Manufacturing Department**

All production process are active in this department area, there are main five operation area as mentioned in Chapter 1. This department have responsibility to check the quality of parts and products from incoming to outgoing.

- **Inventory Department**

The main responsibility is the providing the parts and material into the production line. And they will be ordering when the stock amount is less than the Engineering department's request. Another responsibility, they have to visual checking the exist amount and inform to Purchasing Department when the item level in few amount.

3.2 Identify the problem area

- **High excessive inventory.**

There are no proper inventory system to control when they should order and how many quantity is needed to run the production plan and keep the suitable stock level avoid the shortage event. The MIN-MAX method is not the good solution to optimal inventory cost, moreover the purchasing staff, who has direct responsibility for ordering, manage the inventory improper. The below sample table 3.2 to demonstration the Min-Max level without ABC analysis method and Safety stock level have been created by Factory manager.

No	Item	Code	MIN	MAX	Avr Q	T	Unit price	C	SS=0.2D	I	DxC	Holding Cost	SS Cost
3	BARREL	P-5040-110	83	118	34.58	24	480.00	83.00	38.00	388,400.00	1,251.00	3,002.40	
4	PISTON ROD	M-5032-314	87	148	48.50	20	335.00	87.00	25.13	324,950.00	1,226.98	2,453.95	
5	PISTON ROD	M-5040-315	83	127	43.68	19	370.00	83.00	27.75	307,100.00	1,218.82	2,317.85	
6	BUSH IN ROD BUSHING	P-5032-101	96	144	48.00	20	258.00	96.00	19.35	247,680.00	937.13	1,874.26	
7	Pneumatic pipe for 5032 Size	C-8010-135	105	158	52.50	20	250.00	105.00	18.75	262,500.00	883.48	1,988.87	
43	Operation suit	C-6010-101	13	48	32.50	4	1,200.00	13.00	90.00	156,000.00	2,930.84	1,172.28	
8	BUSH IN ROD BUSHING	P-5040-102	85	130	44.74	19	258.00	85.00	19.35	218,300.00	873.42	1,869.50	
9	BARREL	P-5032-108	100	148	47.82	21	214.00	100.00	18.05	214,000.00	772.55	1,822.35	
10	Pneumatic pipe for 5040 Size	C-8010-136	90	137	47.37	19	260.00	90.00	18.75	225,000.00	898.38	1,703.12	
11	REAR COVER	P-5032-105	108	161	51.90	21	188.88	108.00	14.75	214,368.00	774.57	1,826.81	
12	BACK UP WASHER	P-5040-101	89	138	48.84	19	208.00	89.00	15.80	185,120.00	738.88	1,403.84	
13	BARREL	P-5050-109	37	65	28.08	13	485.00	37.00	36.38	177,025.00	1,026.17	1,334.07	
14	REAR COVER	P-5040-106	90	137	47.11	19	165.00	90.00	12.38	147,750.00	591.10	1,123.09	
15	EYE MOUNTING	P-5040-104	96	144	48.00	20	160.00	96.00	12.00	153,600.00	584.33	1,188.66	
16	BARREL	P-5063-109	35	62	28.92	13	487.00	35.00	36.53	170,450.00	908.04	1,284.45	
17	PISTON ROD	M-5050-314	34	80	28.15	13	380.25	34.00	28.52	128,285.00	750.41	875.54	
18	BARREL	P-5060-108	26	50	23.84	11	480.35	26.00	38.78	127,481.00	873.36	960.89	
19	PISTON ROD	M-5063-314	29	51	23.33	12	385.38	29.00	29.90	107,900.00	678.43	814.11	
20	STOP TUBE	P-5032-103	108	158	53.00	20	98.80	108.00	7.40	104,516.00	401.13	802.28	
21	Pneumatic pipe for 5050 Size	C-8010-137	46	81	35.00	13	250.00	46.50	18.75	113,750.00	882.32	881.07	
22	STOP TUBE	P-5040-116	100	147	47.38	21	100.00	99.50	7.50	99,500.00	363.58	763.51	
23	PISTON ROD	M-5080-314	23	44	20.91	11	395.25	23.00	29.84	90,907.50	623.45	885.80	
24	Glue	W-8010-105	135	194	58.70	23	230.00	135.00	17.25	230,000.00	1,072.88	2,352.17	
25	Cooling water	W-8010-108	88	134	48.32	19	150.00	88.00	11.25	132,000.00	528.08	1,005.27	
26	Lubricant	W-8010-109	95	143	47.50	20	120.00	95.00	9.00	114,000.00	435.74	871.48	
27	WELDING SET	W-8010-104	145	214	69.05	21	65.00	145.00	4.98	94,250.00	348.59	732.03	
28	Cutter for cutting machine	W-8010-107	55	147	91.87	6	130.00	55.00	9.75	71,500.00	909.65	545.79	
29	CYLINDER HEAD	M-5032-302	99	149	49.50	20	1,250.00	99.00	93.75	1,237,500.00	4,649.21	9,298.43	
30	CYLINDER HEAD	M-5040-303	90	137	47.11	19	1,280.00	89.50	96.00	1,145,600.00	4,530.28	8,607.53	
31	PISTON	M-5032-307	100	150	50.00	20	750.00	100.00	56.25	750,000.00	2,821.19	5,842.35	
32	PISTON	M-5040-308	85	132	47.22	19	760.00	85.00	57.00	646,000.00	2,698.86	4,859.74	
33	CYLINDER HEAD	M-5050-302	32	57	24.82	13	1,300.00	32.00	97.50	418,000.00	2,404.27	3,125.55	
34	CYLINDER HEAD	M-5063-302	36	64	27.69	13	1,300.00	36.00	97.50	468,000.00	2,704.80	3,516.25	
35	CYLINDER HEAD	M-5080-302	25	47	22.27	11	1,310.00	24.50	98.25	320,950.00	2,192.16	2,411.38	
36	PISTON	M-5050-307	36	83	27.31	13	790.00	35.50	59.25	280,450.00	1,622.72	2,109.53	
37	PISTON	M-5063-307	29	54	25.91	11	790.38	28.50	59.28	225,252.80	1,540.31	1,694.34	

Table 3.2 Min-Max level without ABC analysis method and Safety stock level

No	Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	DeTx
3	P-5040-110	30	30	30	30	40	40	30	30	40	40	50	20	830
4	M-5032-314	80	30	40	80	80	60	50	80	50	55	30	35	970
5	M-5040-315	80	30	30	40	40	30	35	30	30	80	50	50	830
6	P-5032-101	80	30	40	50	60	60	50	60	50	65	80	80	960
7	C-8010-135	80	20	35	35	80	45	50	55	55	70	70	65	1050
43	C-6010-101	40	50	30	30	30	30	30	30	30	30	30	30	130
8	P-5040-102	30	30	30	40	55	35	40	30	50	60	80	35	850
9	P-5032-108	50	40	80	80	40	40	55	35	30	40	30	80	1000
10	C-8010-136	80	40	50	60	60	50	60	50	55	50	30	60	900
11	P-5032-105	80	30	35	35	80	20	45	50	55	55	70	70	1080
12	P-5040-101	80	30	30	30	30	40	40	40	35	40	50	60	890
13	P-5050-108	40	55	55	35	35	20	20	20	10	10	20	30	385
14	P-5040-106	80	35	30	30	30	40	40	40	35	40	50	75	892
15	P-5040-104	80	30	40	50	60	60	50	60	50	65	80	80	980
16	P-5063-109	40	55	40	35	20	20	20	10	10	20	30	20	350
17	M-5050-314	40	40	60	40	20	20	20	10	10	20	20	20	340
18	P-5060-108	35	15	20	20	20	20	20	20	20	30	40	20	280
19	M-5063-314	15	15	20	20	20	20	20	30	30	30	40	20	280
20	P-5032-103	80	80	60	60	60	50	80	60	55	50	60	40	1080
21	C-8010-137	80	50	55	35	50	40	40	15	10	20	30	20	455
22	P-5040-116	50	40	40	60	60	30	80	80	55	60	80	55	925
23	M-5080-314	35	45	20	20	20	10	10	10	20	20	20	20	230
24	W-8010-105	80	50	50	80	80	80	80	50	50	80	80	80	1250
25	W-8010-108	80	30	30	40	55	35	40	30	50	60	80	30	880
26	W-8010-109	50	30	40	50	60	60	50	50	50	30	60	20	850
27	W-8010-104	80	80	80	150	70	70	100	150	80	80	65	65	1450
28	W-8010-107	100	50	100	100	100	100	100	100	100	100	100	100	550
29	M-5032-302	80	80	40	50	60	80	80	50	55	50	30	80	890
30	M-5040-303	80	30	40	60	80	45	60	50	55	50	30	60	895
31	M-5032-307	80	50	50	60	80	50	80	50	55	50	30	80	1000
32	M-5040-308	80	30	40	60	80	50	80	50	55	50	30	60	850
33	M-5050-302	40	40	40	30	30	15	15	10	10	20	20	20	320
34	M-5063-302	40	50	55	35	20	20	20	10	10	20	30	20	380
35	M-5080-302	20	15	20	20	20	20	20	20	20	20	30	40	245
36	M-5050-307	40	50	50	35	20	20	20	10	10	20	30	20	355
37	M-5063-307	45	15	30	20	20	20	20	25	20	20	30	40	205

The table 3.3 the ordering record from Jan to Dec'06

As the above table, it can be seen that the quantity and ordering period are not base on inventory theory. They decide to use MIN-MAX for all items, that is not the

best ways to optimal cost and maintain the production plan. Therefore the inventory system is needed to be more efficiency.

- **Ordering system**

The ordering system in the moment of this industry is using the worker to count the amount of raw material. It means the workers count the rest of raw material: He stock. If it seems the raw material is almost minimum safety stock or not enough for next production, the workers will inform to the purchasing department to order new set of raw material. The ordering system in the moment of this industry is using the worker to count the amount of raw material. The worker estimate when he should order from the rest of raw material in the stock. The KPI of inventory department found the increase of shortage part in critical parts and exceed amount for most items at the end of the year. From this situation, the operators have not the proper method and suitable procedure to control the inventory. Therefore this study will find out this problem. This industry is the Hydraulic Cylinder industry, so all composition of product involves the mechanical part. The lifetime of all compositions is not long lifetime because the problem of rust, wear and tare, humidity and environment factor. So the factory doesn't want to keep a number of stocks. The total inventory stock is over 15 million Bath, This measurement shows that the inventory control does not use the suit method to control the inventory.

- **Physical Inventory**

Due to there is no report about amount of item in stock, there are no cycle counting and the proper document, which needs operators to check stock regularly as their routine job. Their routine checking is when they pick an item from storage and they notice that it is nearly running out of stock, the staff will inform an administrator to order an item into a warehouse. By the way, there is a periodic physical inventory which has been done once a year and its main purpose is to check quantity of stock, to do this activity, most of other function is warehouse should be stopped until it is finishes and all staff must do it all together. Normally, this activity has been done during a Thai new year festival

- **Operation system**

The study of Inventory operation has founded that there is no system to know where they should store the product and all activities and depends on human memory to memorize it. Each operator has different to perform the warehouse activities. Beside that, the study had founded ; no record about the quantity of products in a warehouse. We can be said that the current warehouse management has no system at all work instruction of the warehouse is not suit to use as a storage area. Therefore the factory can not control the movement and storage of a inventory because of these reasons:

(a) It depends on human memory and experience which is good enough for Small warehouse but when the company has expanded and there are more in a warehouse. Human memory can not remember all of the information to control the items in the warehouse.

(b.) The storage area is messes up because there is no system to indicate the area for a particular item and no manual to guide the operators what to do the warehouse equipment is not fit with the storage products so it is waste of space in a storage area. there is no system or data recording to provide information about each product and remained available storage areas in the warehouse so it is high inventory and high dead stock.

Sometime the operators do not know the products that they need to find cause they use their memory to memorize the product's characters and to identify it. the study has been done, the study shows that the current warehouse system has created many problems for a company and these problems the performance of the warehouse operation and company prosper directly. beconcluded that these problems occur in most company that don't realize the warehouse management.

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The stocking is not good procedure to keep in the right plan and as below Figure

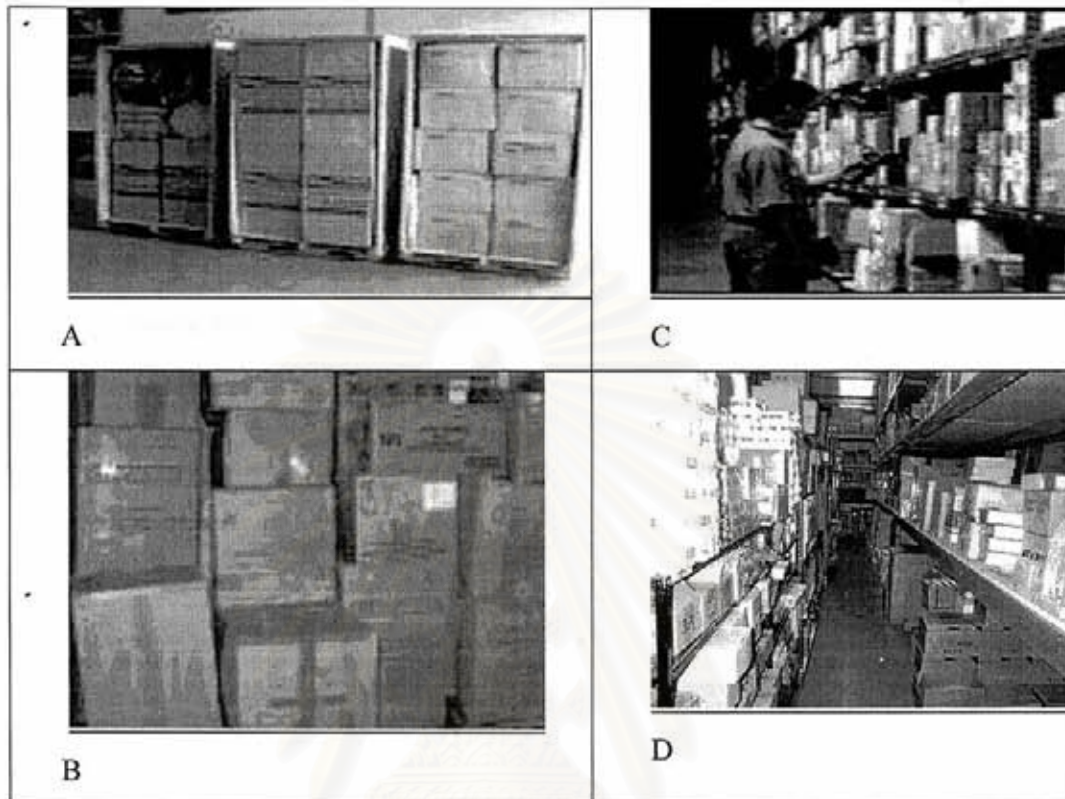


Figure 3.3 current inventory stock

The above Picture A is the incoming shipment to the inventory store, then the staff will expose the big box to individual box in the store area. Because a few operator and no strictly work instruction for Inventory staff, the incoming box will be lay on the floor as long as they have to use it or the new shipment coming, as it can be seen in Picture B. when the parts have been kept on the shelf, it has not the tag to identify what the product is and how many part it has. Moreover the stocking is combine of important part and non-important parts in the same stock. Therefore the mentioned above problem often happen continuously.



CHAPTER IV

METHODOLOGY

4.1 ABC analysis with multi criteria

Steps in doing the ABC analysis are:

- 1.) Determine the annual demand usage in each raw material
- 2.) Multiply the annual demand usage of each raw material by the cost of the items to obtain the total annual Baht usage of each raw material.
- 3.) Sum of annual cost of each raw material to get annual inventory expenditure
- 4.) Take annual cost demand usage in each raw material divided by annual inventory expenditure to obtain the percentage of aggregate usage.
- 5.) Rearrange raw material from highest percentage to lowest percentage
- 6.) Review annual usage distribution and classify raw materials into class

A, B, and C. Classify the Leadtime of each item into I, II or III class according to Regulation. Rearrange new group into group AA BB and CC as below,

$$AA = AI + AII + BI$$

$$BB = BII + AIII + CI$$

$$CC = CII + BIII + CIII$$

Baht - Usage				
Category	No. of Item	% of Item	BHT usage	% of Usage
A	44	30.56	10,351,840	79.71
B	45	31.25	1,909,722.50	15.39
C	55	38.19	630,614.00	4.89
SUM	144	100.00	12,892,176.5	100.00

Table 4.1 Classify group by Baht usage

Class	Lead Time (day)	Lead Time category	No. of Item	% of items
I	$L > 14$	I	10	6.94
II	$14 \geq L \geq 7$	II	103	71.53
III	$L < 7$	III	31	21.53
		Total	144	100.00

Table 4.2 Criteria factor by Lead time.

	I	II	III	Total
A	1	41	2	43
B	2	31	12	46
C	7	31	17	55
		103	31	144

Table 4.3 Classification the parts by 2 criteria in Matrix model

$$\begin{aligned}
 AA &= AI+ AII+ BI \\
 BB &= BII+ AIII+ CI \\
 CC &= CII+ BIII+ CIII
 \end{aligned}$$

The ABC , analyzed by classic method, as follow

Class	BTH usage	% BTH	No of item	% no of item
A	10,276,840.00	79.71	43	29.86
B	1,984,722.50	15.39	42	29.17
C	630,614.00	4.89	59	40.97
	12,892,176.50	100.00	144	100.00

Table 4.4 ABC analysis by Classic method

For the detail of the parts lists for each group, The steps have been shown in Appendix A.

The summary of ABC analysis with multiple criteria.

Class	Baht Usage	% BHT	No of item	% no of item
AA	10,439,340.00	80.97	46.00	31.94
BB	1,335,138.00	10.36	38.00	26.39
CC	1,117,698.50	8.67	60.00	41.67
	12,892,176.50	100.00	144.00	100.00

Table 4.5 ABC analysis by multi criteria

4.2 Implement the inventory system

4.2.1 Checking the demand rate whether fit with EOQ

Normally, EOQ formula is assumed that the consumption rate is constant. But the real demand rate is variance depend on seasonal. Therefore we have to prove whether the demand is proper to apply with EOQ by Peterson and Silver theory.

They present the procedure step by step as below

- 1.) Calculate the estimated average demand per period

$$\bar{d} = \frac{1}{n} \sum_{i=1}^n d_i$$

- 2.) Calculate the estimated variance per the demand period as below formula

$$Est\sigma^2 D = \frac{1}{n} \sum_{i=1}^n d_i^2 - \bar{d}^2$$

When $Est\sigma^2 D$ = the estimated of variance D

- 3.) Calculate the estimate of relation of demand variance called that VC as below formula

$$VC = \frac{Est\sigma^2 n}{(d)^2}$$

It can be seen that d average is constant and the estimated variance of D equal zero, then the VC value is zero. When VC value is going to close zero, that mean the constant demand is reasonable according to the assumption. SO the EOQ formula is proper to apply with these data.

When the VC value less than 0.2, the data can be apply with EOQ formula.

When the VC value more than 0.2, the data can not be apply with EOQ formula. Then other formula like Dynamic Programming or random logic method of Silver-Meal are other solution.

	Model							SUM
	5032	5040	5050	5063	5080	50100	50125	
JAN	70	50	20	20	15	5	5	185
FEB	70	50	20	20	15	5	10	190
MAR	90	70	30	20	20	10	10	250
APR	95	85	30	30	20	10	10	280
MAY	90	85	20	25	20	15	5	260
JUN	70	65	20	15	15	5	5	195
JUL	70	60	25	15	15	5	5	195
AUG	75	60	25	15	15	10	10	210
SEP	90	80	30	20	15	10	10	255
OCT	95	75	30	30	15	10	15	270
NOV	75	60	30	20	20	10	10	225
DEC	60	60	20	20	15	5	5	185
QTY	950	800	300	250	200	100	100	2700
AVRAGE	79.1667	66.6667	25	20.8333	16.6667	8.33333	8.33333	
n	12	12	12	12	12	12	12	
d ²	76800	55000	7750	5500	3400	950	950	
(d-) ²	6267.36	4444.44	625	434.028	277.778	69.4444	69.4444	
Est.varD	132.639	138.889	20.8333	24.3056	5.55556	9.72222	9.72222	
VC	0.02116	0.03125	0.03333	0.056	0.02	0.14	0.14	

Table 4.6 Production plan with the calculation

The VC of all seven model are lower 0.2, that mean the data can be use with EOQ method.

4.2.2 Holding cost

Holding costs or carrying costs are the cost of holding one unit of an item in a period of time. Holding costs are consisted of capital cost, storage costs (land, and building-own, leased, or rented), service costs, risk costs. These are expressed as Baht per unit per a period of time. Holding costs are those costs that increase with the size of the inventory.

The holding cost in this warehouse can be estimated from:

a.) Capital costs: it is the money that invested in inventory and not available for use in the other areas.

b.) Storage costs: this inventory belongs to the factory, not rented and leased so the storage costs is depended on depreciation, property taxes, insurance, or utilities.

From the below Holding cost, we calculate average Holding cost from January to March, and the machining cost is add in the part of 3xx group. Because the value of the 3xx group part increase when passed the machining process.

(A) Warehouse Expend			
No.	Description	Cost	Remark
1	Inventory Staff	42,000	3,500 Bath/Month x 12 Month = 42,000 Bath
2	Depreciation of factory	100,000	20,000 Bath/Month x 12 Month = 240,000 Bath
3	Maintenance	20,000	
4	Factory insurance	50,000	
	Total	212,000	Per year
		17,667	Per Month

(B) Holding cost (W + I)

Month	Holding cost (Baht)				Total
	1xx	2xx	3xx		
			Mat.	M/C	
Jan	435,218	76,410	412,990	182,860	1,107,477
Feb	383,648	120,505	412,990	188,480	1,105,622
March	502,987	100,508	563,750	247,880	1,415,125
Total	1,321,853	297,423	1,389,729	619,220	3,628,224
%	36.43	8.20	38.30	17.07	100.00
Total (Average per month)					1,209,408

Table 4.7 Holding cost

MLR of Thai commercial bank at 2006(i)

$$\begin{aligned}
 &= 7.5 \% \\
 I &= 0.075 \times \text{unit cost} \\
 \text{Warehouse cost (W)} &= 17,667 \times 100 / 1,209,408 \\
 &= 1.4608 \% \text{ Per month} \\
 &= 17.52924 \% \text{ Per Year} \\
 &= 0.1753 \text{ baht/unit/year}
 \end{aligned}$$

$$\begin{aligned}\text{Therefore Holding cost} &= W + I \\ &= W + (I \times C)\end{aligned}$$

Production plan	Model							SUM
	5032	5040	5050	5063	5080	50100	50125	
JAN	70	50	20	20	15	5	5	185
FEB	70	50	20	20	15	5	10	190
MAR	90	70	30	20	20	10	10	250

Table 4.8 Machining cost/ Unit

Machine cost/ Unit	Model							SUM
	5032	5040	5050	5063	5080	50100	50125	
Cylinder head	589	600	610	612	630	650	655	4346
Piston	250	252	255	260	278	290	300	1885
Piston Rod	120	124	130	135	144	158	169	980

Table 4.9 Production plan for Machining parts over three month

Machining cost / month		Model							SUM
		5032	5040	5050	5063	5080	50100	50125	
JAN	Cylinder head	41,230.00	30,000.00	12,200.00	12,240.00	9,450.00	3,250.00	3,275.00	111,645.00
	Piston	17,500.00	12,600.00	5,100.00	5,200.00	4,170.00	1,450.00	1,500.00	47,520.00
	Piston Rod	8,400.00	6,200.00	2,600.00	2,700.00	2,160.00	790.00	845.00	23,695.00
								TOTAL	182,860.00
FEB	Cylinder head	41,230.00	30,000.00	12,200.00	12,240.00	9,450.00	3,250.00	6,550.00	114,920.00
	Piston	17,500.00	12,600.00	5,100.00	5,200.00	4,170.00	1,450.00	3,000.00	49,020.00
	Piston Rod	8,400.00	6,200.00	2,600.00	2,700.00	2,160.00	790.00	1,690.00	24,540.00
								TOTAL	188,480.00
MAR	Cylinder head	53,010.00	42,000.00	18,300.00	12,240.00	12,600.00	6,500.00	6,550.00	151,200.00
	Piston	22,500.00	17,640.00	7,650.00	5,200.00	5,560.00	2,900.00	3,000.00	64,450.00
	Piston Rod	10,800.00	8,680.00	3,900.00	2,700.00	2,880.00	1,580.00	1,690.00	32,230.00
								TOTAL	247,880.00

Table 4.10 Machining cost

The total of machine cost each month from January to March is

January = 182,860.00 Baht

February = 188,480.00 Baht

March = 247,880.00 Baht

The total of mach is 619,220.00

4.2.3 Purchasing cost

The purchasing cost is the expense that occurred from ordering, there are main three supplier to supply the parts and material to the factory. Each supplier has the different of purchasing cost due to the purchasing pattern, Distant between the supplier to Factory and other costs. .therefore the purchasing cost detail of each supplier is described as below.

The summary of purchasing cost for each supplier

For 1xx P = 200 Baht

For 2xx P = 62 Baht

For 3xx P = 248 Baht

As we can see, the purchasing cost of 3xx is the highest cost when compared with the others, because the process must be part to Factory manager to consider about the ordering longer than normal process.

Purchasing Expend

No	Description	Factory Bkk.1xx	Remark
1	Purchasing Staff	101	21,000 Bath/Month /26 Days /8 Hr. /60 Min. x 60 Min. = 101Bath/Order
2	Approve cost from factory manager	72	60,000 Bath/Month /26 Days /8 Hr. /60 Min. x 15 Min. = 72Bath/Order
3	Telephone	12	3 Bath x 4 Times = 12 Bath/Order
4	Fax	9	3 Bath x 3 Times = 9 Bath/Order
5	Paper for P/R ,P/O	6	Include Electric Cost, Printer, Document
6	Transportation	0	
	Total	200	

Table 4.11 Purchasing Expense

No.	Description	Equip. Rangsit store 2xx	Remark
1	Purchasing Staff	50	21,000 Bath/Month /26 Days /8 Hr. /60 Min. x 30 Min. = 50Bath/Order
2	Appove cost from factory manager	0	
3	Telephone	6	3 Bath x 2 Times = 6 Bath/Order
4	Fax	0	
5	Paper for P/R ,P/O	6	Include Electric Cost, Printer, Document
6	Transporation		
	Total	62	

No.	Description	Factory Suphanburi 3xx	Remark
1	Purchasing Staff	101	21,000 Bath/Month /26 Days /8 Hr. /60 Min. x 60 Min. = 101Bath/Order
2	Appove cost from factory manager	120	60,000 Bath/Month /26 Days /8 Hr. /60 Min. x 25 Min. = 120Bath/Order
3	Telephone	12	3 Bath x 4 Times = 12 Bath/Order
4	Fax	9	3 Bath x 3 Times = 9 Bath/Order
5	Paper for P/R ,P/O	6	Include Electric Cost, Printer, Document
6	Transporation	0	
	Total	248	

Table 4.11 Purchasing Expense

4.2.4 Stock out cost

Stock out costs: when raw materials or finished-goods inventory are not enough for demands, the costs will be occurred. Stock out can also include lost sales and dissatisfied customers. Shortage costs result when demand exceeds the supply of inventory on hand. The costs can include the opportunity cost of not making a sale, loss of customer goodwill, lateness charges, and similar costs. Therefore the stock out cost is very important to aware and prevent its problem. The below table 4.12 shown the stock out cost when the parts shortage

Delay Delivery Expend 1 day			
No.	Description	Cost	Remark
1	Overtime of Production Worker	132	33 Bath/hr. x 4hr = 132 Baths
2	Express Purchase	100	
3	Express raw-mat delivery	100	
4	Work in overtime (800	200 Bath/hr. x 4hr = 800 Baths
5	Addition Transportation	500	
6	Telephone (to customer)	12	3 Bath x 4 Times = 12 Bath
	Total	1644	

Table 4.12 Stock out cost

After calculator the related parameter, the next step is analyze the optimal point to save the inventory cost and maintain to operate the production in satisfaction service level.

4.2.5 Group AA BB and CC analysis

4.2.5.1 GROUP AA

To minimize the purchasing cost, the ordering group the part produced with the same supplier into the one purchasing order. To save the involved cost. The inventory in this class is high value and purchasing cost, therefore the strictly control system is needed. Ordering multi parts in the same supplier with constant purchasing period, and the Purchasing period is considered by service level. The Fomula has been shown as below.

Ordering various items to one supplier

$$T = \sqrt{\frac{2P}{\sum[(I+W)D_i]}}$$

$$Q_i = TD_i$$

$$SS_i = Z_i \sigma_{(M_i)} \sqrt{T_{V(M_i)} + T_{(M_i)}}$$

$$S_{(MAX)_i} = SS_i + Q_i$$

$$K = \sum[C_i D_i] + \frac{P}{I} + \sum\left[\frac{(I_i + W_i)Q_i}{2}\right] + \sum[(I_i + W_i)SS_i]$$

Spencer B. Smith: Computer based Production and inventory control 1989

Therefore for this group, it must be separated for analyzing to three group of supplier. After getting the total cost of each group, the total cost will be calculated together. For this, the group AA 2xx will be shown the sample calculate for the total inventory cost and plot the total inventory cost at a period time.

➤ Group AA 2xx

Group AA 2xx												
Item	Code	Annual used							Unit price C	Material Cost DxC	Holding Cost $[(i+W) \times Q] / 2$	SS Cost $(i+W) \times SS$
		D=Σx	$T_{v(D)}$	I	W	Q	σ	SS				
Operation suit	C-8010-201	120	30	90.0	0.1735	10	19.54	45.6	1,200.00	144,000.00	453.02	4103.94
Instruction book for 5032	C-8010-226	950	30	3.8	0.1735	80	12.03	26.0	50.00	47,500.00	156.05	109.94
Instruction book for 5040	C-8010-227	800	30	3.8	0.1735	87	12.31	28.7	50.00	40,000.00	131.41	112.49
Ordering Time (T _v , Year)								0.084 time/year				
Ordering Time (T _v , Month)								1.00 time/month				
* Purchasing Cost (Bath/unit)		62										
* Service level at 95% (z)		1.845										
Material cost		231,500.00										
Ordering Cost (POT)		740.47										
Holding cost		740.47										
Safety stock cost		4326.37										
Total Cost (K)		237,307.31										

Table 4.13 the calculate of total inventory cost for Group AA 2xx

Item	Code	Annual used	Lead Time		Unit price
			$T_{v(D)}$	σ	C
Operation suit	C-6010-201	120	30	19.54	1,200.00
Instruction book for 5032	C-6010-226	950	30	12.03	50.00
Instruction book for 5040	C-6010-227	800	30	12.31	50.00

Table 4.14 Find Total Cost (K) of Group AA 2xx

1.) Interest Cost (Bath/unit/year)

$$I = i \times C \quad (\text{assume } i = 7.5\%)$$

$$I_1 = 0.075 \times 1200 = 90 \text{ Bath/unit/year}$$

$$I_2 = 0.075 \times 50 = 3.8 \text{ Bath/unit/year}$$

$$I_3 = 0.075 \times 50 = 3.8 \text{ Bath/unit/year}$$

2.) Warehouse Cost (Bath/unit/year)

$$W = 0.1753 \text{ Bath/unit/year}$$

3.) Ordering Time (Year)

$$T = \sqrt{\frac{2P}{\sum[(I+W)xD]}}$$

$$= \sqrt{\frac{2 \times 62}{[(90 + 0.1753) \times 120] + [(3.8 + 0.1753) \times 950] + [(3.8 + 0.1753) \times 800]}}$$

$$= 0.084 \text{ year}$$

$$T_m = 0.084 \times 12 = 1.00 \text{ month}$$

*Purchasing Cost (P) = 62 Bath/unit

4.) Order Quantity (Unit)

$$Q = T \times D$$

$$Q_1 = 0.084 \times 120 = 10 \text{ unit}$$

$$Q_2 = 0.084 \times 950 = 80 \text{ unit}$$

$$Q_3 = 0.084 \times 800 = 67 \text{ unit}$$

5.) Safety Stock (Unit)

$$SS = z \times \sigma_M \times \sqrt{Tvm + Tm} \text{ (at 90\% } z=1.28)$$

$$SS_1 = 1.28 \times 19.54 \times \sqrt{30/30 + 1} = 35.4 \text{ unit}$$

$$SS_2 = 1.28 \times 12.03 \times \sqrt{30/30 + 1} = 21.8 \text{ unit}$$

$$SS_3 = 1.28 \times 12.31 \times \sqrt{30/30 + 1} = 22.3 \text{ unit}$$

6.) Total Cost (Bath)

$$K = \sum(CD) + PxInt\left(\frac{1}{T}\right) + \sum\left[\frac{(I+W) \times Q}{2}\right] + \sum[(I+W) \times SS]$$

$$K = (1200 \times 120) + (50 \times 950) + (50 \times 800) + (62 \times 12) +$$

$$\left[\frac{(90 + 0.084) \times 10}{2}\right] + \left[\frac{(3.8 + 0.084) \times 80}{2}\right] + \left[\frac{(3.8 + 0.084) \times 67}{2}\right] +$$

$$[(90 + 0.084) \times 35.4] + [(3.8 + 0.084) \times 21.8] + [(3.8 + 0.084) \times 22.3]$$

$$= 236,347.36 \text{ Bath}$$

Table 4.15 The comparison of calculation for Group AA 2xx

Group AA 2xx							
T_n	T	$1/T$	P/T	C_uD	$(1-1/V) \times (Q/2)$	$(1-1/V) \times SS$	K
Reorder Time	Purchasing Time	Purchasing Cost	Material Cost	Holding Cost	SS Cost	Total Cost	
0.200	0.017	60.0	3,720.00	231,500.00	147.39	3,347.21	238,714.60
1.000	0.083	12.0	744.00	231,500.00	736.98	4,321.23	237,302.18
1.500	0.125	8.0	496.00	231,500.00	1,105.43	4,631.28	237,832.71
2.000	0.167	6.0	372.00	231,500.00	1,473.91	5,292.40	238,638.31
2.500	0.208	4.8	297.60	231,500.00	1,842.38	5,718.44	239,356.42
3.000	0.250	4.0	249.00	231,500.00	2,210.87	6,111.14	240,070.00

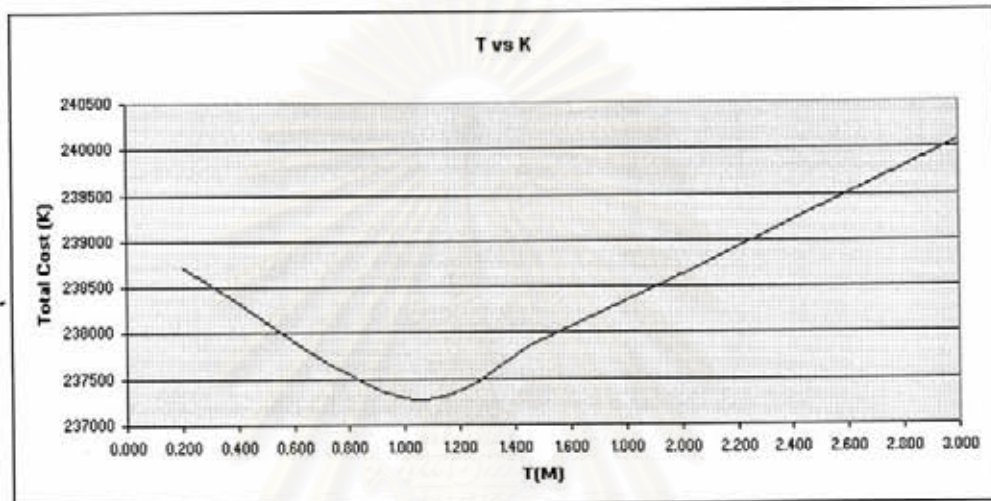


Figure 4.1 Graph T vs K for group AA 2xx

The method for group AA 2xx, the Purchasing will order by period. From the above calculate, **the purchasing once time a month for group 2xx to make optimal cost. For the quantity to order per times,**

➤ Group AA 1xx

The parts of group 1xx are the complete part that has been produced at the supplier site near by Rangsit area.

After calculated, the ordering period time **fore Group AA 1xx to make the minimum total inventory cost is 0.448 times per month or every 14 day.** The process and the result of calculation has been shown as below,

Group AA 1xx

Item	Code	Annual used	T _{re}	l	W	Q	σ	SS	Unit price		Material Cost	Holding Cost	SS Cost
									C	Cx			
BARREL	P-5040-110	800	7	36.0	0.1753	30	12.31	18.7	480.00	384,000.00	540.74	604.88	
BUSH IN ROD BUSHING	P-5032-101	950	7	19.4	0.1753	36	12.03	19.3	258.00	245,100.00	348.58	319.04	
Pneumatic pipe for 5032 Size	C-6010-135	950	7	18.8	0.1753	36	12.03	16.3	250.00	237,500.00	335.93	309.24	
BUSH IN ROD BUSHING	P-5040-102	900	7	19.4	0.1753	30	12.31	18.7	258.00	206,400.00	291.86	326.47	
BARREL	P-5032-109	950	7	16.1	0.1753	36	12.03	16.3	214.00	203,300.00	288.01	265.12	
Pneumatic pipe for 5040 Size	C-6010-136	800	7	18.8	0.1753	30	12.31	16.7	250.00	200,000.00	282.88	316.43	
REAR COVER	P-6032-105	950	7	14.7	0.1753	36	12.03	16.3	196.66	186,827.00	264.92	243.97	
BACK UP WASHER	P-5040-101	800	7	15.8	0.1753	30	12.31	16.7	208.00	166,400.00	235.80	263.77	
BARREL	P-5050-109	300	7	36.4	0.1753	11	4.77	8.5	485.00	145,500.00	204.88	238.81	
REAR COVER	P-5040-108	800	7	12.4	0.1753	30	12.31	16.7	165.00	132,000.00	187.80	209.84	
EYE MOUNTING	P-5040-104	800	7	12.0	0.1753	30	12.31	18.7	160.00	128,000.00	181.99	203.57	
BARREL	P-5063-109	250	7	38.5	0.1753	8	5.15	7.0	487.00	121,750.00	171.43	248.73	
BARREL	P-5060-109	200	7	38.0	0.1753	7	2.46	3.3	490.35	98,070.00	138.08	123.47	
STOP TUBE	P-5032-103	950	7	7.4	0.1753	39	12.03	16.3	98.50	93,870.00	134.38	123.70	
Pneumatic pipe for 5050 Size	C-6010-137	350	7	18.8	0.1753	13	7.02	9.5	250.00	87,500.00	123.76	180.45	
STOP TUBE	P-5040-116	800	7	7.5	0.1753	30	12.31	16.7	100.00	80,000.00	114.73	128.33	
Oxide	W-6010-105	1,000	10	17.3	0.1753	37	16.14	23.4	230.00	230,000.00	325.59	409.06	
Cooling water	W-6010-106	750	10	11.3	0.1753	28	9.65	14.0	160.00	112,500.00	160.11	160.36	
Lubricant	W-6010-109	900	10	9.0	0.1753	34	7.98	11.6	120.00	108,000.00	154.25	108.49	
WELDING SET	W-6010-104	1,500	10	4.8	0.1753	56	27.47	40.0	65.00	97,500.00	141.54	201.78	
Cutter for cutting machine	W-8010-107	800	10	9.8	0.1753	22	6.03	8.8	130.00	78,000.00	111.27	97.05	
BUSH IN ROD BUSHING	P-5050-101	300	7	18.0	0.1753	11	4.77	6.4	250.00	75,000.00	106.08	122.82	
ROD SEAL	P-5032-111	950	6	15.8	0.1753	36	12.03	15.5	210.00	199,500.00	282.66	247.17	
ROD SEAL	P-5040-112	800	5	15.0	0.1753	30	12.31	15.9	200.00	160,000.00	228.84	241.01	

Ordering Time (T_o/Year) 0.037 times/year
 Ordering Time (T_o/Month) 0.45 times/month
 * Purchasing Cost (Bat/yuni) 200
 * Service level at 95% (σ) 1.645

Material cost	3,776,517.00
Ordering Cost (PT)	5351.99
Holding cost	5,351.99
Bat/y stock cost	5,687.22
Total Cost (K)	3,792,908.20

Table 4.16 the calculate of total inventory cost for Group AA 1xx

Table 4.17 The comparison of calculation for Group AA 1xx

Group AA 1xx

T _H	T	1/T	P/T	Cx/D	(l-v)x(Q/2)	(l-v)xSS	K
Reorder Time	Purchasing Time	Purchasing Cost	Material Cost	Holding Cost	SS Cost	Total Cost	
0.200	0.017	60.0	12,000.00	3,776,517.00	2,386.88	4,549.55	3,795,453.53
0.448	0.037	26.8	5,352.36	3,776,517.00	5,351.62	5,687.09	3,792,908.07
0.500	0.042	24.0	4,800.00	3,776,517.00	5,967.46	5,895.61	3,793,180.27
1.500	0.125	8.0	1,800.00	3,776,517.00	17,902.38	9,032.55	3,805,051.93
2.000	0.167	6.0	1,200.00	3,776,517.00	23,869.83	10,246.69	3,811,833.53
2.500	0.208	4.8	960.00	3,776,517.00	29,837.29	11,331.43	3,818,645.72

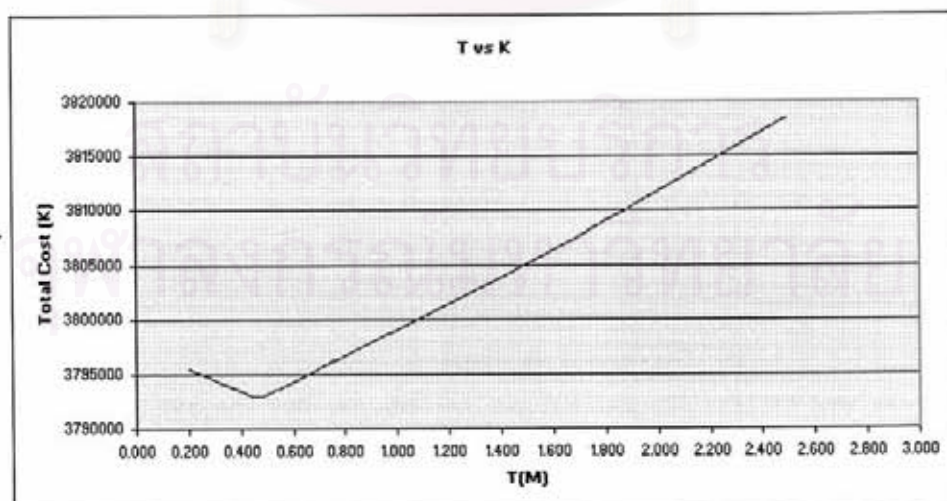


Figure 4.2 Graph T vs K for group AA 1xx

➤ Group AA 3xx

Table 4.18 the calculate of total inventory cost for Group AA 3xx

Item	Code	Annual used								Unit price	Material Cost	Holding Cost	SS Cost
		DxSx	T _{avg}	I	W	Q	σ	SS	C	DxC	(I+W)xQ/2	(I+W)xSS	
PISTON ROD	M-5032-314	980	7	28.10	1753	30	12.03	12.1	335.00	319,250.00	364.82	306.16	
PISTON ROD	M-5040-315	800	7	27.80	1753	26	12.31	12.4	370.00	298,000.00	357.68	345.79	
PISTON ROD	M-5050-314	300	7	28.40	1753	10	4.77	4.8	380.25	114,075.00	137.92	137.60	
PISTON ROD	M-5053-314	250	7	29.90	1753	8	5.15	5.2	385.36	96,340.00	118.39	180.83	
PISTON ROD	M-5080-314	200	7	29.80	1753	8	2.48	2.5	385.25	79,050.00	95.48	73.79	
CYLINDER HEAD	M-5032-302	950	14	93.80	1753	30	12.03	14.2	1,250.00	1,187,500.00	1428.61	1334.14	
CYLINDER HEAD	M-5040-303	800	14	96.00	1753	26	12.31	14.5	1,280.00	1,024,000.00	1231.86	1397.90	
PISTON	M-5032-307	950	14	56.30	1753	30	12.03	14.2	750.00	712,500.00	868.23	801.48	
PISTON	M-5040-308	800	14	57.00	1753	26	12.31	14.5	760.00	608,000.00	732.33	831.04	
CYLINDER HEAD	M-5050-302	300	14	97.50	1753	10	4.77	5.6	1,300.00	390,000.00	489.15	480.12	
CYLINDER HEAD	M-5053-302	250	14	97.50	1753	8	5.51	5.5	1,300.00	325,000.00	380.96	635.46	
CYLINDER HEAD	M-5080-302	200	14	98.30	1753	6	2.46	2.9	1,310.00	262,000.00	315.17	285.89	
PISTON	M-5050-307	300	14	59.30	1753	10	4.77	5.6	780.00	237,000.00	285.43	334.68	
PISTON	M-5083-307	250	14	59.30	1753	8	5.51	5.5	790.36	197,590.00	237.97	386.79	
PISTON	M-5080-307	200	14	59.30	1753	6	2.46	2.9	790.99	158,198.00	180.52	172.82	
CYLINDER HEAD	M-50100-302	100	14	98.80	1753	3	3.26	3.8	1,330.00	133,000.00	159.59	384.63	
CYLINDER HEAD	M-50125-302	100	14	98.10	1753	3	3.26	3.8	1,320.88	132,088.00	158.69	382.00	
PISTON	M-50100-307	100	14	60.40	1753	3	3.26	3.8	805.99	80,599.00	97.08	233.38	
PISTON	M-50125-307	100	14	60.10	1753	3	3.26	3.8	801.33	80,133.00	96.50	232.01	

Ordering Time (T_o/Year) 0.032 time/year
 Ordering Time (T_o/Month) 0.38 time/month
 * Purchasing Cost (Bath/unit) 248
 * Service level at 90% (z) 1.28

Total	6,431,323.00	7744.87	8976.40
Ordering Cost (P/T)		7744.87	
Total Cost (K)	6,455,789.14		

Table 4.19 The comparison of calculation for Group AA 3xx

T _o	T	I/T	P/T	CxD	(I+W)x(Q/2)	(I+W)xSS	K
Reorder Time	Purchasing Time	Purchasing Cost	Material Cost	Holding Cost	SS Cost	Total Cost	
0.200	0.017	60.0	14,880.00	6,431,323.00	4,031.12	10,149.11	6,460,363.22
0.384	0.032	31.2	7,743.05	6,431,323.00	7,745.79	11,530.40	6,458,340.14
0.500	0.042	24.0	5,952.00	6,431,323.00	10,077.79	12,326.73	6,459,679.53
1.000	0.083	12.0	2,976.00	6,431,323.00	20,155.59	15,276.05	6,469,730.64
1.500	0.125	8.0	1,984.00	6,431,323.00	30,233.38	17,739.99	6,481,280.37
2.000	0.167	6.0	1,488.00	6,431,323.00	40,311.17	19,900.63	6,493,022.81

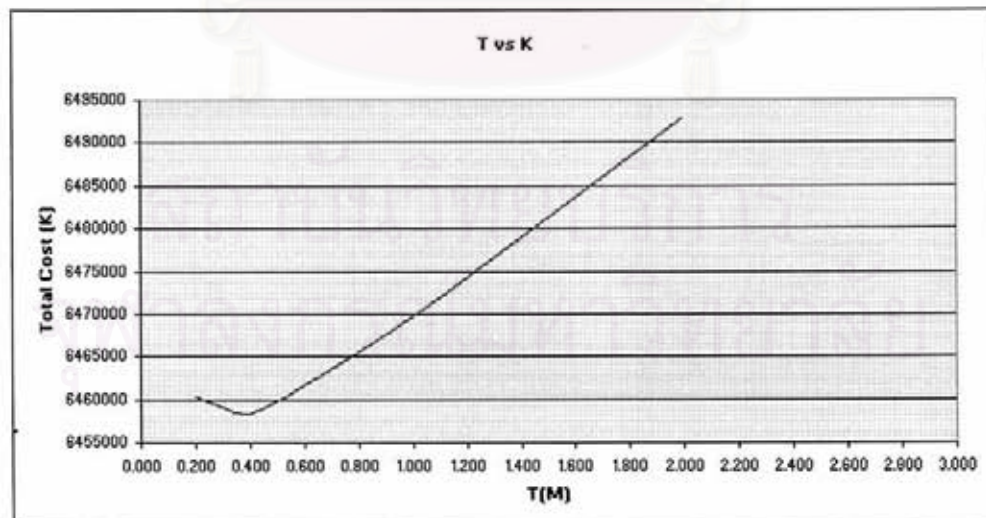


Figure 4.3 Graph T vs K for group AA 3xx

The ordering period time fore Group AA 3xx to make the minimum total inventory cost is 0.384 times per month or every 12 days

4.2.5.2 GROUP BB

This group is the moderate unit price. Each part is ordering independently and the control system is also in strictly. Moreover the recoding the usage history need accuracy, because this group have to define the ordering size, reorder point by EOQ (Economic Order Quantity) that manage continuously the stock level . When the stock reduced in the reorder point, the purchasing will order the constant quantity by considered service level.

EOQ (Economic Order Quantity)

$$Q = \sqrt{\frac{2DP}{(I+W)}}$$

$$SS = \frac{Z\sigma_{(M)}\sqrt{T_{V(M)}}}{\sqrt{R_{(M)}}}$$

$$= Z\sigma_{(M)}\sqrt{T_{V(M)}} \text{ when } R_{(M)} = 1$$

$$S_{(SOP)} = SS + D_{(M)}T_{V(M)}$$

$$S_{(MAX)} = SS + Q$$

$$K = CD + \frac{PD}{Q} + \frac{(I+W)Q}{2} + (I+W)SS$$

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Table 4.20 Find Total Cost (K) of Group BB

		Annual used	Lead Time		Purchase Cost	Unit price
Item	Code	D=σx	T _{v(D)}	σ	P	C
BUSH IN ROD BUSHING	P-5063-101	250	7	5.15	200	251.00

1.) Interest Cost (Bath/unit/year)

$$I = i \times C \text{ (assume } i = 7.5\%)$$

$$I = 0.075 \times 251 = 18.8 \text{ Bath/unit/year}$$

2.) Warehouse Cost (Bath/unit/year)

$$W = 0.1753 \text{ Bath/unit/year}$$

3.) Ordering Quantity (unit)

$$\begin{aligned} Q &= \sqrt{\frac{2DP}{I+W}} \\ &= \sqrt{\frac{2 \times 250 \times 200}{18.8 + 0.1753}} \\ &= 73 \text{ unit} \end{aligned}$$

4.) Safety Stock (Unit)

$$\begin{aligned} \cdot \quad SS &= z \times \sigma_M \times \sqrt{Tvm} \quad (\text{at } 90\% \text{ } z=1.28) \\ SS &= 1.28 \times 5.15 \times \sqrt{7/30} = 3.2 \text{ unit} \end{aligned}$$

5.) Stock at Reorder Point (Unit)

$$\begin{aligned} SS_{ROP} &= SS + [D_M + Tvm] \\ SS_{ROP} &= 3.2 + [(250/12) \times (7/30)] = 8 \text{ unit} \end{aligned}$$

6.) Total Cost (Bath)

$$\begin{aligned} K &= CD + \frac{PD}{Q} + \frac{(I+W)Q}{2} + (I+W)SS \\ K &= (251 \times 250) + \frac{200 \times 250}{73} + \frac{(18.8 + 0.1753) \times 73}{2} + (18.8 + 0.1753) \times 3.2 \\ &= 64188.92 \text{ Bath} \end{aligned}$$

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Table 4.21 The comparison of calculation for Group BB

Group BB											
Q	I	W	SS	SS _{pop}	DRQ	PDIQ	CoD	$(I+W)(Q/2)$	$(I+W)SS$	K	
					Purchasing Time	Purchasing Cost	Material Cost	Holding Cost	SS Cost	Total Cost	
50	18.825	0.1753	4.0922	8.9534	5.0000	1000.00	62,750.00	475.01	77.75	64,302.76	
60	18.825	0.1753	4.0922	8.9534	4.1667	833.33	62,750.00	570.01	77.75	64,231.10	
70	18.825	0.1753	4.0922	8.9534	3.5714	714.29	62,750.00	665.01	77.75	64,207.05	
73	18.825	0.1753	4.0922	8.9534	3.4247	684.93	62,780.00	693.51	77.75	64,206.20	
80	18.825	0.1753	4.0922	8.9534	3.1250	625.00	62,750.00	760.01	77.75	64,212.77	
90	18.825	0.1753	4.0922	8.9534	2.7778	555.56	62,750.00	865.01	77.75	64,238.32	

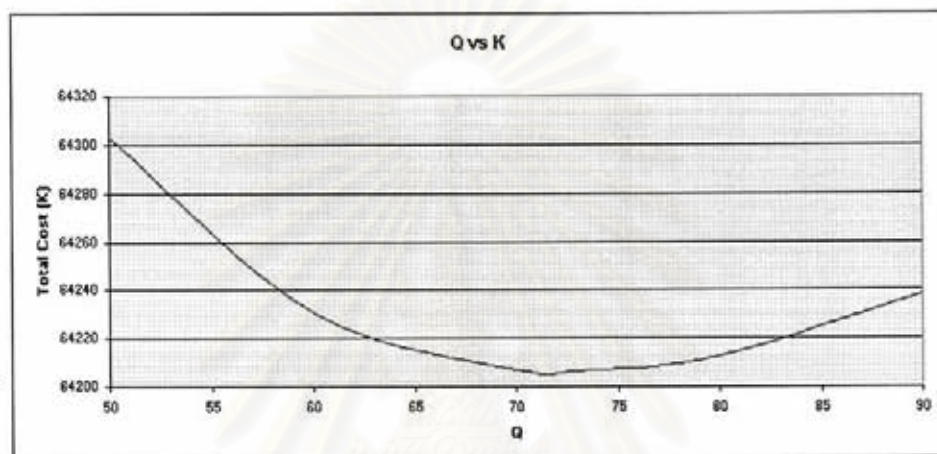


Figure 4.4 Graph Q vs K for group BB

For the Group BB, the purchasing will order when the stock level drop to the reorder point, we will consider about the quantity of individual item that make the minimum total inventory cost as present the above table. As the result, the calculated result of each item by mean of EOQ has been shown on **Appendix F**.

4.2.5.3 GROUP CC

To control technique that based on head of worker, for example, the worker used own experience to estimate reorder point and order quantity. The inevitable effect of this technical is stock outs and excessive inventory. It is the most informal system. To achieve this problem, he offered Min-Max technique as explain below,

$Q = D \cdot (3/12)$ The quantity order for 3 months

$SS = (0.1 \text{ or } 0.2) \times D$ The safety stock keep for 10 or 20 percents of annual usage.

$$K = CD + \frac{PD}{Q} + \frac{(I+W)Q}{2} + (I+W)SS$$

Group CC

Item	Code	Annual used					
		D=Σx	I	W	Q = D/6	SS=0.1D	P
WIPER	P-5032-213	950	5.1	0.1753	158.33	95.00	62
ROD SEAL	P-5050-111	300	15.5	0.1753	50.00	30.00	200
ROD SEAL	P-5063-111	250	15.7	0.1753	41.67	25.00	200
U- RING	P-5032-212	950	4.1	0.1753	158.33	95.00	62
WIPER	P-5040-214	800	4.7	0.1753	133.33	80.00	62
U- RING	P-5040-213	800	4.7	0.1753	133.33	80.00	62
ROD SEAL	P-5080-111	200	15.8	0.1753	33.33	20.00	200
PISTON SEAL	P-5040-207	800	3.8	0.1753	133.33	80.00	62
O-RING COVER	P-5032-210	950	2.9	0.1753	158.33	95.00	62
NUT M8	C-6010-203	21,600	0.1	0.1753	3,600.00	2,160.00	62
O-RING PISTON ROD	P-5040-209	800	3.0	0.1753	133.33	80.00	62
O-RING COVER	P-5040-211	800	2.6	0.1753	133.33	80.00	62
ROD SEAL	P-50125-111	100	16.1	0.1753	16.67	10.00	200
ROD SEAL	P-50100-111	100	15.8	0.1753	16.67	10.00	200
U- RING	P-5050-212	300	4.9	0.1753	50.00	30.00	62
WIPER	P-5050-213	300	4.9	0.1753	50.00	30.00	62
WIPER	P-5063-213	250	5.2	0.1753	41.67	25.00	62
U- RING	P-5063-212	250	5.2	0.1753	41.67	25.00	62
PISTON SEAL	P-5050-206	300	3.9	0.1753	50.00	30.00	62
U- RING	P-5080-212	200	5.4	0.1753	33.33	20.00	62
WIPER	P-5080-213	200	5.4	0.1753	33.33	20.00	62
PISTON SEAL	P-5083-208	250	4.0	0.1753	41.67	25.00	62
PISTON SEAL	P-5080-206	200	4.4	0.1753	33.33	20.00	62
WIPER	P-50125-213	100	6.0	0.1753	16.67	10.00	62
U- RING	P-50125-212	100	5.7	0.1753	16.67	10.00	62
WIPER	P-50100-213	100	5.7	0.1753	16.67	10.00	62
U- RING	P-50100-212	100	5.5	0.1753	16.67	10.00	62
PISTON SEAL	P-50125-206	100	4.5	0.1753	16.67	10.00	62
PISTON SEAL	P-50100-206	100	4.5	0.1753	16.67	10.00	62
STOP TUBE	P-5080-103	200	7.9	0.1753	33.33	20.00	200
wire	W-6010-213	2,100	0.8	0.1753	350.00	210.00	62
REAR COVER	P-50125-105	100	13.9	0.1753	16.67	10.00	200
REAR COVER	P-50100-105	100	13.5	0.1753	16.67	10.00	200
Ear protection	W-6010-211	90	15.0	0.1753	15.00	9.00	62
O-RING PISTON ROD	P-5050-108	300	3.2	0.1753	50.00	30.00	200
PORT OIL	P-5050-104	300	3.2	0.1753	50.00	30.00	200

Group CC

Item	Code	Annual used					
		D=Σx	I	W	Q = D/6	SS=0.1D	P
STOP TUBE	P-50125-103	100	8.7	0.1753	16.67	10.00	200
O-RING COVER	P-5050-110	300	2.8	0.1753	50.00	30.00	200
PORT OIL	P-5063-104	250	3.3	0.1753	41.67	25.00	200
O-RING PISTON ROD	P-5063-108	250	3.3	0.1753	41.67	25.00	200
STOP TUBE	P-50100-103	100	8.1	0.1753	16.67	10.00	200
EYR PROTECTION for welding	W-6010-212	30	28.3	0.1753	5.00	3.00	62
Small box	C-6010-223	1,300	0.6	0.1753	216.67	130.00	62
O-RING PISTON ROD	P-5080-109	200	3.7	0.1753	33.33	20.00	200
O-RING COVER	P-5063-110	250	2.9	0.1753	41.67	25.00	200
PORT OIL	P-5080-104	200	3.4	0.1753	33.33	20.00	200
O-RING COVER	P-5080-110	200	3.0	0.1753	33.33	20.00	200
Glove for operator	W-6010-208	150	3.8	0.1753	25.00	15.00	62
Robe for packing	C-6010-233	1,200	0.4	0.1753	200.00	120.00	62
O-RING PISTON ROD	P-50125-109	100	3.8	0.1753	16.67	10.00	200
O-RING PISTON ROD	P-50100-109	100	3.7	0.1753	16.67	10.00	200
PORT OIL	P-50125-104	100	3.8	0.1753	16.67	10.00	200
PORT OIL	P-50100-104	100	3.5	0.1753	16.67	10.00	200
O-RING COVER	P-50125-110	100	3.3	0.1753	16.67	10.00	200
O-RING COVER	P-50100-110	100	3.2	0.1753	16.67	10.00	200
Sticker on box for 5050	C-6010-218	300	5.6	0.1753	50.00	30.00	62
Sticker on box for 5062	C-6010-219	250	5.6	0.1753	41.67	25.00	62
Sticker on box for 5080	C-6010-220	200	5.8	0.1753	33.33	20.00	62
Sticker on box for 50100	C-6010-221	100	5.8	0.1753	16.67	10.00	62
Sticker on box for 50125	C-6010-222	100	5.6	0.1753	16.67	10.00	62

Table 4.22 the calculate for ordering cost and safety stock cost for Group CC

Item	Code	Annual used D=σx	Purchase Cost P	Unit price C
WIPER	P-5032-213	950	62	68.00

Table 4.23 Find Total Cost (K) of Group CC

1.) Interest Cost (Bath/unit/year)

$$I = i \times C \text{ (assume } i = 7.5\%)$$

$$I = 0.075 \times 68 = 5.1 \text{ Bath/unit/year}$$

2.) Warehouse Cost (Bath/unit/year)

$$W = 0.1753 \text{ Bath/unit/year}$$

3.) Ordering Time (Year)

$$T = 1/6 = 0.167 \text{ yeas (order every 2 month)}$$

4.) Ordering Quantity (unit)

$$Q = TD = 0.167 \times 950 = 158 \text{ unit}$$

5.) Safety Stock (Unit)

$$SS = 0.1D$$

$$= 0.1 \times 950 = 95 \text{ unit **Safety Stock 10\% of Annual used}$$

6.) Total Cost (Bath)

$$K = CD + \frac{PD}{Q} + \frac{(I+W)Q}{2} + (I+W)SS$$

$$K = (68 \times 950) + \frac{62 \times 950}{158} + \frac{(5.1 + 0.1753) \times 158}{2} + (5.1 + 0.1753) \times 95$$

$$= 68551.73 \text{ Bath}$$

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Item	Code	Annual used		I	W	Q = D/I	SS=Q.I.D	P
		D=I x	I					
STOP TUBE	P-50125-103	100	8.7	0.1753	18.67	10.00	200	
O-RING COVER	P-5080-110	300	2.8	0.1753	50.00	30.00	200	
PORT OIL	P-5063-104	250	3.3	0.1753	41.67	25.00	200	
O-RING PISTON ROD	P-5083-108	250	3.3	0.1753	41.67	25.00	200	
STOP TUBE	P-50100-103	100	8.1	0.1753	16.67	10.00	200	
EYR PROTECTION for welding	W-8010-212	30	26.3	0.1753	5.00	3.00	62	
Small box	C-6010-223	1,300	0.6	0.1753	216.67	130.00	62	
O-RING PISTON ROD	P-5080-108	200	3.7	0.1753	33.33	20.00	200	
O-RING COVER	P-5063-110	250	2.9	0.1753	41.67	25.00	200	
PORT OIL	P-5085-104	200	3.4	0.1753	33.33	20.00	200	
O-RING COVER	P-5080-110	200	3.0	0.1753	33.33	20.00	200	
Glove for operator	W-6010-208	150	3.8	0.1753	28.00	15.00	62	
Rabe for packing	C-6010-233	1,200	0.4	0.1753	200.00	120.00	62	
O-RING PISTON ROD	P-50125-108	100	3.8	0.1753	18.87	10.00	200	
O-RING PISTON ROD	P-50100-108	100	3.7	0.1753	16.67	10.00	200	
PORT OIL	P-50125-104	100	3.6	0.1753	18.87	10.00	200	
PORT OIL	P-50100-104	100	3.5	0.1753	16.67	10.00	200	
O-RING COVER	P-50125-110	100	3.3	0.1753	18.87	10.00	200	
O-RING COVER	P-50100-110	100	3.2	0.1753	16.67	10.00	200	
Sticker on box for 5050	C-6010-218	300	5.6	0.1753	50.00	30.00	62	
Sticker on box for 5062	C-6010-219	250	5.6	0.1753	41.67	25.00	62	
Sticker on box for 5080	C-6010-220	200	5.6	0.1753	33.33	20.00	62	
Sticker on box for 50100	C-6010-221	100	5.8	0.1753	16.67	10.00	62	
Sticker on box for 50125	C-6010-222	100	5.6	0.1753	16.67	10.00	62	

Total Cost of Group CC

Item	Code	Annual used D=I x	Unit price C	Material Cost D x C	Ordering Cost P D Q	Holding Cost (I W) x (Q/2)	SS Cost (I+W) SS	Total Cost K
WIPER	P-5032-213	950	88.00	84,800.00	10.33	417.63	501.15	65,529.11
ROD SEAL	P-5050-111	300	208.25	61,875.00	33.33	391.10	469.32	62,768.76
ROD SEAL	P-5063-111	250	208.35	52,337.50	33.33	330.78	396.91	53,098.51
U-RING	P-5032-212	950	55.00	52,250.00	10.33	340.44	408.53	53,009.30
WIPER	P-5040-214	800	83.00	66,400.00	10.33	328.69	392.02	51,129.04
U-RING	P-5040-213	800	62.00	49,600.00	10.33	321.69	386.02	50,318.04
ROD SEAL	P-5080-111	200	210.36	42,072.00	33.33	265.67	310.05	42,680.25
PISTON SEAL	P-5040-207	800	50.00	40,000.00	10.33	261.69	314.02	40,586.04
O-RING COVER	P-5032-210	950	36.00	36,100.00	10.33	239.60	287.40	36,637.24
NUT M B	C-6010-203	21,800	1.50	32,400.00	10.33	518.04	621.65	33,560.02
O-RING PISTON ROD	P-5040-209	800	40.00	32,000.00	10.33	211.68	254.02	32,476.04
O-RING COVER	P-5040-211	800	35.00	28,000.00	10.33	188.68	224.02	28,421.04
ROD SEAL	P-50125-111	100	215.25	21,525.00	33.33	135.88	163.18	21,857.52
ROD SEAL	P-50100-111	100	210.88	21,088.00	33.33	133.28	159.91	21,414.51
U-RING	P-5050-212	300	65.90	19,797.00	10.33	128.11	153.74	20,089.18
WIPER	P-5060-213	300	65.00	19,500.00	10.33	128.28	151.51	19,789.10
WIPER	P-5063-213	250	69.89	17,422.50	10.33	112.54	135.05	17,680.43
U-RING	P-5063-212	250	69.36	17,340.00	10.33	112.03	134.43	17,596.79
PISTON SEAL	P-5050-208	300	52.36	15,708.00	10.33	102.56	123.07	15,943.96
U-RING	P-5080-212	200	71.58	14,316.00	10.33	92.40	110.88	14,529.61
WIPER	P-5080-213	200	71.58	14,316.00	10.33	92.40	110.88	14,529.61
PISTON SEAL	P-5063-208	250	53.68	13,415.00	10.33	87.50	105.00	13,617.82
PISTON SEAL	P-5080-206	200	58.28	11,656.00	10.33	75.77	90.83	11,833.03
WIPER	P-50125-213	100	79.89	7,989.00	10.33	51.27	61.52	8,092.12
U-RING	P-50125-212	100	75.89	7,589.00	10.33	48.68	58.67	7,706.90
WIPER	P-50100-213	100	75.38	7,538.00	10.33	48.58	58.27	7,653.17
U-RING	P-50100-212	100	73.58	7,358.00	10.33	47.45	56.94	7,472.72
PISTON SEAL	P-50125-206	100	80.25	8,025.00	10.33	39.12	46.94	8,121.39
PISTON SEAL	P-50100-208	100	59.65	5,965.00	10.33	36.74	46.49	6,060.57
STOP TUBE	P-5080-103	200	105.00	21,000.00	33.33	134.17	161.01	21,328.51
wire	W-8010-213	2,100	10.00	21,000.00	10.33	161.93	194.31	21,366.57
REAR COVER	P-50125-105	100	185.00	18,500.00	33.33	117.09	140.50	18,760.92
REAR COVER	P-50100-105	100	180.00	18,000.00	33.33	113.96	136.75	18,264.05
Ear protection	W-8010-211	90	200.00	18,000.00	10.33	113.01	136.58	18,260.73
O-RING PISTON ROD	P-5050-108	300	42.28	12,678.00	33.33	83.62	100.34	12,895.30
PORT OIL	P-5050-104	300	42.00	12,600.00	33.33	83.13	99.78	12,818.22

Table 4.24 the calculate for Total inventory cost for Group CC

Total Cost of Group CC

Item	Code	Annual used	Unit price	Material Cost	Ordering Cost	Holding Cost	SS Cost	Total Cost
		D=Σx	C	DxC	PD/Q	(HW)(Q/2)	(I+W) SS	K
STOP TUBE	P-50125-103	100	115.35	11,535.00	33.33	73.55	88.27	11,730.15
O-RING COVER	P-5060-110	300	37.00	11,100.00	33.33	73.76	88.51	11,295.60
PORT OIL	P-5063-104	250	44.00	11,000.00	33.33	72.40	86.88	11,192.62
O-RING PISTON ROD	P-5063-108	250	43.85	10,912.50	33.33	71.86	86.23	11,103.91
STOP TUBE	P-50100-103	100	108.65	10,865.00	33.33	69.37	83.24	11,050.94
EYR PROTECTION for welding	W-8010-212	30	350.00	10,500.00	10.33	66.06	79.26	10,655.67
Small box	C-6010-223	1,300	8.00	10,400.00	10.33	83.99	100.79	10,595.11
O-RING PISTON ROD	P-5080-108	200	48.95	9,790.00	33.33	84.11	76.93	9,964.37
O-RING COVER	P-5083-110	250	39.00	9,750.00	33.33	64.59	77.51	9,925.43
PORT OIL	P-5080-104	200	45.36	9,072.00	33.33	59.62	71.55	9,236.90
O-RING COVER	P-5080-110	200	40.00	8,000.00	33.33	62.62	83.51	8,149.76
Glove for operator	W-8010-208	150	50.00	7,500.00	10.33	49.07	59.89	7,618.28
Robe for packing	C-6010-233	1,200	5.00	6,000.00	10.33	55.03	66.04	6,131.40
O-RING PISTON ROD	P-50125-108	100	50.26	5,026.00	33.33	32.67	38.45	5,131.65
O-RING PISTON ROD	P-50100-108	100	49.58	4,958.00	33.33	32.45	38.94	5,062.72
PORT OIL	P-50125-104	100	48.00	4,800.00	33.33	31.46	37.75	4,902.55
PORT OIL	P-50100-104	100	46.00	4,600.00	33.33	30.21	36.25	4,699.80
O-RING COVER	P-50125-110	100	44.66	4,466.00	33.33	29.37	35.25	4,563.65
O-RING COVER	P-50100-110	100	42.36	4,236.00	33.33	27.94	33.52	4,330.79
Sticker on box for 5050	C-6010-218	300	75.00	22,500.00	10.33	145.01	174.01	22,829.35
Sticker on box for 5062	C-6010-219	250	75.00	18,750.00	10.33	120.94	145.01	19,026.18
Sticker on box for 5080	C-6010-220	200	75.00	15,000.00	10.33	96.67	116.01	15,223.01
Sticker on box for 50100	C-6010-221	100	75.00	7,500.00	10.33	48.34	59.00	7,616.67
Sticker on box for 50125	C-6010-222	100	75.00	7,500.00	10.33	48.34	59.00	7,616.67
Total Cost								1,135,596.24

Table 4.25 the calculate for Total inventory cost for Group CC (Cont)

For the inventory control for Group CC that is less strictly control than group AA and BB. Therefore we can set the safe stock at 10 percent of annual usage and order every 2 months. The total inventory cost for Group CC is about 1,135,596.24 Baht

4.2.6 The improvement for Procedure and Document

4.2.6.1 Develop the procedure for each department

The document, needed beside the Bill of material paper that is the general paper from the Engineering department to The Inventory department, is the Service card document. The service card or "called Kanban" help the operator to easily to check and monitoring the quantity and the status of the product manufacturing. Moreover the card is very useful for the inventory control to monitoring the amount demand and monitor the claim part or the exceed amount from the production side. When the document passed to the Inventory with the finished goods and the rest parts. The inventory staff will check the quantity and the store area and identify the information in the paper. After that the document will be copy to Purchasing Department for recording and planning to next order and to Engineering department to monitoring the order status and pass them to Sale department.

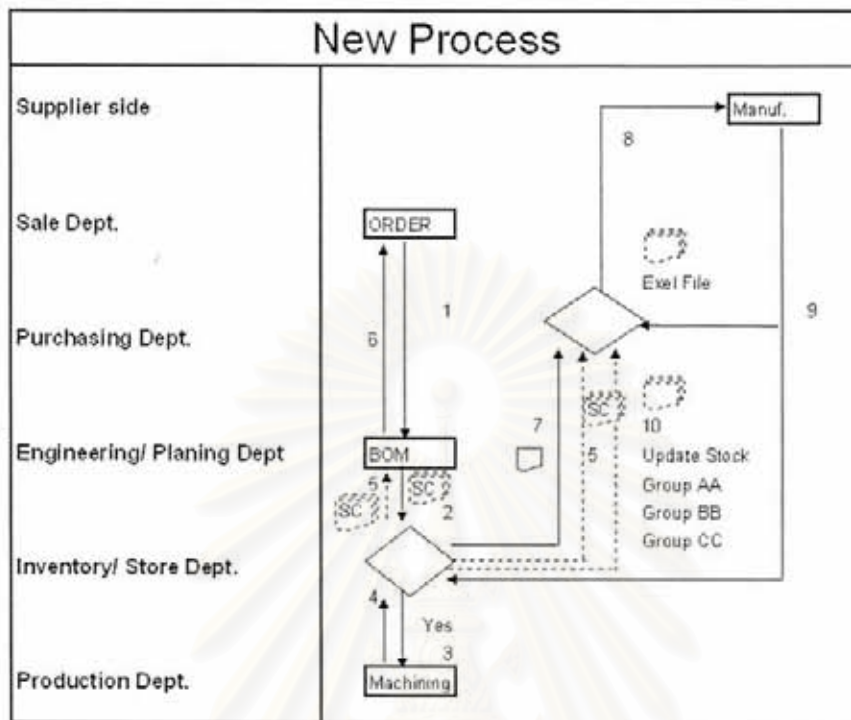


Figure 4.5 New process

4.2.6.2 DESIGN INVENTORY OPERATION

Inventory management must ensure that the manufacturing always has been available at the correct stock level to production line. The inventory capacity is both economic and efficient. And the finish goods are suitable kept. Therefore the main function performed by a inventory are.

- 1.) Receiving the goods from a source
- 2.) Storing the parts until the users require.
- 3.) Submit the parts to the correct users.

The operation are needed to perform these functions efficiently to identify and establish standards for tasks to be performed and the operation procedure. After the new systems has been designed to maintain its objectives. The inventory operation is established to perform function of this inventory must satisfy the operation objective. These operations must be established standards procedure to be the direction the operations of three main department that involved with inventory system directly as following

- **Inventory control for Incoming**

These operations must be established standards procedure to guide the of this operation to perform it efficiently. This operation starts when supplier deliver product to a inventory.

Kanban box no.	Store no.	Supplier name.
Part no.		
Part name.		
The next process no.	QTY:	

Table 4.26 TAG paper (Incoming Kanban)

When the supplier unload the ordered parts from their trucks to a receiving area which is in front of the factory and nearby administration's office. At first, Inventory staff must check amount of items and the quantity of each item with the number in the invoice paper and the TAG paper on the package. If the amount and item lists are not correct, the inventory staff informs Purchasing Department to manage about it. The parts are incorrect specification that will be claimed back to the supplier. When the amount and item list are correct according to purchase order(PO). They will be checked the amount and quality by visual from Inventory staff. However they will be randomed to check the quality by the engineering department, it is checked about 10% of total incoming product. Then the correct amount and specify parts will be taken into the inventory store. The staff must record the result of quality into the quality checking paper and record them into the excel file, and the amount of parts will be recorded into the inventory record. Then the inventory staff will inform the summary recode to the purchasing department to synchronize the information between both departments. Table 4.27 The standard procedure of receiving operation is shown in the below.

Detail	Operator	Document/ record	Excel	Equipment
Receiving operation				
1. The items unload into a inventory area	Supplier's staff/ Inventory staff	Delivery bill		Life transportation
2. Inventory staff must check amount of items and the quantity of each item with the number in the invoice paper.	Inventory staff	Invoice paper and Purchasing order		Calculator
3. the staff will record the exactly quantity and the quality by visual	Inventory staff	The quality checking form and the inventory record		A computer with excel program
4. the staff hand carry the sample part by 10% of total incoming parts	Inventory staff	The quality checking form		Hand truck
5. the staff take the result of quality checking and correct amount together with the invoice paper from supplier.	Inventory staff	Invoice paper and the result of checking record		No

Table 4.27 The standard procedure of receiving operation

▪ **Identify item and determine its storage location**

The identification items and determination for storage location are to quickly and easily operation. The recognition prevents error and save time for either keeping or selecting of the items. Item identifying method uses the tag name at the exterior of the package that the factory request the supplier to make them. When the operator receive a goods from supplier at store area, the operator will identify each package from the exterior tag on the package and check them with the invoice paper. If the amount and items are correct, the operator will sign his names by manual on the tag.

After that, the operator will manage the location for each items and record the information in the database(excel file). The database is created to help the operator locate the parts into its suit storage location. When item identification has been

designed, the operator must use it to identify the location of them, The operator check the database of allocation system code to find the allocation system code of each item. Then he will write down to the storage recoding paper. This code will help operators to know where they should put item in. When the operator check the allocation for each items, he will take them into the new storage, that are design for Group AA, BB and CC separately. The system makes the operator work more convenience and efficiency. As a result, the standard procedure of identifying item and determine its storage location in the below table 4.28

Detail	Operator	Document/ Excel record	Equipment
Identify item and determine its storage location			
1. The operator will identify each package from the exterior tag on the package and check them with the invoice paper.	Inventory staff/ Supplier staff	Tag paper, Invoice paper	No
2. If the amount and items are correct, the operator will sign his names by manual on the tag.	Inventory staff	Tag paper	No
3. After that, the operator will manage the location for each items	Inventory staff	Allocation system code	No
4. and record the information in the database(excel file)	Inventory staff	Storage recoding database(Excel file)	The computer
5. When the operator check the allocation for each items, he will take them into the new storage, that are design for Group AA, BB and CC separately.	Inventory staff	Storage recording paper	Lift transportation

Table 4.28 the standard procedure of identifying item and determine its storage location

- **Design Picking and submitting items to Engineering department**

Picking and submitting items are the physical act that are take from storage and place them in the Engineering department before distributing to manufacturing unit. The purpose of this operation is to pick an required parts from storage area to Engineering department. This activity of the inventory staff start when the service card issued by Engineering department arrive, Engineering department will breakdown the component parts and assign into the service card. Once the inventory staff receive the service card, he will check the availability of the items that are orders in the stock by checking with “ Inventory movement record in database system”. The staff will pick the items and place them on the lift transportation or hand truck and then the staff must tick the box at the service card to inform the completed providing if the parts are available. But if not, the Inventory staff will issue the required items paper to Purchasing department to work on it.

After all required items have been picked, the staff moves the hand truck or lift transportation that load the items to the Engineering department.

Once the production process have been completed, the operator at the last production process will check the amount of return, claim and finish parts and write their down in the service card. Then the service card and all items will be sent to the inventory department for stocking and updating the record. The inventory staff will take the item in to the rack according to the allocation system and record the amount and store area into the service card. Then the inventory will copy the completed service card to both Engineering department and Purchasing department. This operation is help to monitor all parts status and finish goods, that useful to check the status of their ordering where they have been kept and to update the exactly remained part in inventory between inventory and Purchasing.

As a result of the standard procedure of this operation is shown in the below table.

Detail	Operator	Document/ Excel record	Equipment
<u>Picking and submitting to Engineering department</u>			
1.This activity of the inventory staff start when the service card issued by Engineering department arrive,	Engineering department	Service card	The master parts book
2. Once the inventory staff receive the service card, he will check the availability of the items that are orders in the stock by checking with “Inventory movement record in database system”.	Inventory staff	Service card/ Inventory movement record	Computer
3. The staff will pick the items and place them on the lift transportation or hand truck	Inventory staff	Service card/ Inventory movement record	lift transportation or hand truck
4. The staff must tick the box at the service card to inform the completed providing if the parts are available.	Inventory staff	Service card	No
5. The items will be token to engineering department	Inventory staff	Service card	lift transportation or hand truck
<u>Recording after production process</u>			
1. the operator at the last production process will check the amount of return, claim and finish parts and write their down in the service card	Production staff/ Inventory staff	Service card	No
2. Then the service card and all items will be sent to the inventory department for stocking and updating the record	Inventory staff	Service card/ Movement inventory record	lift transportation or hand truck

Table 4.29 the standard procedure of Picking and submitting to Engineering department

Detail	Operator	Document/ record	Excel	Equipment
3. The inventory staff will take the item in to the rack according to the allocation system and record the amount and store area into the service card.	Inventory staff	Service card		lift transportation
4. Then the inventory will copy the completed service card to both Engineering department and Purchasing department	Inventory staff	Service card		No

Table 4.29 the standard procedure of Picking and submitting to Engineering department(Cont)

- **Physical inventory**

The purpose of this operation is to count the exist quantity of stock keeping units and compare them to the amount in the data base. From the past of counting, the staff will count the items and amount in the store in every end of the year. That make many problem during the year such as the suck cost, holding cost and manufacturing plan. For new counting system, that are design to three class of items that divided to Group AA, BB and CC. each group are different of critical factor to prevent the problem occurred from the old method. Therefore the frequency of each group are design in different period as following.

Checking period

Group AA	Every two month
Group BB	Every four month
Group CC	Every six month

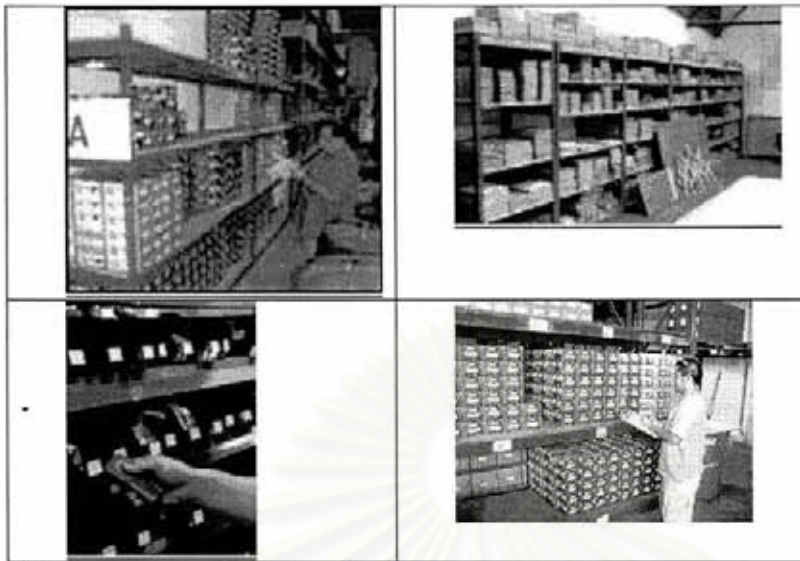


Figure 4.6 New store keeping

Date: _____

Item No.	Computer Balance	Count	Item Unit Cost

Table 4.30 Inventory Item cycle count form

The physical inventory of this inventory should use “Cycle counting” method, because the inventory system needs operators to do this operation regularly as their procedure. When found the error, it is easy to analyse the root cause of the error and to prevent the big problem in case of production line stopping. The operator uses the **Inventory Item cycle count form** to perform this operation.

After all parts in the storage location have been checked in the term of quality and quantity, the result must be checked and recorded into the count form. And the staff have to check the existing counting amount with the inventory movement record in his data base(excel file). When the paper is checked and issued completely, he handed the record paper to a purchasing to regularly synchronize the inventory stock. As a result, the standard procedure is shown in the below table.

Detail	Operator	Document/ Excel record	Equipment
<u>Recording and Physical inventory</u>			
1. count the exist quantity of stock keeping units and compare them to the amount in the data base.	Inventory staff	Movement inventory paper	Computer/ Lift transportation
2. write the amount down the Inventory Item cycle count form	Inventory staff	Inventory Item cycle count form	No
3. the staff will cycle counting as the setting of checking period and sent the result back to Purchasing to synchronize the data	Inventory staff	Inventory Item cycle count form	No.

Table 4.31 the standard procedure of Recording and Physical

4.2.6.3 Design Purchasing operation

The main task of purchasing department is to provide the parts according to manufacturing planning.. For ordering parts, they are divided to three classes of parts from ABC analysis with multi criteria. And calculate the optimum of ordering period time to minimum stock that are shown in the Inventory planning. The purchasing department will operate to provide the parts according to Inventory planning. That are defined to four main processed as following

(a) Recording and ordering

The completed service card will sent to Purchasing after the inventory fill the last coloum finished.

Detail	Operator	Document/ Excel record	Equipment
<u>Incoming process</u>			
1. When the incoming parts arrive the inventory store, the Engineering team will random to pick the parts up for checking the quality by 10% of total incoming product	Engineering department	Quality checking record	Micrometer/ surface testing/ Elastic testing
2. The result of quality checking will be recorded into the quality history.	Engineering department	Quality checking record paper and data base (excel file)	No

Table 4.35 The standard procedure for incoming process of Engineering department

<u>Issuing service card</u>			
1. this process start from getting the order bill of sales department	Sales department	The order bill	No
2. The engineer team will check the components of that model and break down to the bill of material according to master manufacturing book	Engineering department	Service card	No
3. Then the break downed parts are described in the service card paper	Engineering department	Service card	No
4. The service card will be passed to the inventory department to prepare the component parts	Engineering department	Service card	No

Table 4.36 The standard procedure for issuing service card of Engineering department

Detail	Operator	Document/ Excel record	Equipment
5. When completed, all component parts will be sent to engineering department to distribute the parts to each manufacturing process	Engineering department/ Inventory department	Service card	lift transportation or hand truck
6. The engineering department is the initial inspecting process before put them into the manufacturing process.	Engineering department	Quality checking record	No
7. The service card move together with the parts to monitor the status at the end of process	Production department/ Engineering department	Service card	lift transportation or hand truck

Table 4.36 The standard procedure for issuing service card of Engineering department (cont)

<u>Delivery finished goods</u>			
1. the engineering team will check the quality of finished goods for final inspection.	Engineering department	Quality checking record	No
2. Once the quality control passed, the engineering team will record the data to the database (excel file).	Engineering department	Quality checking record/ data base (excel file)	computer
3. They will issue Delivery slip to Sale department.	Engineering department	Shipment slip	No

Table 4.37 The standard procedure for Delivery finish goods of Engineering department

4.2.7 Reporting

The reporting is one of main procedure to monitor the situation of inventory to the related department and the management team. Therefore i would like to create the two of inventory reporting type. The one report is to related department for operating monitoring, and another is to the management team for reporting the situation of the inventory.

4.2.7.1 The Reporting in manufacturing process

The first paper to monitor is the paper from engineering department ' called service card. The card show the process from engineering department to inventory department, then the document will be copied to the related department at the end of process as purchasing and engineering. At the first step when engineering dept receiving the order bill from sales department, the engineer will distribute the bill-of material to the service card about what part they need and how many quantity they prepare for the production.

The next step, the service card will be passed to the inventory department to distribute the items and the quantity as engineering's identification. then, the parts will be moved to the engineering dept with the service card. When receiving, the engineer will check the parts' quality and quantity. If it complete, the engineer submit them to the manufacturing process with the service card. At the end of manufacturing process, the amount of return, no good and finish goods will be recorded within the paper together with the store area. And the document will be copied to purchasing for monitoring the inventory situation and to engineering for planning manufacturing plan. For the next step, the engineering will inform the order report to sales department, sales take easily them to customer.

4.2.7.2 The reporting document for management

The reporting to the management team is very important process, because it present them the summary of inventory situation that make the management understand the inventory status and make decision to increase or decrease the annual investment. Generally, the report will be summarized by Factory manager. The

manager is more understand the situation and the exist factors than others. The report should compose the indicator of inventory performance as following below

- Inventory Turnover.

This is the one of the most important ratio to present the situation of inventory related to the business. The management can see the factory situation from Inventory Turnover ratio. That is more clarify information and good presentation to the management, when the report can present the criteria's and compare the ratio over last five year.

- Total Inventory Baht

Total inventory Baht is the total cost to the transit agency of all items held in inventory at a given point in time. This indicator is simple and usually present to the management. Because This indicator measures the size of inventory in terms of the Baht that the factory invested in the inventory. However the amont of total inventory Baht should consider with the production planning. If the business is growing, the total inventory cost increasing surely. If not, the report have to explain the reason with the solution such as Reinventory, Implementing inventory software or etc.

- Percent Inventory Carrying Cost

This report section help the management to look out the problem that the factory face on it .The cost of maintaining inventory includes the following,

- Storage cost, the cost of storage space and equipment
- Insurance cost, the cost, if any, of insuring inventory
- Obsolescence, the cost of items that become obsolete

The report should highlight the inventory problem that cause carrying cost, then the solution and the effective date to solve this problem as well as the reduction percent after implement the solution. Moreover the history of carrying cost over last five year will be the excellent monitoring for improvement of its.

- Future plan and saving campaign

The important thing for reporting is the future plan for inventory. That should explain the objective and the requirement to be the proposal of new project. Moreover the saving campaign is one of the most important to be considered for management. However the trend of the above indicator and performance rate. Because the trend help the management to foresee the further situation. In case of new inventory system with new equipment and software, they need the approval budget for the new project from management.

4.2.8 Inventory equipment

Industrial truck is a vehicle capable of picking up a unit load, with the unit load traveling through a warehouse aisle and performing the unit-load deposit. The inventory equipment can be divided into 2 types. There are material handling equipment and storage equipment

4.2.8.1 Material handling equipment

(a) 2-Wheel Hand truck:

Purpose of use: 2-Wheel Hand truck is used product from a warehouse to a selling store or to a customer vehicle. Thus, be said that it is used for shipping activity only.

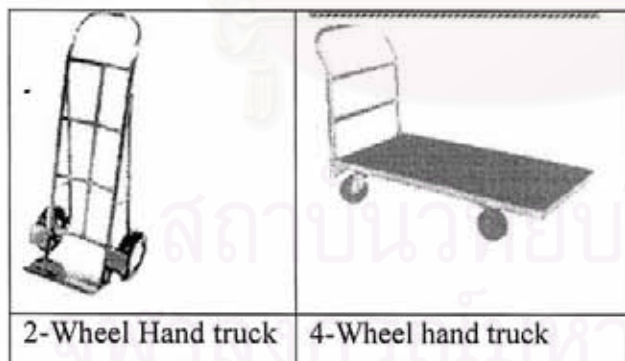


Figure 4.7 Hand truck for both 2 and 4 -wheel hand truck

(b) Lift : Purpose of use: There is one lift in each building in a

It is used to move item in and out from storage area. It is very useful in use because it can carry variance parts type and heavy weight.

4.2.8.2 Storage equipment



Wooden pallet and shelves are the only storage equipments which are used re items in this warehouse.

(a) Wooden Pallet: Purpose of use: Most items that are contained with plastic sack will be stored by stacking on a wooden pallet. A wooden pallet used a product that is difficult to stack or pile properly. It can carry many items. Wooden pallet is provided ease of storage and good use of cubic space. ~ is never used to move an item with handling equipment.

(b) Shelves: Purpose of use: Shelves are used to store items and it storage capacity by good use of cubic space. Shelving is a very basic method that affords the user significant flexibility in the type and quantity of s that can be stored, and at a relatively low capital investment. Some items which have special size or weight. Therefore, the type of equipment that is suit to the condition of this is the hand truck. It is a vehicle that required hand-operated truck. It is ' to use with small to medium size and light weight items. Beside that, it call aisle width to move around storage area.

4.2.8.3 Managing Inventory area

To locate the storage areas and determine equipment, including shelve, the operator have to identify the current size of storage, how many shelves there are available and how many items will be kept in this store. That make to maximize the inventory space and use the fully of equipment capacity.

	
Shelves size 150H x 200W x 50D	* Shelves size 300H x 200W x 50D
Figure 4.8 Both of Shelves dimension	

After considering the current lay out, they can be more improvement about the space, equipment and allocation store for new system with ABC analysis. As the result, the utilize space can be saver than the old method about 25 percent.

The allocation store are considered about Group AA, BB and CC as well as the family parts. For example, the critical parts of group AA should be kept in the same shelves. One more thing, the weigh of parts is the one of criteria to design which floor to be kept in. the maximum of safety stock have been considered for space analysis.

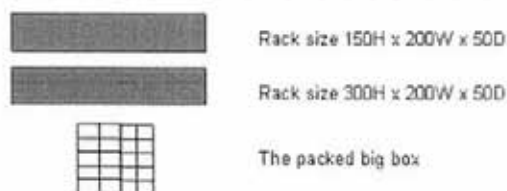
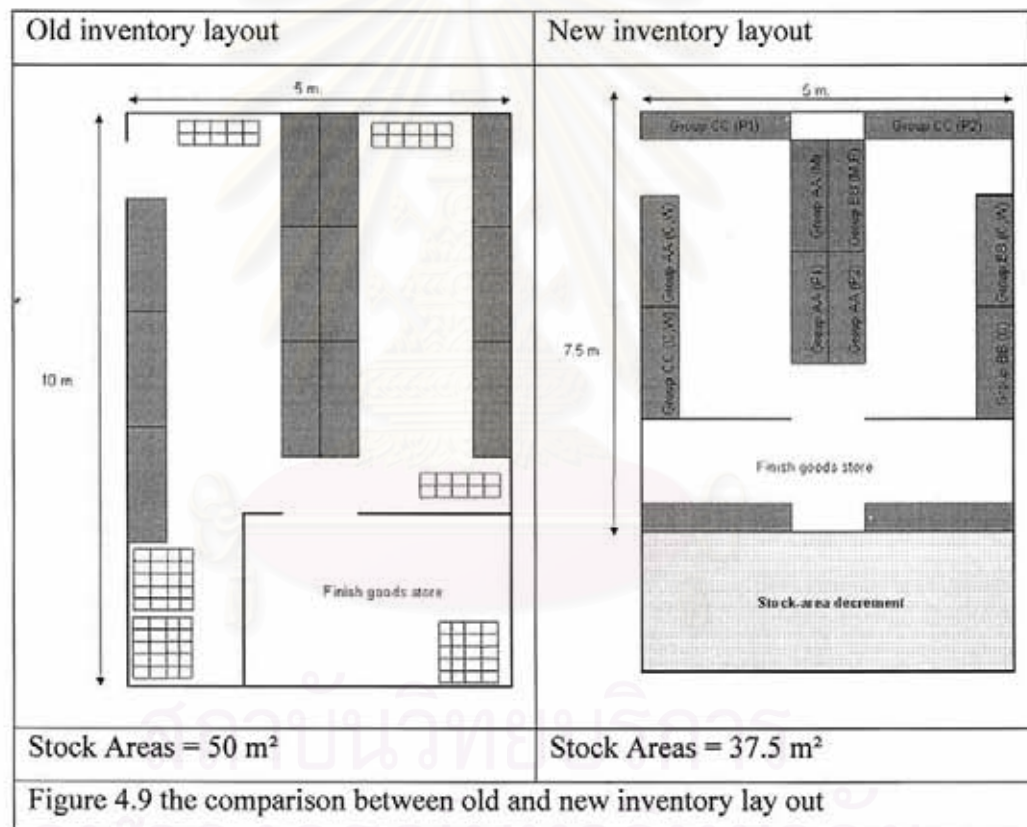


Figure 4.10 the dimension and meaning of the symbol in the lay out

Group AA (M)			
Item	Code	SS _{MAX}	floor
CYLINDER HEAD	M-50100-302	7	1
CYLINDER HEAD	M-50125-302	7	1
CYLINDER HEAD	M-5032-302	45	1
CYLINDER HEAD	M-5040-303	40	1
CYLINDER HEAD	M-5050-302	15	2
CYLINDER HEAD	M-5063-302	15	2
CYLINDER HEAD	M-5080-302	9	2
PISTON	M-50100-307	7	3
PISTON	M-50125-307	7	3
PISTON	M-5032-307	45	3
PISTON	M-5040-308	40	3
PISTON	M-5050-307	15	4
PISTON	M-5063-307	15	4
PISTON	M-5080-307	9	4
PISTON ROD	M-5032-314	43	5
PISTON ROD	M-5040-315	38	5
PISTON ROD	M-5050-314	14	6
PISTON ROD	M-5063-314	13	6
PISTON ROD	M-5080-314	9	6

Table 4.38 allocate store for Group AA (M)

Group AA (P1)			
Item	Code	SS _{MAX}	floor
BARREL	P-5032-109	48	1
BARREL	P-5040-110	43	1
BARREL	P-5050-109	16	1
BARREL	P-5063-109	15	1
BARREL	P-5080-109	10	1
BUSH IN ROD BUSHING	P-5032-101	48	2
BUSH IN ROD BUSHING	P-5040-102	43	2
BUSH IN ROD BUSHING	P-5050-101	16	2
BACK UP WASHER	P-5040-101	43	3
EYE MOUNTING	P-5040-104	43	3

Table 4.39 allocate store for Group AA (P1)

CHAPTER V

RESULT AND RECOMMENDATION

Conclusion

This research studied as a case study of Hydraulic Cylinder. The objective is to make optimal inventory level with limited area and minimize costs.

To achieve this objective, inventory control starts from historical data collection over a year, especially, data in demand usage. First of all, all parts are separated the important classification by using ABC analysis with multi criteria. It's classified into three categories: AA, BB, and CC. AA is the most important, BB is normally, and CC is less important. To achieve in inventory control, each group have been applied to the inventory theory and system. The result has been presented as following,

Group AA use the method of ordering various items with one supplier to save the related ordering cost. The result is calculated to be the ordering period for each supplier as presented below,

Supplier code 1xx : Order every 14 days

Supplier code 2xx : Order every 30 days

Supplier code 2xx : Order every 12 days

Group BB are used fixed order quantity model to find the economic order quantity, safety stock, and reorder point. Purchasing Department will order raw materials when raw materials level falls to reorder point and order in a fixed quantity in each time. The result of each ROP has been shown in Appendix F.

In group CC, it's used Min-Max model to find the safety stock, target stock level, and order quantity. Department will order the part when the time is reach; it means Purchasing Department define the fixed the ordering time for every two months

The improvement of operation, there are develop for the operator procedure not only the inventory staff but also the purchasing and Engineering department and another development is the inventory control document to support planning, analyzing and monitoring. Cycle counting can reduce errors and maintain a high level of inventory accuracy and the cause of discrepancies and eliminating the conditions that produce inventory errors and imbalances. Examples of causes include mislabeled bins, sloppy housekeeping, confusing procedures for recording transactions, and improper storehouse security. Therefore the frequency of each group are design in different period as following .

Checking period

Group AA Every two month

Group BB Every four month

• Group CC Every six month

In order to maintain the system and to maximize the labor and equipment capacity, the new procedure of three main department have been designed for each department. For the improvement of inventory layout, that can saver the space than the old lay out about 25 percent.

The total cost for the old method

Total inventory cost =	Material cost	Purchasing cost	Holding cost	Safety stock cost	Obsolesce cost	Shortage cost
=	14,645,634.25	11,000.00	79,933.29	111,344.33	103,654.00	50,980
=	15,002,545.87					

• The total cost for New method

Group	Annual amount (K)
AA	
1xx	3,792,908.20
2xx	237,307.31
3xx	6,459,669.91
sub total	10,489,885.42
BB	1,369,127.93
CC	1,135,596.24
TOTAL	12,994,609.59

Diff between Old and new

method = 2,007,936.28
= 13.38 %

Table 4.40 the comparison of total inventory cost between old and new system

For inventory system improvement, the inventory procedure and the related documents have been redesign to be more efficiency. From the study, a new inventory system for a Hydraulics Cylinder can save 2,007,936.28 or 13.38 percent of total inventory cost.

Recommendation for Future Study

The recommendations for future study are following:

- Training course schedules should be set up in order to improve the efficiency of workers. And job design and work method should be applied by put the right man into the right job in order to increase the standard of worker and receive the highest performance in each job. In additional, redesign the inventory layout to appropriate for the quantities of raw materials and easy to move in/out.
- The material requirements planning (MRP) should be applied to reduce the time for calculation and the increase the performance to control the inventory system.
- In order to minimize dead-stock product's parts regarding technology change. The equipment that firstly deposited in the inventory should be the first one retrieving. The First In First Out (FIFO) storage system is a suitable and most effective method to be eliminate this problems. To make thing easier and be more efficient, a new effective Inventory system is truly needed.

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Appendices

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

Appendix A

The table for ABC method



สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

Appendix A.1: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Curriculum	% Baht usage	Class
2	CYLINDER HEAD	M-5032-302	950	1,250.00	1,187,500.00	14	1,187,500.00	9.21	A
20	CYLINDER HEAD	M-5040-303	800	1,280.00	1,024,000.00	14	2,211,500.00	17.15	A
7	PISTON	M-5032-307	950	750.00	712,500.00	14	2,924,000.00	22.68	A
30	PISTON	M-5040-308	800	760.00	608,000.00	14	3,532,000.00	27.40	A
35	CYLINDER HEAD	M-5050-302	300	1,300.00	390,000.00	14	3,922,000.00	30.42	A
22	BARREL	P-5040-110	800	480.00	384,000.00	7	4,306,000.00	33.40	A
53	CYLINDER HEAD	M-5063-302	250	1,300.00	325,000.00	14	4,631,000.00	35.92	A
14	PISTON ROD	M-5032-314	950	335.00	318,250.00	7	4,949,250.00	38.39	A
27	PISTON ROD	M-5040-315	800	370.00	296,000.00	7	5,245,250.00	40.69	A
63	CYLINDER HEAD	M-5080-302	200	1,310.00	262,000.00	14	5,507,250.00	42.72	A
1	BUSH IN ROD BUSHING	P-5032-101	950	258.00	245,100.00	7	5,752,350.00	44.62	A
138	Pneumatic pipe for 5032 Size	C-6010-135	950	250.00	237,500.00	7	5,989,850.00	46.46	A
45	PISTON	M-5050-307	300	790.00	237,000.00	14	6,226,850.00	48.30	A
108	Glue	W-6010-105	1,000	230.00	230,000.00	10	6,456,850.00	50.08	A
19	BUSH IN ROD BUSHING	P-5040-102	800	258.00	206,400.00	7	6,663,250.00	51.68	A
9	BARREL	P-5032-109	950	214.00	203,300.00	7	6,866,550.00	53.26	A
139	Pneumatic pipe for 5040 Size	C-6010-136	800	250.00	200,000.00	7	7,066,550.00	54.81	A
11	ROD SEAL	P-5032-111	950	210.00	199,500.00	5	7,266,050.00	56.36	A
49	PISTON	M-5063-307	250	790.36	197,590.00	14	7,463,640.00	57.89	A
5	REAR COVER	P-5032-105	950	196.66	186,827.00	7	7,650,467.00	59.34	A
15	BACK UP WASHER	P-5040-101	800	208.00	166,400.00	7	7,816,867.00	60.63	A
24	ROD SEAL	P-5040-112	800	200.00	160,000.00	5	7,976,867.00	61.87	A
72	PISTON	M-5080-307	200	790.99	158,198.00	14	8,135,065.00	63.10	A
36	BARREL	P-5050-109	300	485.00	145,500.00	7	8,280,565.00	64.23	A
104	Operation suit	C-6010-101	120	1,200.00	144,000.00	30	8,424,565.00	65.35	A
84	CYLINDER HEAD	M-50100-302	100	1,330.00	133,000.00	14	8,557,565.00	66.38	A
95	CYLINDER HEAD	M-50125-302	100	1,320.88	132,088.00	14	8,689,653.00	67.40	A
28	REAR COVER	P-5040-106	800	165.00	132,000.00	7	8,821,653.00	68.43	A
21	EYE MOUNTING	P-5040-104	800	160.00	128,000.00	7	8,949,653.00	69.42	A
51	BARREL	P-5063-109	250	487.00	121,750.00	7	9,071,403.00	70.36	A
47	PISTON ROD	M-5050-314	300	380.25	114,075.00	7	9,185,478.00	71.25	A
109	Cooling water	W-6010-106	750	150.00	112,500.00	10	9,297,978.00	72.12	A

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Appendix A.2: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Curriculum	% Baht usage	Class
112	Lubricant	W-6010-109	900	120.00	108,000.00	10	9,405,978.00	72.96	A
64	BARREL	P-5080-109	200	490.35	98,070.00	7	9,504,048.00	73.72	A
107	WELDING SET	W-6010-104	1,500	65.00	97,500.00	10	9,601,548.00	74.48	A
61	PISTON ROD	M-5063-314	250	385.36	96,340.00	7	9,697,888.00	75.22	A
3	STOP TUBE	P-5032-103	950	98.60	93,670.00	7	9,791,558.00	75.95	A
140	Pneumatic pipe for 5050 Size	C-6010-137	350	250.00	87,500.00	7	9,879,058.00	76.63	A
77	PISTON	M-50100-307	100	805.99	80,599.00	14	9,959,657.00	77.25	A
100	PISTON	M-50125-307	100	801.33	80,133.00	14	10,039,790.00	77.88	A
32	STOP TUBE	P-5040-116	800	100.00	80,000.00	7	10,119,790.00	78.50	A
75	PISTON ROD	M-5080-314	200	395.25	79,050.00	7	10,198,840.00	79.11	A
110	Cutter for cutting machine	W-6010-107	600	130.00	78,000.00	10	10,276,840.00	79.71	A
34	BUSH IN ROD BUSHING	P-5050-101	300	250.00	75,000.00	7	10,351,840.00	80.30	A
119	Sticker on box for 5032	C-6010-216	950	75.00	71,250.00	14	10,423,090.00	80.85	B
105	Metal BELT	C-6010-102	5,400	13.00	70,200.00	14	10,493,290.00	81.39	B
13	WIPER	P-5032-213	950	68.00	64,600.00	5	10,557,890.00	81.89	B
48	BUSH IN ROD BUSHING	P-5063-101	250	251.00	62,750.00	7	10,620,640.00	82.38	B
141	Pneumatic pipe for 5062 Size	C-6010-138	250	250.00	62,500.00	7	10,683,140.00	82.87	B
38	ROD SEAL	P-5050-111	300	206.25	61,875.00	5	10,745,015.00	83.35	B
120	Sticker on box for 5040	C-6010-217	800	75.00	60,000.00	14	10,805,015.00	83.81	B
58	ROD SEAL	P-5063-111	250	209.35	52,337.50	5	10,857,352.50	84.22	B
12	U- RING	P-5032-212	950	55.00	52,250.00	5	10,909,602.50	84.62	B
43	REAR COVER	P-5050-105	300	170.25	51,075.00	7	10,960,677.50	85.02	B
62	BUSH IN ROD BUSHING	P-5080-101	200	255.00	51,000.00	7	11,011,677.50	85.41	B
26	WIPER	P-5040-214	800	63.00	50,400.00	5	11,062,077.50	85.80	B
92	BARREL	P-50125-109	100	501.25	50,125.00	7	11,112,202.50	86.19	B
142	Pneumatic pipe for 5080 Size	C-6010-139	200	250.00	50,000.00	7	11,162,202.50	86.58	B
79	BARREL	P-50100-109	100	499.25	49,925.00	7	11,212,127.50	86.97	B
25	U-RING	P-5040-213	800	62.00	49,600.00	5	11,261,727.50	87.35	B
6	PISTON SEAL	P-5032-206	950	51.00	48,450.00	7	11,310,177.50	87.73	B
16	TUBE	P-5040-117	800	60.00	48,000.00	7	11,358,177.50	88.10	B
129	Instruction book for 5032	C-6010-226	950	50.00	47,500.00	30	11,405,677.50	88.47	B
117	PLUG	W-6010-214	5,400	8.00	43,200.00	7	11,448,877.50	88.80	B
56	REAR COVER	P-5063-105	250	172.00	43,000.00	7	11,491,877.50	89.14	B
66	ROD SEAL	P-5080-111	200	210.36	42,072.00	5	11,533,949.50	89.46	B
29	PISTON SEAL	P-5040-207	800	50.00	40,000.00	5	11,573,949.50	89.77	B

Appendix A.3: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Curriculum	% Baht usage	Class
130	Instruction book for 5040	C-6010-227	800	50.00	40,000.00	30	11,613,949.50	90.09	B
103	PISTON ROD	M-50125-314	100	399.35	39,935.00	7	11,653,884.50	90.40	B
8	O-RING PISTON ROD	P-5032-108	950	42.00	39,900.00	7	11,693,784.50	90.70	B
89	PISTON ROD	M-50100-314	100	398.65	39,865.00	7	11,733,649.50	91.01	B
10	O-RING COVER	P-5032-210	950	38.00	36,100.00	5	11,769,749.50	91.29	B
137	Protection foam	C-6010-234	1,200	30.00	36,000.00	14	11,805,749.50	91.57	B
70	REAR COVER	P-5080-105	200	178.26	35,652.00	7	11,841,401.50	91.85	B
106	NUT M.8	C-6010-203	21,600	1.50	32,400.00	5	11,873,801.50	92.10	B
17	PORT OIL SQUARE ELBOW(1)	P-5040-118	800	40.00	32,000.00	7	11,905,801.50	92.35	B
18	PORT OIL SQUARE ELBOW(2)	P-5040-119	800	40.00	32,000.00	7	11,937,801.50	92.60	B
31	O-RING PISTON ROD	P-5040-209	800	40.00	32,000.00	5	11,969,801.50	92.85	B
33	PORT OIL	P-5040-117	800	40.00	32,000.00	7	12,001,801.50	93.09	B
41	STOP TUBE	P-5050-103	300	100.02	30,006.00	7	12,031,807.50	93.33	B
23	O-RING COVER	P-5040-211	800	35.00	28,000.00	5	12,059,807.50	93.54	B
128	An-ti dust Powder	C-6010-225	300	90.00	27,000.00	14	12,086,807.50	93.75	B
54	STOP TUBE	P-5063-103	250	103.00	25,750.00	7	12,112,557.50	93.95	B
76	BUSH IN ROD BUSHING	P-50100-101	100	257.00	25,700.00	7	12,138,257.50	94.15	B
90	BUSH IN ROD BUSHING	P-50125-101	100	256.00	25,600.00	7	12,163,857.50	94.35	B
113	Cap for Operator	W-6010-210	100	250.00	25,000.00	7	12,188,857.50	94.54	B
143	Pneumatic pipe for 50100 Size	C-6010-140	100	250.00	25,000.00	7	12,213,857.50	94.74	B
144	Pneumatic pipe for 50125 Size	C-6010-141	100	250.00	25,000.00	7	12,238,857.50	94.93	B
4	PORT OIL	P-5032-104	950	23.90	22,705.00	7	12,261,562.50	95.11	B
121	Sticker on box for 5050	C-6010-218	300	75.00	22,500.00	14	12,284,062.50	95.28	C
94	ROD SEAL	P-50125-111	100	215.25	21,525.00	5	12,305,587.50	95.45	C
81	ROD SEAL	P-50100-111	100	210.88	21,088.00	5	12,326,675.50	95.61	C
68	STOP TUBE	P-5080-103	200	105.00	21,000.00	7	12,347,675.50	95.78	C
116	wire	W-6010-213	2,100	10.00	21,000.00	7	12,368,675.50	95.94	C
39	U- RING	P-5050-212	300	65.99	19,797.00	5	12,388,472.50	96.09	C
40	WIPER	P-5050-213	300	65.00	19,500.00	5	12,407,972.50	96.24	C
122	Sticker on box for 5062	C-6010-219	250	75.00	18,750.00	14	12,426,722.50	96.39	C
98	REAR COVER	P-50125-105	100	185.00	18,500.00	7	12,445,222.50	96.53	C
87	REAR COVER	P-50100-105	100	180.00	18,000.00	7	12,463,222.50	96.67	C
114	Ear protection	W-6010-211	90	200.00	18,000.00	7	12,481,222.50	96.81	C
60	WIPER	P-5063-213	250	69.69	17,422.50	5	12,498,645.00	96.95	C
59	U- RING	P-5063-212	250	69.36	17,340.00	5	12,515,985.00	97.08	C

Appendix A.4: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Curriculum	% Baht usage	Class
44	PISTON SEAL	P-5050-206	300	52.36	15,708.00	5	12,531,693.00	97.20	C
123	Sticker on box for 5080	C-6010-220	200	75.00	15,000.00	14	12,546,693.00	97.32	C
131	Instruction book for 5050	C-6010-228	300	50.00	15,000.00	30	12,561,693.00	97.44	C
67	U- RING	P-5080-212	200	71.58	14,316.00	5	12,576,009.00	97.55	C
74	WIPER	P-5080-213	200	71.58	14,316.00	5	12,590,325.00	97.66	C
57	PISTON SEAL	P-5063-206	250	53.66	13,415.00	5	12,603,740.00	97.76	C
46	O-RING PISTON ROD	P-5050-108	300	42.26	12,678.00	7	12,616,418.00	97.86	C
42	PORT OIL	P-5050-104	300	42.00	12,600.00	7	12,629,018.00	97.96	C
132	Instruction book for 5062	C-6010-229	250	50.00	12,500.00	30	12,641,518.00	98.06	C
71	PISTON SEAL	P-5080-206	200	58.28	11,656.00	5	12,653,174.00	98.15	C
96	STOP TUBE	P-50125-103	100	115.35	11,535.00	7	12,664,709.00	98.24	C
37	O-RING COVER	P-5050-110	300	37.00	11,100.00	7	12,675,809.00	98.32	C
55	PORT OIL	P-5063-104	250	44.00	11,000.00	7	12,686,809.00	98.41	C
50	O-RING PISTON ROD	P-5063-108	250	43.65	10,912.50	7	12,697,721.50	98.49	C
85	STOP TUBE	P-50100-103	100	108.65	10,865.00	7	12,708,586.50	98.58	C
115	EYR PROTECTION for welding	W-6010-212	30	350.00	10,500.00	7	12,719,086.50	98.66	C
126	Small box	C-6010-223	1,300	8.00	10,400.00	7	12,729,486.50	98.74	C
133	Instruction book for 5080	C-6010-230	200	50.00	10,000.00	30	12,739,486.50	98.82	C
73	O-RING PISTON ROD	P-5080-108	200	48.95	9,790.00	7	12,749,276.50	98.89	C
52	O-RING COVER	P-5063-110	250	39.00	9,750.00	7	12,759,026.50	98.97	C
69	PORT OIL	P-5080-104	200	45.36	9,072.00	7	12,768,098.50	99.04	C
65	O-RING COVER	P-5080-110	200	40.00	8,000.00	7	12,776,098.50	99.10	C
102	WIPER	P-50125-213	100	79.69	7,969.00	5	12,784,067.50	99.16	C
101	U- RING	P-50125-212	100	75.89	7,589.00	5	12,791,656.50	99.22	C
83	WIPER	P-50100-213	100	75.36	7,536.00	5	12,799,192.50	99.28	C
111	Glove for operator	W-6010-208	150	50.00	7,500.00	7	12,806,692.50	99.34	C
124	Sticker on box for 50100	C-6010-221	100	75.00	7,500.00	14	12,814,192.50	99.40	C
125	Sticker on box for 50125	C-6010-222	100	75.00	7,500.00	14	12,821,692.50	99.45	C
82	U- RING	P-50100-212	100	73.58	7,358.00	5	12,829,050.50	99.51	C
99	PISTON SEAL	P-50125-206	100	60.25	6,025.00	5	12,835,075.50	99.56	C
136	Robe for packing	C-6010-233	1,200	5.00	6,000.00	7	12,841,075.50	99.60	C
88	PISTON SEAL	P-50100-206	100	59.65	5,965.00	5	12,847,040.50	99.65	C
118	Plastic bag	W-6010-215	2,100	2.50	5,250.00	15	12,852,290.50	99.69	C
91	O-RING PISTON ROD	P-50125-108	100	50.26	5,026.00	7	12,857,316.50	99.73	C
134	Instruction book for 50100	C-6010-231	100	50.00	5,000.00	30	12,862,316.50	99.77	C
135	Instruction book for 50125	C-6010-232	100	50.00	5,000.00	30	12,867,316.50	99.81	C
78	O-RING PISTON ROD	P-50100-108	100	49.58	4,958.00	7	12,872,274.50	99.85	C
97	PORT OIL	P-50125-104	100	48.00	4,800.00	7	12,877,074.50	99.88	C
86	PORT OIL	P-50100-104	100	46.00	4,600.00	7	12,881,674.50	99.92	C
93	O-RING COVER	P-50125-110	100	44.66	4,466.00	7	12,886,140.50	99.95	C
80	O-RING COVER	P-50100-110	100	42.36	4,236.00	7	12,890,376.50	99.99	C
127	Big Box 12x	C-6010-224	120	15.00	1,800.00	30	12,892,176.50	100.00	C

Appendix A.5: The table for ABC method with multi criteria

Baht - Usage				
Category	No. of Item	% of Item	BHT usage	% of Usage
A	44	30.56	10,351,840.00	79.71
B	45	31.25	1,909,722.50	15.39
C	55	38.19	630,614.00	4.89
SUM	144	100.00	12,892,176.50	100.00

ITEM	I	II	III	Total
A	1	41	2	43
B	2	31	12	46
C	7	31	17	55
Total	10	103	31	144

AA = AIAIIBI
 BB = BIIAIIICI
 CC = CIIBIIICI

Class	Lead Time (day)
I	$L > 4$
II	$4 \geq L \geq 7$
III	$L < 7$

Lead Time category	No. of Item	% of items
I	10	6.94
II	103	71.53
III	31	21.53
Total	144	100.00

Class	Baht Usage	% BHT	No of item	% no of item
AA	8,634.35	57.52	46.00	31.94
BB	3,759.53	25.05	38.00	26.39
CC	2,616.02	17.43	60.00	41.67
	15,009.90	100.00	144.00	100.00

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Appendix A.6: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
1	ROD SEAL	P-5032-111	950	210.80	199,500.00	5	A III *
2	ROD SEAL	P-5040-112	800	200.00	160,000.00	5	A III
3	BARREL	P-5040-110	800	480.00	384,000.00	7	A II
4	PISTON ROD	M-5032-314	950	335.00	318,250.00	7	A II
5	PISTON ROD	M-5040-315	800	370.00	296,000.00	7	A II
6	BUSH IN ROD BUSHING	P-5032-101	950	258.00	245,100.00	7	A II
7	Pneumatic pipe for 5032 Size	C-6010-135	950	250.00	237,500.00	7	A II
8	BUSH IN ROD BUSHING	P-5040-102	800	258.00	206,400.00	7	A II
9	BARREL	P-5032-109	950	214.00	203,300.00	7	A II
10	Pneumatic pipe for 5040 Size	C-6010-136	800	250.00	200,000.00	7	A II
11	REAR COVER	P-5032-105	950	196.66	186,827.00	7	A II
12	BACK UP WASHER	P-5040-101	800	208.00	166,400.00	7	A II
13	BARREL	P-5050-109	300	485.00	145,500.00	7	A II
14	REAR COVER	P-5040-106	800	165.00	132,000.00	7	A II
15	EYE MOUNTING	P-5040-104	800	160.00	128,000.00	7	A II
16	BARREL	P-5063-109	250	487.00	121,750.00	7	A II
17	PISTON ROD	M-5050-314	300	380.25	114,075.00	7	A II
18	BARREL	P-5080-109	200	490.35	98,070.00	7	A II
19	PISTON ROD	M-5063-314	250	385.36	96,340.00	7	A II
20	STOP TUBE	P-5032-103	950	98.60	93,670.00	7	A II
21	Pneumatic pipe for 5050 Size	C-6010-137	350	250.00	87,500.00	7	A II
22	STOP TUBE	P-5040-116	800	100.00	80,000.00	7	A II
23	PISTON ROD	M-5080-314	200	395.25	79,050.00	7	A II
24	Glue	W-6010-105	1,000	230.00	230,000.00	10	A II
25	Cooling water	W-6010-106	750	150.00	112,500.00	10	A II
26	Lubricant	W-6010-109	900	120.00	108,000.00	10	A II
27	WELDING SET	W-6010-104	1,500	65.00	97,500.00	10	A II
28	Cutter for cutting machine	W-6010-107	600	130.00	78,000.00	10	A II
29	CYLINDER HEAD	M-5032-302	950	1,250.00	1,187,500.00	14	A II
30	CYLINDER HEAD	M-5040-303	800	1,280.00	1,024,000.00	14	A II
31	PISTON	M-5032-307	950	750.00	712,500.00	14	A II
32	PISTON	M-5040-308	800	760.00	608,000.00	14	A II
33	CYLINDER HEAD	M-5050-302	300	1,300.00	390,000.00	14	A II
34	CYLINDER HEAD	M-5063-302	250	1,300.00	325,000.00	14	A II

Appendix A.7: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
35	CYLINDER HEAD	M-5080-302	200	1,310.00	262,000.00	14	A II
36	PISTON	M-5050-307	300	790.00	237,000.00	14	A II
37	PISTON	M-5063-307	250	790.36	197,590.00	14	A II
38	PISTON	M-5080-307	200	790.99	158,198.00	14	A II
39	CYLINDER HEAD	M-50100-302	100	1,330.00	133,000.00	14	A III
40	CYLINDER HEAD	M-50125-302	100	1,320.88	132,088.00	14	A III
41	PISTON	M-50100-307	100	805.99	80,599.00	14	A II
42	PISTON	M-50125-307	100	801.33	80,133.00	14	A III
56	BUSH IN ROD BUSHING	P-5050-101	300	250.00	75,000.00	7	A II
43	Operation suit	C-6010-101	120	1,200.00	144,000.00	30	A I
44	WIPER	P-5032-213	950	68.00	64,600.00	5	B III
45	ROD SEAL	P-5050-111	300	206.25	61,875.00	5	B III
46	ROD SEAL	P-5063-111	250	209.35	52,337.50	5	B III
47	U- RING	P-5032-212	950	55.00	52,250.00	5	B III
48	WIPER	P-5040-214	800	63.00	50,400.00	5	B III
49	U-RING	P-5040-213	800	62.00	49,600.00	5	B III
50	ROD SEAL	P-5080-111	200	210.36	42,072.00	5	B III
51	PISTON SEAL	P-5040-207	800	50.00	40,000.00	5	B III
52	O-RING COVER	P-5032-210	950	38.00	36,100.00	5	B III
53	NUT M.8	C-6010-203	21,600	1.50	32,400.00	5	B III
54	O-RING PISTON ROD	P-5040-209	800	40.00	32,000.00	5	B III
55	O-RING COVER	P-5040-211	800	35.00	28,000.00	5	B III
57	BUSH IN ROD BUSHING	P-5063-101	250	251.00	62,750.00	7	B II
58	Pneumatic pipe for 5062 Size	C-6010-138	250	250.00	62,500.00	7	B II
66	PLUG	W-6010-214	5,400	8.00	43,200.00	7	B II
59	REAR COVER	P-5050-105	300	170.25	51,075.00	7	B II
60	BUSH IN ROD BUSHING	P-5080-101	200	255.00	51,000.00	7	B II
61	BARREL	P-50125-109	100	501.25	50,125.00	7	B II
62	Pneumatic pipe for 5080 Size	C-6010-139	200	250.00	50,000.00	7	B II
63	BARREL	P-50100-109	100	499.25	49,925.00	7	B II
64	PISTON SEAL	P-5032-206	950	51.00	48,450.00	7	B II
65	TUBE	P-5040-117	800	60.00	48,000.00	7	B II
67	REAR COVER	P-5063-105	250	172.00	43,000.00	7	B II
68	PISTON ROD	M-50125-314	100	399.35	39,935.00	7	B II

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Appendix A.8: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
69	O-RING PISTON ROD	P-5032-108	950	42.00	39,900.00	7	B III
70	PKSTON ROD	M-50100-314	100	398.65	39,865.00	7	B II
71	REAR COVER	P-5080-105	200	178.26	35,652.00	7	B II
72	PORT OIL SQUARE ELBOW(1)	P-5040-118	800	40.00	32,000.00	7	B II
73	PORT OIL SQUARE ELBOW(2)	P-5040-119	800	40.00	32,000.00	7	B II
74	PORT OIL	P-5040-117	800	40.00	32,000.00	7	B II
75	STOP TUBE	P-5050-103	300	100.02	30,006.00	7	B II
76	STOP TUBE	P-5063-103	250	103.00	25,750.00	7	B II
77	BUSH IN ROD BUSHING	P-50100-101	100	257.00	25,700.00	7	B II
78	BUSH IN ROD BUSHING	P-50125-101	100	256.00	25,600.00	7	B II
79	Cap for Operator	W-6010-210	100	250.00	25,000.00	7	B II
80	Pneumatic pipe for 50100 Size	C-6010-140	100	250.00	25,000.00	7	B II
81	Pneumatic pipe for 50125 Size	C-6010-141	100	250.00	25,000.00	7	B II
82	PORT OIL	P-5032-104	950	23.90	22,705.00	7	B II
83	Sticker on box for 5032	C-6010-216	950	75.00	71,250.00	14	B II
84	Metal BELT	C-6010-102	5,400	13.00	70,200.00	14	B II
85	Sticker on box for 5040	C-6010-217	800	75.00	60,000.00	14	B II
86	Protection foam	C-6010-234	1,200	30.00	36,000.00	14	B II
87	An-ti dust Powder	C-6010-225	300	90.00	27,000.00	14	B II
88	Instruction book for 5032	C-6010-226	950	50.00	47,500.00	30	B I
89	Instruction book for 5040	C-6010-227	800	50.00	40,000.00	30	B I
90	ROD SEAL	P-50125-111	100	215.25	21,525.00	5	C III
91	ROD SEAL	P-50100-111	100	210.88	21,088.00	5	C III
92	U- RING	P-5050-212	300	65.99	19,797.00	5	C III
93	WIPER	P-5050-213	300	65.00	19,500.00	5	C III
94	WIPER	P-5063-213	250	69.69	17,422.50	5	C III
95	U- RING	P-5063-212	250	69.36	17,340.00	5	C III

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Appendix A.9: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
96	PISTON SEAL	P-5050-206	300	52.36	15,708.00	5	C III
97	U- RING	P-5080-212	200	71.58	14,316.80	5	C III
98	WIPER	P-5080-213	200	71.58	14,316.00	5	C III
99	PISTON SEAL	P-5063-206	250	53.66	13,415.00	5	C III
100	PISTON SEAL	P-5080-206	200	58.28	11,656.00	5	C III
101	WIPER	P-50125-213	100	79.69	7,969.00	5	C III
102	U- RING	P-50125-212	100	75.89	7,589.00	5	C III
103	WIPER	P-50100-213	100	75.36	7,536.00	5	C III
104	U- RING	P-50100-212	100	73.58	7,358.00	5	C III
105	PISTON SEAL	P-50125-206	100	60.25	6,025.00	5	C III
106	PISTON SEAL	P-50100-206	100	59.65	5,965.00	5	C III
107	STOP TUBE	P-5080-103	200	105.00	21,000.00	7	C II
108	wire	W-6010-213	2,100	10.00	21,000.00	7	C II
109	REAR COVER	P-50125-105	100	185.00	18,500.00	7	C II
110	REAR COVER	P-50100-105	100	180.00	18,000.00	7	C II
111	Ear protection	W-6010-211	90	200.00	18,000.00	7	C II
112	O-RING PISTON ROD	P-5050-108	300	42.26	12,678.00	7	C II
113	PORT OIL	P-5050-104	300	42.00	12,600.00	7	C II
114	STOP TUBE	P-50125-103	100	115.35	11,535.00	7	C II
115	O-RING COVER	P-5050-110	300	37.00	11,100.00	7	C II
116	PORT OIL	P-5063-104	250	44.00	11,000.00	7	C II
117	O-RING PISTON ROD	P-5063-108	250	43.65	10,912.50	7	C II
118	STOP TUBE	P-50100-103	100	108.65	10,865.00	7	C II
119	EYR PROTECTION for welding	W-6010-212	30	350.00	10,500.00	7	C II
120	Small box	C-6010-223	1,300	8.00	10,400.00	7	C II
121	O-RING PISTON ROD	P-5080-108	200	48.95	9,790.00	7	C II
122	O-RING COVER	P-5063-110	250	39.00	9,750.00	7	C II
123	PORT OIL	P-5080-104	200	45.36	9,072.00	7	C II

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Appendix A.10: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
124	O-RING COVER	P-5080-110	200	40.00	8,000.00	7	C II
125	Glove for operator	W-6010-208	150	50.00	7,500.00	7	C II
126	Robe for packing	C-6010-233	1,200	5.00	6,000.00	7	C II
127	O-RING PISTON ROD	P-50125-108	100	50.26	5,026.00	7	C II
128	O-RING PISTON ROD	P-50100-108	100	49.58	4,958.00	7	C II
129	PORT OIL	P-50125-104	100	48.00	4,800.00	7	C II
130	PORT OIL	P-50100-104	100	46.00	4,600.00	7	C II
131	O-RING COVER	P-50125-110	100	44.66	4,466.00	7	C II
132	O-RING COVER	P-50100-110	100	42.36	4,236.00	7	C II
133	Sticker on box for 5050	C-6010-218	300	75.00	22,500.00	14	C II
134	Sticker on box for 5062	C-6010-219	250	75.00	18,750.00	14	C II
135	Sticker on box for 5080	C-6010-220	200	75.00	15,000.00	14	C II
136	Sticker on box for 50100	C-6010-221	100	75.00	7,500.00	14	C II
137	Sticker on box for 50125	C-6010-222	100	75.00	7,500.00	14	C II
138	Plastic bag	W-6010-215	2,100	2.50	5,250.00	15	C I
139	Instruction book for 5050	C-6010-228	300	50.00	15,000.00	30	C I
140	Instruction book for 5062	C-6010-229	250	50.00	12,500.00	30	C I
141	Instruction book for 5080	C-6010-230	200	50.00	10,000.00	30	C I
142	Instruction book for 50100	C-6010-231	100	50.00	5,000.00	30	C I
143	Instruction book for 50125	C-6010-232	100	50.00	5,000.00	30	C I
144	Big Box 12x	C-6010-224	120	15.00	1,800.00	30	C I

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Appendix A.11: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
43	Operation suit	C-6010-101	120	1,200.00	144,000.00	30	A I
3	BARREL	P-5040-110	800	480.00	384,000.00	7	A II
4	PISTON ROD	M-5032-314	950	335.00	318,250.00	7	A II
5	PISTON ROD	M-5040-315	800	370.00	296,000.00	7	A II
6	BUSH IN ROD BUSHING	P-5032-101	950	258.00	245,100.00	7	A II
7	Pneumatic pipe for 5032 Size	C-6010-135	950	250.00	237,500.00	7	A II
8	BUSH IN ROD BUSHING	P-5040-102	800	258.00	206,400.00	7	A II
9	BARREL	P-5032-109	950	214.00	203,300.00	7	A II
10	Pneumatic pipe for 5040 Size	C-6010-136	800	250.00	200,000.00	7	A II
11	REAR COVER	P-5032-105	950	196.66	186,827.00	7	A II
12	BACK UP WASHER	P-5040-101	800	208.00	166,400.00	7	A II
13	BARREL	P-5050-109	300	485.00	145,500.00	7	A II
14	REAR COVER	P-5040-106	800	165.00	132,000.00	7	A II
15	EYE MOUNTING	P-5040-104	800	160.00	128,000.00	7	A II
16	BARREL	P-5063-109	250	487.00	121,750.00	7	A II
17	PISTON ROD	M-5050-314	300	380.25	114,075.00	7	A II
18	BARREL	P-5080-109	200	490.35	98,070.00	7	A II
19	PISTON ROD	M-5063-314	250	385.36	96,340.00	7	A II
20	STOP TUBE	P-5032-103	950	98.60	93,670.00	7	A II
21	Pneumatic pipe for 5050 Size	C-6010-137	350	250.00	87,500.00	7	A II
22	STOP TUBE	P-5040-116	800	100.00	80,000.00	7	A II
23	PISTON ROD	M-5080-314	200	395.25	79,050.00	7	A II
24	Glue	W-6010-105	1,000	230.00	230,000.00	10	A II
25	Cooling water	W-6010-106	750	150.00	112,500.00	10	A II
26	Lubricant	W-6010-109	900	120.00	108,000.00	10	A II
27	WELDING SET	W-6010-104	1,500	65.00	97,500.00	10	A II

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Appendix A.12: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
28	Cutter for cutting machine	W-6010-107	600	130.00	78,000.00	10	A II
29	CYLINDER HEAD	M-5032-302	950	1,250.00	1,187,500.00	14	A II
30	CYLINDER HEAD	M-5040-303	800	1,280.00	1,024,000.00	14	A II
31	PISTON	M-5032-307	950	750.00	712,500.00	14	A II
32	PISTON	M-5040-308	800	760.00	608,000.00	14	A II
33	CYLINDER HEAD	M-5050-302	300	1,300.00	390,000.00	14	A II
34	CYLINDER HEAD	M-5063-302	250	1,300.00	325,000.00	14	A II
35	CYLINDER HEAD	M-5080-302	200	1,310.00	262,000.00	14	A II
36	PISTON	M-5050-307	300	790.00	237,000.00	14	A II
37	PISTON	M-5063-307	250	790.36	197,590.00	14	A II
38	PISTON	M-5080-307	200	790.99	158,198.00	14	A II
39	CYLINDER HEAD	M-50100-302	100	1,330.00	133,000.00	14	A II
40	CYLINDER HEAD	M-50125-302	100	1,320.88	132,088.00	14	A II
41	PISTON	M-50100-307	100	805.99	80,599.00	14	A II
42	PISTON	M-50125-307	100	801.33	80,133.00	14	A II
56	BUSH IN ROD BUSHING	P-5050-101	300	250.00	75,000.00	7	A II
88	Instruction book for 5032	C-6010-226	950	50.00	47,500.00	30	B I
89	Instruction book for 5040	C-6010-227	800	50.00	40,000.00	30	B I
1	ROD SEAL	P-5032-111	950	210.00	199,500.00	5	A III
2	ROD SEAL	P-5040-112	800	200.00	160,000.00	5	A III
57	BUSH IN ROD BUSHING	P-5063-101	250	251.00	62,750.00	7	B II
58	Pneumatic pipe for 5062 Size	C-6010-138	250	250.00	62,500.00	7	B II
59	REAR COVER	P-5050-105	300	170.25	51,075.00	7	B II

Appendix A.13 The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
60	BUSH IN ROD BUSHING	P-5080-101	200	255.00	51,000.00	7	B II
61	BARREL	P-50125-109	100	501.25	50,125.00	7	B II
62	Pneumatic pipe for 5080 Size	C-6010-139	200	250.00	50,000.00	7	B II
63	BARREL	P-50100-109	100	499.25	49,925.00	7	B II
64	PISTON SEAL	P-5032-206	950	51.00	48,450.00	7	B II
65	TUBE	P-5040-117	800	60.00	48,000.00	7	B II
66	PLUG	W-6010-214	5,400	8.00	43,200.00	7	B II
67	REAR COVER	P-5063-105	250	172.00	43,000.00	7	B II
68	PISTON ROD	M-50125-314	100	399.35	39,935.00	7	B II
69	O-RING PISTON ROD	P-5032-108	950	42.00	39,900.00	7	B II
70	PISTON ROD	M-50100-314	100	398.65	39,865.00	7	B II
71	REAR COVER	P-5080-105	200	178.26	35,652.00	7	B II
72	PORT OIL SQUARE ELBOW(1)	P-5040-118	800	40.00	32,000.00	7	B II
73	PORT OIL SQUARE ELBOW(2)	P-5040-119	800	40.00	32,000.00	7	B II
74	PORT OIL	P-5040-117	800	40.00	32,000.00	7	B II
75	STOP TUBE	P-5050-103	300	100.02	30,006.00	7	B II
76	STOP TUBE	P-5063-103	250	103.00	25,750.00	7	B II
77	BUSH IN ROD BUSHING	P-50100-101	100	257.00	25,700.00	7	B II
78	BUSH IN ROD BUSHING	P-50125-101	100	256.00	25,600.00	7	B II
79	Cap for Operator	W-6010-210	100	250.00	25,000.00	7	B II
80	Pneumatic pipe for 50100 Size	C-6010-140	100	250.00	25,000.00	7	B II
81	Pneumatic pipe for 50125 Size	C-6010-141	100	250.00	25,000.00	7	B II
82	PORT OIL	P-5032-104	950	23.90	22,705.00	7	B II
83	Sticker on box for 5032	C-6010-216	950	75.00	71,250.00	14	B II
84	Metal BELT	C-6010-102	5,400	13.00	70,200.00	14	B II
85	Sticker on box for 5040	C-6010-217	800	75.00	60,000.00	14	B II

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Appendix A.14: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
86	Protection foam	C-6010-234	1,200	30.00	36,000.00	14	B II
87	An-ti dust Powder	C-6010-225	300	90.00	27,000.00	14	B II
138	Plastic bag	W-6010-215	2,100	2.50	5,250.00	15	C I
139	Instruction book for 5050	C-6010-228	300	50.00	15,000.00	30	C I
140	Instruction book for 5062	C-6010-229	250	50.00	12,500.00	30	C I
141	Instruction book for 5080	C-6010-230	200	50.00	10,000.00	30	C I
142	Instruction book for 50100	C-6010-231	100	50.00	5,000.00	30	C I
143	Instruction book for 50125	C-6010-232	100	50.00	5,000.00	30	C I
144	Big Box 12x	C-6010-224	120	15.00	1,800.00	30	C I
44	WIPER	P-5032-213	950	68.00	64,600.00	5	B III
45	ROD SEAL	P-5050-111	300	206.25	61,875.00	5	B III
46	ROD SEAL	P-5063-111	250	209.35	52,337.50	5	B III
47	U- RING	P-5032-212	950	55.00	52,250.00	5	B III
48	WIPER	P-5040-214	800	63.00	50,400.00	5	B III
49	U-RING	P-5040-213	800	62.00	49,600.00	5	B III
50	ROD SEAL	P-5080-111	200	210.36	42,072.00	5	B III
51	PISTON SEAL	P-5040-207	800	50.00	40,000.00	5	B III
52	O-RING COVER	P-5032-210	950	38.00	36,100.00	5	B III
53	NUT M.8	C-6010-203	21,600	1.50	32,400.00	5	B III
54	O-RING PISTON ROD	P-5040-209	800	40.00	32,000.00	5	B III
55	O-RING COVER	P-5040-211	800	35.00	28,000.00	5	B III
90	ROD SEAL	P-50125-111	100	215.25	21,525.00	5	C III
91	ROD SEAL	P-50100-111	100	210.88	21,088.00	5	C III
92	U- RING	P-5050-212	300	65.99	19,797.00	5	C III
93	WIPER	P-5050-213	300	65.00	19,500.00	5	C III
94	WIPER	P-5063-213	250	69.69	17,422.50	5	C III

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Appendix A.15: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
95	U- RING	P-5063-212	250	69.36	17,340.00	5	C III
96	PISTON SEAL	P-5050-206	300	52.36	15,708.00	5	C III
97	U- RING	P-5080-212	200	71.58	14,316.00	5	C III
98	WIPER	P-5080-213	200	71.58	14,316.00	5	C III
99	PISTON SEAL	P-5063-206	250	53.66	13,415.00	5	C III
100	PISTON SEAL	P-5080-206	200	58.28	11,656.00	5	C III
101	WIPER	P-50125-213	100	79.69	7,969.00	5	C III
102	U- RING	P-50125-212	100	75.89	7,589.00	5	C III
103	WIPER	P-50100-213	100	75.36	7,536.00	5	C III
104	U- RING	P-50100-212	100	73.58	7,358.00	5	C III
105	PISTON SEAL	P-50125-206	100	60.25	6,025.00	5	C III
106	PISTON SEAL	P-50100-206	100	59.65	5,965.00	5	C III
107	STOP TUBE	P-5080-103	200	105.00	21,000.00	7	C II
108	wire	W-6010-213	2,100	10.00	21,000.00	7	C II
109	REAR COVER	P-50125-105	100	185.00	18,500.00	7	C II
110	REAR COVER	P-50100-105	100	180.00	18,000.00	7	C II
111	Ear protection	W-6010-211	90	200.00	18,000.00	7	C II
112	O-RING PISTON ROD	P-5050-108	300	42.26	12,678.00	7	C II
113	PORT OIL	P-5050-104	300	42.00	12,600.00	7	C II
114	STOP TUBE	P-50125-103	100	115.35	11,535.00	7	C II
115	O-RING COVER	P-5050-110	300	37.00	11,100.00	7	C II
116	PORT OIL	P-5063-104	250	44.00	11,000.00	7	C II
117	O-RING PISTON ROD	P-5063-108	250	43.65	10,912.50	7	C II
118	STOP TUBE	P-50100-103	100	108.65	10,865.00	7	C II
119	EYR PROTECTION for welding	W-6010-212	30	350.00	10,500.00	7	C II

Appendix A.16: The table for ABC method with multi criteria

No	Item	Code	Annual used	Unit price	Total BHT	Lead time	Combination
120	Small box	C-6010-223	1,300	8.00	10,400.00	7	C II
121	O-RING PISTON ROD	P-5080-108	200	48.95	9,790.00	7	C II
122	O-RING COVER	P-5063-110	250	39.00	9,750.00	7	C II
123	PORT OIL	P-5080-104	200	45.36	9,072.00	7	C II
124	O-RING COVER	P-5080-110	200	40.00	8,000.00	7	C II
125	Glove for operator	W-6010-208	150	50.00	7,500.00	7	C II
126	Robe for packing	C-6010-233	1,200	5.00	6,000.00	7	C II
127	O-RING PISTON ROD	P-50125-108	100	50.26	5,026.00	7	C II
128	O-RING PISTON ROD	P-50100-108	100	49.58	4,958.00	7	C II
129	PORT OIL	P-50125-104	100	48.00	4,800.00	7	C II
130	PORT OIL	P-50100-104	100	46.00	4,600.00	7	C II
131	O-RING COVER	P-50125-110	100	44.66	4,466.00	7	C II
132	O-RING COVER	P-50100-110	100	42.36	4,236.00	7	C II
133	Sticker on box for 5050	C-6010-218	300	75.00	22,500.00	14	C II
134	Sticker on box for 5062	C-6010-219	250	75.00	18,750.00	14	C II
135	Sticker on box for 5080	C-6010-220	200	75.00	15,000.00	14	C II
136	Sticker on box for 50100	C-6010-221	100	75.00	7,500.00	14	C II
137	Sticker on box for 50125	C-6010-222	100	75.00	7,500.00	14	C II

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Appendix B

**The Table shown the machining cost
for 3xx over three months**



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Appendix B.1: The table of the machining cost for 3xx over three months

No.	Item	Code	Unit price C	Qty Usage			BHT usage		
				Jan	Feb	Mar	Jan	Feb	Mar
1	BUSH IN ROD BUSHING	P-5032-101	258.00	70	70	90	18060	18060	23220
3	STOP TUBE	P-5032-103	98.60	70	70	90	6902	6902	8874
4	PORT OIL	P-5032-104	23.90	70	70	90	1673	1673	2151
5	REAR COVER	P-5032-105	196.66	70	70	90	13766.2	13766.2	17699.4
8	O-RING PISTON ROD	P-5032-108	42.00	70	70	90	2940	2940	3780
9	BARREL	P-5032-109	214.00	70	70	90	14980	14980	19260
11	ROD SEAL	P-5032-111	210.00	70	70	90	14700	14700	18900
15	BACK UP WASHER	P-5040-101	208.00	50	50	70	10400	10400	14560
16	TUBE	P-5040-117	60.00	50	50	70	3000	3000	4200
17	PORT OIL SQUARE ELBOW(1)	P-5040-118	40.00	50	50	70	2000	2000	2800
18	PORT OIL SQUARE ELBOW(2)	P-5040-119	40.00	50	50	70	2000	2000	2800
19	BUSH IN ROD BUSHING	P-5040-102	258.00	50	50	70	12900	12900	18060
21	EYE MOUNTING	P-5040-104	160.00	50	50	70	8000	8000	11200
22	BARREL	P-5040-110	480.00	50	50	70	24000	24000	33600
24	ROD SEAL	P-5040-112	200.00	50	50	70	10000	10000	14000
28	REAR COVER	P-5040-106	165.00	50	50	70	8250	8250	11550
32	STOP TUBE	P-5040-116	100.00	50	50	70	5000	5000	7000
33	PORT OIL	P-5040-117	40.00	50	50	70	2000	2000	2800
34	BUSH IN ROD BUSHING	P-5050-101	250.00	20	20	30	5000	5000	7500
36	BARREL	P-5050-109	485.00	20	20	30	9700	9700	14550
37	O-RING COVER	P-5050-110	37.00	20	20	30	740	740	1110
38	ROD SEAL	P-5050-111	206.25	20	20	30	4125	4125	6187.5
41	STOP TUBE	P-5050-103	100.02	20	20	30	2000.4	2000.4	3000.6
42	PORT OIL	P-5050-104	42.00	20	20	30	840	840	1260
43	REAR COVER	P-5050-105	170.25	20	20	30	3405	3405	5107.5
46	O-RING PISTON ROD	P-5050-108	42.26	20	20	30	845.2	845.2	1267.8
48	BUSH IN ROD BUSHING	P-5063-101	251.00	20	20	20	5020	5020	5020
50	O-RING PISTON ROD	P-5063-108	43.65	20	20	20	873	873	873
51	BARREL	P-5063-109	487.00	20	20	20	9740	9740	9740
52	O-RING COVER	P-5063-110	39.00	20	20	20	780	780	780
53	CYLINDER HEAD	P-5063-102	1,300.00	20	20	20	26000	26000	26000
54	STOP TUBE	P-5063-103	103.00	20	20	20	2060	2060	2060
55	PORT OIL	P-5063-104	44.00	20	20	20	880	880	880
56	REAR COVER	P-5063-105	172.00	20	20	20	3440	3440	3440
58	ROD SEAL	P-5063-111	209.35	20	20	20	4187	4187	4187
62	BUSH IN ROD BUSHING	P-5080-101	255.00	15	15	20	3825	3825	5100
64	BARREL	P-5080-109	490.35	15	15	20	7355.25	7355.25	9807
65	O-RING COVER	P-5080-110	40.00	15	15	20	600	600	800

Appendix B.2: The table of the machining cost for 3xx over three months

No.	Item	Code	Unit price C	Qty Usage			BHT usage		
				Jan	Feb	Mar	Jan	Feb	Mar
66	ROD SEAL	P-5080-111	210.36	15	15	20	3155.4	3155.4	4207.2
68	STOP TUBE	P-5080-103	105.00	15	15	20	1575	1575	2100
69	PORT OIL	P-5080-104	45.36	15	15	20	680.4	680.4	907.2
70	REAR COVER	P-5080-105	178.26	15	15	20	2673.9	2673.9	3565.2
73	O-RING PISTON ROD	P-5080-108	48.95	15	15	20	734.25	734.25	979
76	BUSH IN ROD BUSHING	P-50100-101	257.00	5	5	10	1285	1285	2570
78	O-RING PISTON ROD	P-50100-108	49.58	5	5	10	247.9	247.9	495.8
79	BARREL	P-50100-109	499.25	5	5	10	2496.25	2496.25	4992.5
80	O-RING COVER	P-50100-110	42.36	5	5	10	211.8	211.8	423.6
81	ROD SEAL	P-50100-111	210.88	5	5	10	1054.4	1054.4	2108.8
85	STOP TUBE	P-50100-103	108.65	5	5	10	543.25	543.25	1086.5
86	PORT OIL	P-50100-104	46.00	5	5	10	230	230	460
87	REAR COVER	P-50100-105	180.00	5	5	10	900	900	1800
90	BUSH IN ROD BUSHING	P-50125-101	256.00	5	5	10	1280	1280	2560
91	O-RING PISTON ROD	P-50125-108	50.26	5	5	10	251.3	251.3	502.6
92	BARREL	P-50125-109	501.25	5	5	10	2506.25	2506.25	5012.5
93	O-RING COVER	P-50125-110	44.66	5	5	10	223.3	223.3	446.6
94	ROD SEAL	P-50125-111	215.25	5	5	10	1076.25	1076.25	2152.5
95	CYLINDER HEAD	P-50125-102	1,320.88	5	5	10	6604.4	6604.4	13208.8
96	STOP TUBE	P-50125-103	115.35	5	5	10	576.75	576.75	1153.5
97	PORT OIL	P-50125-104	48.00	5	5	10	240	240	480
98	REAR COVER	P-50125-105	185.00	5	5	10	925	925	1850
104	Operation suit	C-6010-101	1,200.00	50	0	0	60000	0	0
105	Metal BELT	C-6010-102	13.00	370	380	500	4810	4940	6500
107	WELDING SET	W-6010-104	65.00	80	100	150	5200	6500	9750
108	Glue	W-6010-105	230.00	60	80	90	13800	18400	20700
109	Cooling water	W-6010-106	150.00	50	50	70	7500	7500	10500
110	Cutter for cutting machine	W-6010-107	130.00	50	40	50	6500	5200	6500
112	Lubricant	W-6010-109	120.00	60	70	80	7200	8400	9600
138	Pneumatic pipe for 5032 Size	C-6010-135	250.00	70	70	90	17500	17500	22500
139	Pneumatic pipe for 5040 Size	C-6010-136	250.00	50	50	70	12500	12500	17500
140	Pneumatic pipe for 5050 Size	C-6010-137	250.00	30	30	30	7500	7500	7500
141	Pneumatic pipe for 5062 Size	C-6010-138	250.00	20	20	20	5000	5000	5000
142	Pneumatic pipe for 5080 Size	C-6010-139	250.00	15	15	15	3750	3750	3750
143	Pneumatic pipe for 50100 Size	C-6010-140	250.00	5	10	10	1250	2500	2500
144	Pneumatic pipe for 50125 Size	C-6010-141	250.00	5	10	10	1250	2500	2500
6	PISTON SEAL	P-5032-206	51.00	70	70	90	3570	3570	4590
10	O-RING COVER	P-5032-210	38.00	70	70	90	2660	2660	3420

Appendix B.3: The table of the machining cost for 3xx over three months

No.	Item	Code	Unit price C	Qty Usage			BHT usage		
				Jan	Feb	Mar	Jan	Feb	Mar
12	U- RING	P-5032-212	55.00	70	70	90	3850	3850	4950
13	WIPER	P-5032-213	68.00	70	70	90	4760	4760	6120
23	O-RING COVER	P-5040-211	35.00	50	50	70	1750	1750	2450
25	U-RING	P-5040-213	62.00	50	50	70	3100	3100	4340
26	WIPER	P-5040-214	63.00	50	50	70	3150	3150	4410
29	PISTON SEAL	P-5040-207	50.00	50	50	70	2500	2500	3500
31	O-RING PISTON ROD	P-5040-209	40.00	50	50	70	2000	2000	2800
39	U- RING	P-5050-212	65.99	20	20	30	1319.8	1319.8	1979.7
40	WIPER	P-5050-213	65.00	20	20	30	1300	1300	1950
44	PISTON SEAL	P-5050-206	52.36	20	20	30	1047.2	1047.2	1570.8
57	PISTON SEAL	P-5063-206	53.66	20	20	20	1073.2	1073.2	1073.2
59	U- RING	P-5063-212	69.36	20	20	20	1387.2	1387.2	1387.2
60	WIPER	P-5063-213	69.69	20	20	20	1393.8	1393.8	1393.8
67	U- RING	P-5080-212	71.58	15	15	20	1073.7	1073.7	1431.6
71	PISTON SEAL	P-5080-206	58.28	15	15	20	874.2	874.2	1165.6
74	WIPER	P-5080-213	71.58	15	15	20	1073.7	1073.7	1431.6
82	U- RING	P-50100-212	73.58	5	5	10	367.9	367.9	735.8
83	WIPER	P-50100-213	75.36	5	5	10	376.8	376.8	753.6
88	PISTON SEAL	P-50100-206	59.65	5	5	10	298.25	298.25	596.5
99	PISTON SEAL	P-50125-206	60.25	5	5	10	301.25	301.25	602.5
101	U- RING	P-50125-212	75.89	5	5	10	379.45	379.45	758.9
102	WIPER	P-50125-213	79.69	5	5	10	398.45	398.45	796.9
106	NUT M.8	C-6010-203	1.50	1480	1520	2000	2220	2280	3000
111	Glove for operator	W-6010-208	50.00	0	80	0	0	4000	0
113	Cap for Operator	W-6010-210	250.00	0	70	0	0	17500	0
114	Ear protection	W-6010-211	200.00	0	70	0	0	14000	0
115	EYR PROTECTION for welding	W-6010-212	350.00	0	20	0	0	7000	0
116	wire	W-6010-213	10.00	150	180	200	1500	1800	2000
117	PLUG	W-6010-214	8.00	370	370	380	2960	2960	3040
118	Plastic bag	W-6010-215	2.50	180	180	180	450	450	450
119	Sticker on box for 5032	C-6010-216	75.00	70	70	90	5250	5250	6750
120	Sticker on box for 5040	C-6010-217	75.00	50	50	70	3750	3750	5250
121	Sticker on box for 5050	C-6010-218	75.00	20	20	30	1500	1500	2250
122	Sticker on box for 5062	C-6010-219	75.00	20	20	20	1500	1500	1500
123	Sticker on box for 5080	C-6010-220	75.00	15	15	20	1125	1125	1500
124	Sticker on box for 50100	C-6010-221	75.00	5	5	10	375	375	750
125	Sticker on box for 50125	C-6010-222	75.00	5	10	10	375	750	750
126	Small box	C-6010-223	8.00	100	120	120	800	960	960



Appendix B.4: The table of the machining cost for 3xx over three months

No.	Item	Code	Unit price C	Qty Usage			BHT usage		
				Jan	Feb	Mar	Jan	Feb	Mar
127	Big Box 12x	C-6010-224	15.00	10	10	10	150	150	150
128	Anti dust Powder	C-6010-225	90.00	20	25	30	1800	2250	2700
129	Instruction book for 5032	C-6010-226	50.00	70	70	90	3500	3500	4500
130	Instruction book for 5040	C-6010-227	50.00	50	50	70	2500	2500	3500
131	Instruction book for 5050	C-6010-228	50.00	20	20	20	1000	1000	1000
132	Instruction book for 5062	C-6010-229	50.00	20	20	20	1000	1000	1000
133	Instruction book for 5080	C-6010-230	50.00	15	15	15	750	750	750
134	Instruction book for 50100	C-6010-231	50.00	10	10	10	500	500	500
135	Instruction book for 50125	C-6010-232	50.00	5	10	10	250	500	500
136	Robe for packing	C-6010-233	5.00	90	90	100	450	450	500
137	Protection foam	C-6010-234	30.00	90	90	100	2700	2700	3000
2	CYLINDER HEAD	M-5032-302	1,250.00	70	70	90	87500	87500	112500
7	PISTON	M-5032-307	750.00	70	70	90	52500	52500	67500
14	PISTON ROD	M-5032-314	335.00	70	70	90	23450	23450	30150
20	CYLINDER HEAD	M-5040-303	1,280.00	50	50	70	64000	64000	89600
27	PISTON ROD	M-5040-315	370.00	50	50	70	18500	18500	25900
30	PISTON	M-5040-308	760.00	50	50	70	38000	38000	53200
35	CYLINDER HEAD	M-5050-302	1,300.00	20	20	30	26000	26000	39000
45	PISTON	M-5050-307	790.00	20	20	30	15800	15800	23700
47	PISTON ROD	M-5050-314	380.25	20	20	30	7605	7605	11407.5
49	PISTON	M-5063-307	790.36	20	20	20	15807.2	15807.2	15807.2
61	PISTON ROD	M-5063-314	385.36	20	20	20	7707.2	7707.2	7707.2
63	CYLINDER HEAD	M-5080-302	1,310.00	15	15	20	19650	19650	26200
72	PISTON	M-5080-307	790.99	15	15	20	11864.85	11864.85	15819.8
75	PISTON ROD	M-5080-314	395.25	15	15	20	5928.75	5928.75	7905
77	PISTON	M-50100-307	805.99	5	5	10	4029.95	4029.95	8059.9
84	CYLINDER HEAD	M-50100-302	1,330.00	5	5	10	6650	6650	13300
89	PISTON ROD	M-50100-314	398.65	5	5	10	1993.25	1993.25	3986.5
100	PISTON	M-50125-307	801.33	5	5	10	4006.65	4006.65	8013.3
103	PISTON ROD	M-50125-314	399.35	5	5	10	1996.75	1996.75	3993.5
	Total						924617.35	917142.35	1167245

	Jan	Feb	Mar	Total
1xx	435,217.85	383,647.85	502,987.10	1,321,852.80
2xx	76,409.90	120,504.90	100,507.70	297,422.50
3xx	412,989.60	412,989.60	563,749.90	1,389,729.10
	924,617.35	917,142.35	1,167,244.70	3,009,004.40

Appendix C

Ordering history from Jan to Dec in 2006



สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

Appendix C.1: Ordering history and Inventory cost in 2006

No.	Code	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov		Dec		D=Σx
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
3	P-5040-110	30	30	30	30	40	40	30	30	40	40	30	30	40	40	50	20	50	40	30	40	40	30	20	30	830
4	M-5032-314	60	30	40	60	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	970
5	M-5040-315	60		30	30	40	40	30	40	30	35	30	30		60	50	50	50	65	60	60			40		830
6	P-5032-101	60	30	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	960
7	C-6010-135	80	20	35	35	80		45	50	55	55	70		70	65	65	35	40	40	80		60		40	30	1050
43	C-6010-101	40			30					30									30							130
8	P-5040-102	30	30	30	40	55	35	40	30	50	60	80		35		65	35		30	65	80	30	30			850
9	P-5032-109	50	40	80		60	40	40	55	35	30	40	30	50		50		40	45	55	45	55	60	60	40	1000
10	C-6010-136	60		40	50	60	60		50	60	50	55	50		30	60	20	65		50		55	30	35	20	900
11	P-5032-105	80	30	35	35	80	20	45	50	55	55	70		70	65	65	35	40	40	80		70		40	30	1090
12	P-5040-101	60		30	30	30	30	40	40	40	35	40	50		60	50	50	75	70	60	60			40		890
13	P-5050-109	40		55		55		35		20		20	20	10	10		20		30		30		20			365
14	P-5040-106	60		35	30	30	30	40	40	40	35	40	50		60	50	50	75	70	60	60			40		895
15	P-5040-104	60	30	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	960
16	P-5063-109	40		55		40		35		20		20	20	10	10		20		30		30		20			350
17	M-5050-314	40		40		60		40		20		20	20	10	10		20		20		20		20			340
18	P-5080-109	35		15		20		20		20		20		20		20		20		30		40				260
19	M-5063-314	15		15		20		20		20		20		20		30		30		30		40		20		280
20	P-5032-103	60	60	40	60	60	60		50	60	60	65	50		50	60	40	65		80		55	30	35	20	1060
21	C-6010-137	60		50		55		35		50		40	40	15	10		20		30		30		20			455
22	P-5040-116	50	40	40	50	60	60	30	50	65	50	55	50		30	60	20	65		80		55	30	35	20	995
23	M-5080-314	35		45		20		20		20		10		10		10		20		20		20				230
24	W-6010-105	60	50	50	50	80	60	50	50	60	80	55	50	50	80	60	90	65	90	80		55	30	35	20	1350
25	W-6010-106	60	30	30	40	55	35	40	30	50	60	80		35		65	35		30	65	80	30	30			880
26	W-6010-109	50	30	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	950
27	W-6010-104	60	80	50	150	70	70	100	150	80	80	55	50		30	60	80	65		80		55	30	35	20	1450
28	W-6010-107	100			50			100				100					100				100					550
29	M-5032-302	60	60	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	990
30	M-5040-303	60	30	40	50	60	45		60	50	55	50		30	60	20	65		80		55	30	35	20		895
31	M-5032-307	60	60	50	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	1000
32	M-5040-308	60	30	40	50	60	60		50	60		55	50		60	20	65		50		55	30	35	20		850
33	M-5050-302	40		40		40		30		20		15	15	10	10		20		30		30		20			320
34	M-5063-302	40		50		55		35		20		20	20	10	10		20		30		30		20			360
35	M-5080-302	20		15		20		20		20		20		20				20		30		40		20		245
36	M-5050-307	40		50		50		35		20		20	20	10	10		20		30		30		20			355
37	M-5063-307	45		15		30		20		20		20		25		20		20		30		40				285

Appendix C.2: Ordering history and Inventory cost in 2006

No.	Code	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov		Dec		D=? x
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
38	M-5080-307	15		15		20		20		20		20		20				20		30		40		20		240
39	M-50100-302	20			10			10		20			30			10				20						120
40	M-50125-302	20			10			10		20			30			10			20		10					130
41	M-50100-307	20			10			10		20			30			10			20		10					130
42	M-50125-307	20			15			10		10			20			10			20		10					115
56	P-5050-101	40		35		40		35		20		15	15	10	10		20		30		30		20			320
88	C-6010-226	60	50	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	980
89	C-6010-227	60	30	40	50	60			50	60	30	55	50		30	50	20	65		80		55	30	35	20	870
1	P-5032-111	60	50	60	50	60	80		65	60	50	55	50		30	60	20	65		80		55	30	35	20	1035
2	P-5040-112	60	30	40	50		60		55	60	50	55	50			60	20	65		80		55	30	35	20	875
57	P-5063-101	15		40		20		25		20		20		20		20		20		30		40				270
58	C-6010-138	15		15		20		30		30		20		30		20		20		30		40		20		290
59	P-5050-105	30		40		55		35		20		20		10	10		20		30		20		20	10		320
60	P-5080-101	15		15		20		40		20				20		15		20		30		40				235
61	P-50125-109	40		5	15		5	20		10		5	25			10		20		20		10				165
62	C-6010-139	15		30		25		20		20		20			10		20		20		30		40			230
63	P-50100-109	40		5	15		5	20		10		5	25			10		20		20		10				165
64	P-5032-206	60	50	70	50	60	65		80	60	60	55	50		30	60	20	65		80		55	30	35	20	1055
65	P-5040-117	60	30	40	50	40	40		50	45	50	55	50		30	60	20	45		80		60	30	35	20	890
66	W-6010-214	2000					1000				1000				1000					890						5890
67	P-5063-105	30		20		30		30		30		20		20		20		20		30		40				290
68	M-50125-314	30		5	15		5	10		10		5	15			10		20		20		10				135
69	P-5032-108	60	50	40	50	60	75		50	60	50	55	50		30	60	20	65		80		55	30	35	20	995
70	M-50100-314	30		5	15		5	10		10		5	15			10		20		20		10				135
71	P-5080-105	30		25		20		20		20		20			20		20		20		30		20			225
72	P-5040-118	60	30	40	50	60			50	30	50	55	50		30	60	20	65		80		55	30	35	20	870
73	P-5040-119	60	30	40	50	60	50		50	60	50	55	50		30	60	20	65		80		55	30	35	20	950
74	P-5040-117	60	30	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	960
75	P-5050-103	40		55		55		35		20		20	20	10	10		20		30		30		20			365
76	P-5063-103	40		55		55		35		20		20	20	10			15		30		30		20			350
77	P-50100-101	35		15		20		20		20		20		20		20		20		30		30		30		250
78	P-50125-101	30		5	15		5	10		10		5	15			10		20		20		10				135
79	W-6010-210	30		5	15		5	10		10		5	15			10		20		20		10				135
80	C-6010-140	20		5	15		5	10		10		5	15			10		20		20		10				125
81	C-6010-141	30		20	15		10	10		10		5	15			10		20		20		10				155
82	P-5032-104	65	30	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	965
83	C-6010-216	60	50	55	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	995

Appendix C.3: Ordering history and Inventory cost in 2006

No.	Code	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov		Dec		D=? x
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
84	C-6010-102	2000						1000		*			2000					800		*						5800
85	C-6010-217	60	30	40	50	60	40		50	30	50	55	50		30	40	20	65		50		55	30	35	20	860
86	C-6010-234	1000									350															1350
87	C-6010-225	40		40		45		35		20		20	20	10	10				30		30		20			320
138	W-6010-215	1500							500							500										2500
139	C-6010-228	40		55		45		35		20		20		10	10		20		30		20		20			325
140	C-6010-229	35		35		20		35		30		20		20		20		20		30		30				295
141	C-6010-230	35		15		20		20		20		20		20		20		20		30		30				250
142	C-6010-231	30		20	15		5	10		10		5	15			10			20		10					150
143	C-6010-232	30		20	15		5			10		5	15			10			20		10					140
144	C-6010-224	30		20	15		5	10		10		5	15			10			20		10					150
44	P-5032-213	60	50	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	980
45	P-5050-111	40		40		55		35		20		20	20	10	10		20		30		30		20			350
46	P-5063-111	35		15		20		30		30		20		20		20		30		30		40				290
47	P-5032-212	60	55	40	50	60	60		75	60	50	55	50		55	60	30	65		80		55	30	35	20	1045
48	P-5040-214	60	30	40	50	60			50	60	50	55	50			60	20	45		80		55	30	35	20	850
49	P-5040-213	60	30	40	50	60	60		50	60		55	50			60		65		80		45	30	35	20	850
50	P-5080-111	40		25		20		20		20		15		15		15		20		30		25				245
51	P-5040-207	60	30	40	50	60	60		50	60	50	55	50		30	60	20	65		65		55	30			890
52	P-5032-210	60	35	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55	30	35	20	965
53	C-6010-203	500				350				500					500					500						2350
54	P-5040-209	60	30	40	50	60	60		50	60		55	50			60		65		80		55	30	35	10	850
55	P-5040-211	60	30	40	50	60	60		50	60	50	55	50		30	60	20	65		80		55		35	20	930
90	P-50125-111	30		20	20		5	10		10		5	15			10			20		10					155
91	P-50100-111	30		35	15		5	10		10		5	15			10			20		10					165
92	P-5050-212	40		40		55		30		20			20	10	10		15		30		30		20			320
93	P-5050-213	40		55		50		35		20		20	20	10	10		20		30		30		20			360
94	P-5063-213	35		15		20		30		30		20		20		20		20		30		40				280
95	P-5063-212	15		15		30		30		30		20		20		20		20		30		40		20		290
96	P-5050-206	40		35		55		35		20		20	20	10	10		20		30		30		20	20		365
97	P-5080-212	20		20		20		20		20		20		20	15	20		20		30		40				265
98	P-5080-213	15		15		30		30		20		20			25			20		30		20		20		245
99	P-5063-206	15		15		20		20		20		20	15	20		20		20		30		40		20		275
100	P-5080-206	40		35		50		30		20		20	15	10	10		20		30		30		20	20		350
101	P-50125-213	15		30		20		20		20		20		20		20		20		30		20				235
102	P-50125-212	15		20		20		25		20		20		20		20		20		30		40		15		265
103	P-50100-213	30		20	15		5	10		10		5	15			10			20		10					150

Appendix C.4: Ordering history and Inventory cost in 2006

No.	Code	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov		Dec		D=?x
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
104	P-50100-212	30		20	15		5	10		10		5	15			10			20		10					150
105	P-50125-206	30		30	15		5	10		10		5	15			10			20		10					160
106	P-50100-206	30		30	30		15	10		10		5	15			10			20		10					185
107	P-5080-103	15		25		20		20		25		20		25		20			20		30		40			260
108	W-6010-213	1000										500							500				300			2300
109	P-50125-105	30		20	15		5	10		10		5	15			10			20		10					150
110	P-50100-105	30		30	15		5	10		10		5	15			10			20		10					160
111	W-6010-211	45		20	15		5	10		10		5	15			10			20		10					165
112	P-5050-108	40		55		55		35		20		20	20	10		20			30		30		20			355
113	P-5050-104	40		55		45		35		20		20	20	10		20			30		30					325
114	P-50125-103	30		20				10		10			15			10			20		20		5			120
115	P-5050-110	40		30		55		35		20		20	20			20			30		30		20			320
116	P-5063-104	30		40		20		20		30		20		20		20			20		30		40			290
117	P-5063-108	30		20		20		20		20		20		20		20			20		30		40		20	280
118	P-50100-103	30		20	15		20	10		10		5	15			10			20		10					165
119	W-6010-212	30												5												35
120	C-6010-223	300				500			300				300				100									1500
121	P-5080-108	25		20		25		25		20		20		20		20			20		30		40			265
122	P-5063-110	20		20		25		30		30		20		20		20			20		30		40		20	295
123	P-5080-104	15		15		15		20		20		20		20		20			20		30		40		20	255
124	P-5080-110	15		15		20		20		20		10		10		10			20		30		20		20	210
125	W-6010-208	30		30	15		5	10		10		5	15			10			20		10					160
126	C-6010-233	300			100			200				100			300				300			100				1400
127	P-50125-108	30			15			10		10			15			10			20		10					120
128	P-50100-108	30		20	15		5			10		5	5			20			20		5					135
129	P-50125-104	30		30	15		5			10		5	5			20			20		5					145
130	P-50100-104	30		20	10		30			10		5	5			20			20		5					155
131	P-50125-110	30		20	30		5			10		5	5			20			20		5					150
132	P-50100-110	30		20	30		20			10		5	5			20			20		5					165
133	C-6010-218	40		55		55		35		20		30	30	10	20		20			30		30		20		395
134	C-6010-219	30		25		20		20		20		20		20		20			20		30		40			265
135	C-6010-220	15		15		20		20		20		15		15		15			20		30		35		20	240
136	C-6010-221	30		20	10		20			5		5	5			20			20		5					140
137	C-6010-222	30		30	30		20			10		5	5			20			20		5					175

Appendix D
The calculation of inventory cost for 2006



สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

Appendix D.I: The calculation of inventory cost for 2006

No.	Item	Code	MIN	MAX	Avr Q	T	Unit price		Material Cost		Holding Cost	SS Cost
							C	SS=0.2D	I	DxC	(I+W) avrQ	(I+W) SS
3	BARREL	P-5040-110	83	118	34.58	24	480.00	83.00	36.00	398,400.00	1,251.00	3,002.40
4	PISTON ROD	M-5032-314	97	146	48.50	20	335.00	97.00	25.13	324,950.00	1,226.98	2,453.95
5	PISTON ROD	M-5040-315	83	127	43.68	19	370.00	83.00	27.75	307,100.00	1,219.82	2,317.65
6	BUSH IN ROD BUSHING	P-5032-101	96	144	48.00	20	258.00	96.00	19.35	247,680.00	937.13	1,874.26
7	Pneumatic pipe for 5032 Size	C-6010-135	105	158	52.50	20	250.00	105.00	18.75	262,500.00	993.48	1,986.97
43	Operation suit	C-6010-101	13	46	32.50	4	1,200.00	13.00	90.00	156,000.00	2,930.64	1,172.26
8	BUSH IN ROD BUSHING	P-5040-102	85	130	44.74	19	258.00	85.00	19.35	219,300.00	873.42	1,659.50
9	BARREL	P-5032-109	100	148	47.62	21	214.00	100.00	16.05	214,000.00	772.55	1,622.35
10	Pneumatic pipe for 5040 Size	C-6010-136	90	137	47.37	19	250.00	90.00	18.75	225,000.00	896.38	1,703.12
11	REAR COVER	P-5032-105	109	161	51.90	21	196.66	109.00	14.75	214,359.40	774.57	1,626.61
12	BACK UP WASHER	P-5040-101	89	136	46.84	19	208.00	89.00	15.60	185,120.00	738.86	1,403.84
13	BARREL	P-5050-109	37	65	28.08	13	485.00	36.50	36.38	177,025.00	1,026.17	1,334.02
14	REAR COVER	P-5040-106	90	137	47.11	19	165.00	89.50	12.38	147,675.00	591.10	1,123.09
15	EYE MOUNTING	P-5040-104	96	144	48.00	20	160.00	96.00	12.00	153,600.00	584.33	1,168.66
16	BARREL	P-5063-109	35	62	26.92	13	487.00	35.00	36.53	170,450.00	988.04	1,284.45
17	PISTON ROD	M-5050-314	34	60	26.15	13	380.25	34.00	28.52	129,285.00	750.41	975.54
18	BARREL	P-5080-109	26	50	23.64	11	490.35	26.00	36.78	127,491.00	873.36	960.69
19	PISTON ROD	M-5063-314	28	51	23.33	12	385.36	28.00	28.90	107,900.80	678.43	814.11
20	STOP TUBE	P-5032-103	106	159	53.00	20	98.60	106.00	7.40	104,516.00	401.13	802.26
21	Pneumatic pipe for 5050 Size	C-6010-137	46	81	35.00	13	250.00	45.50	18.75	113,750.00	662.32	861.02
22	STOP TUBE	P-5040-116	100	147	47.38	21	100.00	99.50	7.50	99,500.00	363.58	763.51
23	PISTON ROD	M-5080-314	23	44	20.91	11	395.25	23.00	29.64	90,907.50	623.45	685.80
24	Glue	W-6010-105	135	194	58.70	23	230.00	135.00	17.25	310,500.00	1,022.68	2,352.17
25	Cooling water	W-6010-106	88	134	46.32	19	150.00	88.00	11.25	132,000.00	529.09	1,005.27
26	Lubricant	W-6010-109	95	143	47.50	20	120.00	95.00	9.00	114,000.00	435.74	871.48
27	WELDING SET	W-6010-104	145	214	69.05	21	65.00	145.00	4.88	94,250.00	348.59	732.03
28	Cutter for cutting machine	W-6010-107	55	147	91.67	6	130.00	55.00	9.75	71,500.00	909.65	545.79
29	CYLINDER HEAD	M-5032-302	99	149	49.50	20	1,250.00	99.00	93.75	1,237,500.00	4,649.21	9,298.43
30	CYLINDER HEAD	M-5040-303	90	137	47.11	19	1,280.00	89.50	96.00	1,145,600.00	4,530.28	8,607.53
31	PISTON	M-5032-307	100	150	50.00	20	750.00	100.00	56.25	750,000.00	2,821.18	5,642.35
32	PISTON	M-5040-308	85	132	47.22	18	760.00	85.00	57.00	646,000.00	2,699.86	4,859.75
33	CYLINDER HEAD	M-5050-302	32	57	24.62	13	1,300.00	32.00	97.50	416,000.00	2,404.27	3,125.55
34	CYLINDER HEAD	M-5063-302	36	64	27.69	13	1,300.00	36.00	97.50	468,000.00	2,704.80	3,516.25
35	CYLINDER HEAD	M-5080-302	25	47	22.27	11	1,310.00	24.50	98.25	320,950.00	2,192.16	2,411.38
36	PISTON	M-5050-307	36	63	27.31	13	790.00	35.50	59.25	280,450.00	1,622.72	2,109.53
37	PISTON	M-5063-307	29	54	25.91	11	790.36	28.50	59.28	225,252.60	1,540.31	1,694.34

Appendix D.2: The calculation of inventory cost for 2006

No.	Item	Code	MIN	MAX	Avr Q	T	Unit price			Material Cost		Holding Cost	SS Cost
							C	SS=0.2D	I	DxC	(I+W) avrQ	(I+W) SS	
38	PISTON	M-5080-307	24	46	21.82	11	790.99	24.00	59.32	189,837.60	1,298.13	1,427.95	
39	CYLINDER HEAD	M-50100-302	12	29	17.14	7	1,330.00	12.00	99.75	159,600.00	1,712.97	1,199.08	
40	CYLINDER HEAD	M-50125-302	13	29	16.25	8	1,320.88	13.00	99.07	171,714.40	1,612.64	1,290.11	
41	PISTON	M-50100-307	13	29	16.25	8	805.99	13.00	60.45	104,778.70	985.12	788.10	
42	PISTON	M-50125-307	12	26	14.38	8	801.33	11.50	60.10	92,152.95	866.43	693.14	
56	BUSH IN ROD BUSHING	P-5050-101	32	57	24.62	13	250.00	32.00	18.75	80,000.00	465.81	605.55	
88	Instruction book for 5032	C-6010-226	98	147	49.00	20	50.00	98.00	3.75	49,000.00	192.25	384.50	
89	Instruction book for 5040	C-6010-227	87	133	45.79	19	50.00	87.00	3.75	43,500.00	179.66	341.34	
1	ROD SEAL	P-5032-111	104	155	51.75	20	210.00	103.50	15.75	217,350.00	824.04	1,648.08	
2	ROD SEAL	P-5040-112	88	136	48.61	18	200.00	87.50	15.00	175,000.00	737.60	1,327.68	
57	BUSH IN ROD BUSHING	P-5063-101	27	52	24.55	11	251.00	27.00	18.83	67,770.00	466.33	512.96	
58	Pneumatic pipe for 5062 Size	C-6010-138	29	53	24.17	12	250.00	29.00	18.75	72,500.00	457.32	548.78	
59	REAR COVER	P-5050-105	32	57	24.62	13	170.25	32.00	12.77	54,480.00	318.58	414.15	
60	BUSH IN ROD BUSHING	P-5080-101	24	47	23.50	10	255.00	23.50	19.13	59,925.00	453.51	453.51	
61	BARREL	P-50125-109	17	32	15.00	11	501.25	16.50	37.59	82,706.25	566.51	623.16	
62	Pneumatic pipe for 5080 Size	C-6010-139	23	46	23.00	10	250.00	23.00	18.75	57,500.00	435.24	435.24	
63	BARREL	P-50100-109	17	32	15.00	11	499.25	16.50	37.44	82,376.25	564.26	620.68	
64	PISTON SEAL	P-5032-206	106	158	52.75	20	51.00	105.50	3.83	53,805.00	210.92	421.84	
65	TUBE	P-5040-117	89	134	44.50	20	60.00	89.00	4.50	53,400.00	207.97	415.94	
66	PLUG	W-6010-214	589	1,767	1178.00	5	8.00	589.00	0.60	47,120.00	911.18	455.59	
67	REAR COVER	P-5063-105	29	55	26.36	11	172.00	29.00	12.90	49,880.00	344.67	379.13	
68	PISTON ROD	M-50125-314	14	26	12.27	11	399.35	13.50	29.95	53,912.25	369.71	406.68	
69	O-RING PISTON ROD	P-5032-108	100	149	49.75	20	42.00	99.50	3.15	41,790.00	165.34	330.69	
70	PISTON ROD	M-50100-314	14	26	12.27	11	398.65	13.50	29.90	53,817.75	369.07	405.98	
71	REAR COVER	P-5080-105	23	45	22.50	10	178.26	22.50	13.37	40,108.50	304.72	304.72	
72	PORT OIL SQUARE ELBOW(1)	P-5040-118	87	133	45.79	19	40.00	87.00	3.00	34,800.00	145.31	276.09	
73	PORT OIL SQUARE ELBOW(2)	P-5040-119	95	143	47.50	20	40.00	95.00	3.00	38,000.00	150.74	301.48	
74	PORT OIL	P-5040-117	96	144	48.00	20	40.00	96.00	3.00	38,400.00	152.33	304.66	
75	STOP TUBE	P-5050-103	37	65	28.08	13	100.02	36.50	7.50	36,507.30	215.49	280.14	
76	STOP TUBE	P-5063-103	35	64	29.17	12	103.00	35.00	7.73	36,050.00	230.37	276.45	
77	BUSH IN ROD BUSHING	P-50100-101	25	48	22.73	11	257.00	25.00	19.28	64,250.00	442.01	486.21	
78	BUSH IN ROD BUSHING	P-50125-101	14	26	12.27	11	256.00	13.50	19.20	34,560.00	237.77	261.54	
79	Cap for Operator	W-6010-210	14	26	12.27	11	250.00	13.50	18.75	33,750.00	232.24	255.47	
80	Pneumatic pipe for 50100 Size	C-6010-140	13	24	11.36	11	250.00	12.50	18.75	31,250.00	215.04	236.54	
81	Pneumatic pipe for 50125 Size	C-6010-141	16	30	14.09	11	250.00	15.50	18.75	38,750.00	266.65	293.31	
82	PORT OIL	P-5032-104	97	145	48.25	20	23.90	96.50	1.79	23,063.50	94.86	189.72	
83	Sticker on box for 5032	C-6010-216	100	149	49.75	20	75.00	99.50	5.63	74,625.00	288.48	576.95	

Appendix D.3: The calculation of inventory cost for 2006

No.	Item	Code	MIN	MAX	Avr Q	T	Unit price C	SS=0.2D	I	Material Cost DxC	Holding Cost (I+W) avrQ	SS Cost (I+W) SS
84	Metal BELT	C-6010-102	580	2,030	1450.00	4	13.00	580.00	0.98	75,400.00	1,665.33	666.13
85	Sticker on box for 5040	C-6010-217	86	129	43.00	20	75.00	86.00	5.63	64,500.00	249.34	498.67
86	Protection foam	C-6010-234	135	810	675.00	2	30.00	135.00	2.25	40,500.00	1,635.86	327.17
87	An-ti dust Powder	C-6010-225	32	59	26.67	12	90.00	32.00	6.75	28,800.00	184.63	221.55
138	Plastic bag	W-6010-215	250	1,083	833.33	3	2.50	250.00	0.19	6,250.00	300.83	90.25
139	Instruction book for 5050	C-6010-228	33	60	27.08	12	50.00	32.50	3.75	16,250.00	106.26	127.51
140	Instruction book for 5062	C-6010-229	30	56	26.82	11	50.00	29.50	3.75	14,750.00	105.22	115.74
141	Instruction book for 5080	C-6010-230	25	48	22.73	11	50.00	25.00	3.75	12,500.00	89.17	98.09
142	Instruction book for 50100	C-6010-231	15	29	13.64	11	50.00	15.00	3.75	7,500.00	53.50	58.85
143	Instruction book for 50125	C-6010-232	14	28	14.00	10	50.00	14.00	3.75	7,000.00	54.93	54.93
144	Big Box 12x	C-6010-224	15	29	13.64	11	15.00	15.00	1.13	2,250.00	17.71	19.48
44	WIPER	P-5032-213	98	147	49.00	20	68.00	98.00	5.10	66,640.00	258.40	516.80
45	ROD SEAL	P-5050-111	35	62	26.92	13	206.25	35.00	15.47	72,187.50	421.14	547.48
46	ROD SEAL	P-5063-111	29	55	26.36	11	209.35	29.00	15.70	60,711.50	418.52	460.37
47	U- RING	P-5032-212	105	157	52.25	20	55.00	104.50	4.13	57,475.00	224.60	449.19
48	WIPER	P-5040-214	85	132	47.22	18	63.00	85.00	4.73	53,550.00	231.32	416.37
49	U-RING	P-5040-213	85	135	50.00	17	62.00	85.00	4.65	52,700.00	241.18	410.00
50	ROD SEAL	P-5080-111	25	47	22.27	11	210.36	24.50	15.78	51,538.20	355.26	390.79
51	PISTON SEAL	P-5040-207	89	138	49.44	18	50.00	89.00	3.75	44,500.00	194.00	349.19
52	O-RING COVER	P-5032-210	97	145	48.25	20	38.00	96.50	2.85	36,670.00	145.88	291.77
53	NUT M.8	C-6010-203	235	705	470.00	5	1.50	235.00	0.11	3,525.00	134.42	67.21
54	O-RING PISTON ROD	P-5040-209	85	135	50.00	17	40.00	85.00	3.00	34,000.00	158.68	269.75
55	O-RING COVER	P-5040-211	93	142	48.95	19	35.00	93.00	2.63	32,550.00	136.98	260.26
90	ROD SEAL	P-50125-111	16	30	14.09	11	215.25	15.50	16.14	33,363.75	229.92	252.92
91	ROD SEAL	P-50100-111	17	32	15.00	11	210.88	16.50	15.82	34,795.20	239.84	263.83
92	U- RING	P-5050-212	32	59	26.67	12	65.99	32.00	4.95	21,116.80	136.61	163.93
93	WIPER	P-5050-213	36	64	27.69	13	65.00	36.00	4.88	23,400.00	139.80	181.75
94	WIPER	P-5063-213	28	53	25.45	11	69.69	28.00	5.23	19,513.20	137.46	151.21
95	U- RING	P-5063-212	29	53	24.17	12	69.36	29.00	5.20	20,114.40	129.91	155.89
96	PISTON SEAL	P-5050-206	37	63	26.07	14	52.36	36.50	3.93	19,111.40	106.91	149.67
97	U- RING	P-5080-212	27	49	22.08	12	71.58	26.50	5.37	18,968.70	122.39	146.86
98	WIPER	P-5080-213	25	47	22.27	11	71.58	24.50	5.37	17,537.10	123.44	135.78
99	PISTON SEAL	P-5063-206	28	49	21.15	13	53.66	27.50	4.02	14,756.50	88.80	115.45
100	PISTON SEAL	P-5080-206	35	60	25.00	14	58.28	35.00	4.37	20,398.00	113.61	159.06
101	WIPER	P-50125-213	24	45	21.36	11	79.69	23.50	5.98	18,727.15	131.39	144.53
102	U- RING	P-50125-212	27	49	22.08	12	75.89	26.50	5.69	20,110.85	129.52	155.43
103	WIPER	P-50100-213	15	29	13.64	11	75.36	15.00	5.65	11,304.00	79.44	87.38

Appendix D.4: The calculation of inventory cost for 2006

No.	Item	Code	MIN	MAX	Avr Q	T	Unit price			Material Cost DxC	Holding Cost (I+W) avrQ	SS Cost (I+W) SS
							C	SS=0.2D	I			
104	U- RING	P-50100-212	15	29	13.64	11	73.58	15.00	5.52	11,037.00	77.62	85.38
105	PISTON SEAL	P-50125-206	16	31	14.55	11	60.25	16.00	4.52	9,640.00	68.25	75.08
106	PISTON SEAL	P-50100-206	19	35	16.82	11	59.65	18.50	4.47	11,035.25	78.16	85.97
107	STOP TUBE	P-5080-103	26	50	23.64	11	105.00	26.00	7.88	27,300.00	190.24	209.26
108	wire	W-6010-213	230	805	575.00	4	10.00	230.00	0.75	23,000.00	531.01	212.41
109	REAR COVER	P-50125-105	15	29	13.64	11	185.00	15.00	13.88	27,750.00	191.57	210.73
110	REAR COVER	P-50100-105	16	31	14.55	11	180.00	16.00	13.50	28,800.00	198.89	218.78
111	Ear protection	W-6010-211	17	32	15.00	11	200.00	16.50	15.00	33,000.00	227.60	250.36
112	O-RING PISTON ROD	P-5050-108	36	65	29.58	12	42.26	35.50	3.17	15,002.30	98.90	118.68
113	PORT OIL	P-5050-104	33	62	29.55	11	42.00	32.50	3.15	13,650.00	98.19	108.01
114	STOP TUBE	P-50125-103	12	27	15.00	8	115.35	12.00	8.65	13,842.00	132.37	105.90
115	O-RING COVER	P-5050-110	32	61	29.09	11	37.00	32.00	2.78	11,840.00	85.77	94.35
116	PORT OIL	P-5063-104	29	55	26.36	11	44.00	29.00	3.30	12,760.00	91.57	100.73
117	O-RING PISTON ROD	P-5063-108	28	51	23.33	12	43.65	28.00	3.27	12,222.00	80.44	96.52
118	STOP TUBE	P-50100-103	17	32	15.00	11	108.65	16.50	8.15	17,927.25	124.83	137.32
119	EYE PROTECTION for welding	W-6010-212	4	21	17.50	2	350.00	3.50	26.25	12,250.00	462.41	92.48
120	Small box	C-6010-223	150	450	300.00	5	8.00	150.00	0.60	12,000.00	232.05	116.03
121	O-RING PISTON ROD	P-5080-108	27	51	24.09	11	48.95	26.50	3.67	12,971.75	92.62	101.89
122	O-RING COVER	P-5063-110	30	54	24.58	12	39.00	29.50	2.93	11,505.00	76.17	91.41
123	PORT OIL	P-5080-104	26	47	21.25	12	45.36	25.50	3.40	11,566.80	75.98	91.18
124	O-RING COVER	P-5080-110	21	39	17.50	12	40.00	21.00	3.00	8,400.00	55.54	66.64
125	Glove for operator	W-6010-208	16	31	14.55	11	50.00	16.00	3.75	8,000.00	57.07	62.78
126	Robe for packing	C-6010-233	140	340	200.00	7	5.00	140.00	0.38	7,000.00	109.70	76.79
127	O-RING PISTON ROD	P-50125-108	12	27	15.00	8	50.26	12.00	3.77	6,031.20	59.15	47.32
128	O-RING PISTON ROD	P-50100-108	14	27	13.50	10	49.58	13.50	3.72	6,693.30	52.54	52.54
129	PORT OIL	P-50125-104	15	29	14.50	10	48.00	14.50	3.60	6,960.00	54.72	54.72
130	PORT OIL	P-50100-104	16	31	15.50	10	46.00	15.50	3.45	7,130.00	56.16	56.16
131	O-RING COVER	P-50125-110	15	30	15.00	10	44.68	15.00	3.35	6,699.00	52.85	52.85
132	O-RING COVER	P-50100-110	17	33	16.50	10	42.36	16.50	3.18	6,989.40	55.28	55.28
133	Sticker on box for 5050	C-6010-218	40	70	30.38	13	75.00	39.50	5.63	29,625.00	176.19	229.04
134	Sticker on box for 5062	C-6010-219	27	51	24.09	11	75.00	26.50	5.63	19,875.00	139.69	153.66
135	Sticker on box for 5080	C-6010-220	24	44	20.00	12	75.00	24.00	5.63	18,000.00	115.97	139.16
136	Sticker on box for 50100	C-6010-221	14	28	14.00	10	75.00	14.00	5.63	10,500.00	81.18	81.18
137	Sticker on box for 50125	C-6010-222	18	35	17.50	10	75.00	17.50	5.63	13,125.00	101.47	101.47
Total										14,645,634.25	79,933.29	111,344.33

Appendix E
The allocation store for new system



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Appendix E.1: The allocation store for new system

Group AA (M)			
Item	Code	SS _{MAX}	floor
CYLINDER HEAD	M-50100-302	7	1
CYLINDER HEAD	M-50125-302	7	1
CYLINDER HEAD	M-5032-302	45	1
CYLINDER HEAD	M-5040-303	40	1
CYLINDER HEAD	M-5050-302	15	2
CYLINDER HEAD	M-5063-302	15	2
CYLINDER HEAD	M-5080-302	9	2
PISTON	M-50100-307	7	3
PISTON	M-50125-307	7	3
PISTON	M-5032-307	45	3
PISTON	M-5040-308	40	3
PISTON	M-5050-307	15	4
PISTON	M-5063-307	15	4
PISTON	M-5080-307	9	4
PISTON ROD	M-5032-314	43	5
PISTON ROD	M-5040-315	38	5
PISTON ROD	M-5050-314	14	6
PISTON ROD	M-5063-314	13	6
PISTON ROD	M-5080-314	9	6

Group AA (P1)			
Item	Code	SS _{MAX}	floor
BARREL	P-5032-109	48	1
BARREL	P-5040-110	43	1
BARREL	P-5050-109	16	1
BARREL	P-5063-109	15	1
BARREL	P-5080-109	10	1
BUSH IN ROD BUSHING	P-5032-101	48	2
BUSH IN ROD BUSHING	P-5040-102	43	2
BUSH IN ROD BUSHING	P-5050-101	16	2
BACK UP WASHER	P-5040-101	43	3
EYE MOUNTING	P-5040-104	43	3

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Appendix E.2: The allocation store for new system

Group AA (P2)			
Item	Code	SS _{MAX}	floor
REAR COVER	P-5032-105	48	1
REAR COVER	P-5040-106	43	1
ROD SEAL	P-5032-111	48	2
ROD SEAL	P-5040-112	42	2
STOP TUBE	P-5032-103	48	3
STOP TUBE	P-5040-116	43	3

Group AA (C,W)			
Item	Code	SS _{MAX}	floor
Cooling water	W-6010-106	39	1
Cutter for cutting machine	W-6010-107	29	1
Glue	W-6010-105	56	1
Lubricant	W-6010-109	43	1
WELDING SET	W-6010-104	87	1
Operation suit	C-6010-201	45	2
Instruction book for 5032	C-6010-226	101	2
Instruction book for 5040	C-6010-227	89	2
Pneumatic pipe for 5032 Size	C-6010-135	48	3
Pneumatic pipe for 5040 Size	C-6010-136	43	3
Pneumatic pipe for 5050 Size	C-6010-137	20	3

Group BB (M,P)			
Item	Code	SS _{MAX}	floor
PISTON ROD	M-50100-314	46	1
PISTON ROD	M-50125-314	22	1
BARREL	P-50100-109	35	1
BARREL	P-50125-109	35	1
BUSH IN ROD BUSHING	P-50100-101	47	2
BUSH IN ROD BUSHING	P-50125-101	47	2
BUSH IN ROD BUSHING	P-5063-101	76	2
BUSH IN ROD BUSHING	P-5080-101	66	2
PORT OIL	P-5032-104	447	3
PORT OIL	P-5040-117	325	3
PORT OIL SQUARE ELBOW(1)	P-5040-118	325	3
PORT OIL SQUARE ELBOW(2)	P-5040-119	325	3
REAR COVER	P-5050-105	99	4
REAR COVER	P-5063-105	91	4
REAR COVER	P-5080-105	78	4
STOP TUBE	P-5050-103	128	5
STOP TUBE	P-5063-103	116	5
O-RING PISTON ROD	P-5032-108	345	6
PISTON SEAL	P-5032-206	174	6
TUBE	P-5040-117	269	6

Appendix E.3: The allocation store for new system

Group BB (C)			
Item	Code	SS _{MAX}	floor
Pneumatic pipe for 5062 Size	C-6010-138	76	1
Pneumatic pipe for 5080 Size	C-6010-139	68	1
Pneumatic pipe for 50100 Size	C-6010-140	48	1
Pneumatic pipe for 50125 Size	C-6010-141	47	1
Sticker on box for 5032	C-6010-216	153	2
Sticker on box for 5040	C-6010-217	142	2
Instruction book for 5050	C-6010-228	106	2
Instruction book for 5062	C-6010-229	95	2
Instruction book for 5080	C-6010-230	83	2
Instruction book for 50100	C-6010-231	59	2
Instruction book for 50125	C-6010-232	59	2
An-ti dust Powder	C-6010-225	77	3
Big Box 12x	C-6010-224	107	3
Protection foam	C-6010-234	258	3

Group BB (C,W)			
Item	Code	SS _{MAX}	floor
Metal BELT	C-6010-102	1,433	1
Cap for Operator	W-6010-210	39	2
PLUG	W-6010-214	974	2
Plastic bag	W-6010-215	862	2

Group CC (P1)			
Item	Code	SS _{MAX}	floor
O-RING COVER	P-50100-110	27	1
O-RING COVER	P-50125-110	27	1
O-RING COVER	P-5032-210	253	1
O-RING COVER	P-5040-211	213	1
O-RING COVER	P-5050-110	80	1
O-RING COVER	P-5063-110	67	1
O-RING COVER	P-5080-110	53	1
O-RING PISTON ROD	P-50100-108	27	2
O-RING PISTON ROD	P-50125-108	27	2
O-RING PISTON ROD	P-5040-209	213	2
O-RING PISTON ROD	P-5050-108	80	2
O-RING PISTON ROD	P-5063-108	67	2
O-RING PISTON ROD	P-5080-108	53	2
PISTON SEAL	P-50100-206	27	3
PISTON SEAL	P-50125-206	27	3
PISTON SEAL	P-5040-207	213	3
PISTON SEAL	P-5050-206	80	3
PISTON SEAL	P-5063-206	67	3
PISTON SEAL	P-5080-206	53	3

Appendix E.4: The allocation store for new system

Group CC (P2)			
Item	Code	SS _{MAX}	floor
PORT OIL	P-50100-104	27	1
PORT OIL	P-50125-104	27	1
PORT OIL	P-5050-104	80	1
PORT OIL	P-5063-104	67	1
PORT OIL	P-5080-104	53	1
REAR COVER	P-50100-105	27	1
REAR COVER	P-50125-105	27	1
ROD SEAL	P-50100-111	27	2
ROD SEAL	P-50125-111	27	2
ROD SEAL	P-5050-111	80	2
ROD SEAL	P-5063-111	67	2
ROD SEAL	P-5080-111	53	2
STOP TUBE	P-50100-103	27	2
STOP TUBE	P-50125-103	27	2
STOP TUBE	P-5080-103	53	2
U- RING	P-50100-212	27	3
U- RING	P-50125-212	27	3
U- RING	P-5032-212	253	3
U- RING	P-5040-213	213	3
U- RING	P-5050-212	80	3
U- RING	P-5063-212	67	3
U- RING	P-5080-212	53	3
WIPER	P-50100-213	27	3
WIPER	P-50125-213	27	3
WIPER	P-5032-213	253	3
WIPER	P-5040-214	213	3
WIPER	P-5050-213	80	3
WIPER	P-5063-213	67	3
WIPER	P-5080-213	53	3

Group CC (C,W)			
Item	Code	SS _{MAX}	floor
NUT M.8	C-6010-203	5,760	1
Sticker on box for 5050	C-6010-218	80	2
Sticker on box for 5062	C-6010-219	67	2
Sticker on box for 5080	C-6010-220	53	2
Sticker on box for 50100	C-6010-221	27	2
Sticker on box for 50125	C-6010-222	27	2
Small box	C-6010-223	347	2
Robe for packing	C-6010-233	320	2
Glove for operator	W-6010-208	40	3
Ear protection	W-6010-211	24	3
EYR PROTECTION for welding	W-6010-212	8	3
wire	W-6010-213	560	3

Appendix F

The calculated result of Group BB by EOQ method



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Appendix F The calculated result of Group BB by EOQ method

Item	Code	D=Sx	Tv(D)	s	I	W	P	Q	SS	SSROP
BUSH IN ROD BUSHING	P-5063-101	250	7	5.15	18.8	0.1753	200	73	3.2	8.0
Pneumatic pipe for 5062 Size	C-6010-138	250	7	5.97	18.8	0.1753	200	73	3.7	8.6
REAR COVER	P-5050-105	300	7	4.77	12.8	0.1753	200	96	2.9	8.8
BUSH IN ROD BUSHING	P-5080-101	200	7	2.46	19.1	0.1753	200	64	1.5	5.4
BARREL	P-50125-109	100	7	3.26	37.6	0.1753	200	33	2.0	4.0
Pneumatic pipe for 5080 Size	C-6010-139	200	7	4.44	18.8	0.1753	200	65	2.7	6.6
BARREL	P-50100-109	100	7	3.26	37.4	0.1753	200	33	2.0	4.0
PISTON SEAL	P-5032-206	950	7	3.26	3.8	0.1753	62	172	2.0	20.5
TUBE	P-5040-117	800	7	12.31	4.5	0.1753	200	262	7.6	23.2
PLUG	W-6010-214	5,400	7	71.98	0.6	0.1753	62	929	44.5	149.5
REAR COVER	P-5063-105	250	7	5.15	12.9	0.1753	200	87	3.2	8.0
PISTON ROD	M-50125-314	100	7	3.26	30.0	0.1753	62	20	2.0	4.0
O-RING PISTON ROD	P-5032-108	950	7	12.03	3.2	0.1753	200	338	7.4	25.9
PISTON ROD	M-50100-314	100	7	3.26	29.9	0.1753	293	44	2.0	4.0
REAR COVER	P-5080-105	200	7	2.46	13.4	0.1753	200	77	1.5	5.4
PORT OIL SQUARE ELBOW(1)	P-5040-118	800	7	12.31	3.0	0.1753	200	317	7.6	23.2
PORT OIL SQUARE ELBOW(2)	P-5040-119	800	7	12.31	3.0	0.1753	200	317	7.6	23.2
PORT OIL	P-5040-117	800	7	12.31	3.0	0.1753	200	317	7.6	23.2
STOP TUBE	P-5050-103	300	7	4.77	7.5	0.1753	200	125	2.9	8.8
STOP TUBE	P-5063-103	250	7	5.15	7.7	0.1753	200	113	3.2	8.0
BUSH IN ROD BUSHING	P-50100-101	100	7	3.26	19.3	0.1753	200	45	2.0	4.0
BUSH IN ROD BUSHING	P-50125-101	100	7	3.26	19.2	0.1753	200	45	2.0	4.0
Cap for Operator	W-6010-210	100	7	21.25	18.8	0.1753	62	26	13.1	15.1
Pneumatic pipe for 50100 Size	C-6010-140	100	7	3.26	18.8	0.1753	200	46	2.0	4.0
Pneumatic pipe for 50125 Size	C-6010-141	100	7	2.46	18.8	0.1753	200	46	1.5	3.5
PORT OIL	P-5032-104	950	7	12.03	1.8	0.1753	200	439	7.4	25.9
Sticker on box for 5032	C-6010-216	950	14	12.03	5.6	0.1753	62	143	10.5	47.5
Metal BELT	C-6010-102	5,400	14	71.98	1.0	0.1753	200	1370	62.9	272.9
Sticker on box for 5040	C-6010-217	800	14	12.31	5.6	0.1753	62	131	10.8	41.9
Protection foam	C-6010-234	1,200	14	11.28	2.3	0.1753	62	248	9.9	56.5
An-ti dust Powder	C-6010-225	300	14	4.26	6.8	0.1753	62	73	3.7	15.4
Plastic bag	W-6010-215	2,100	15	16.79	0.2	0.1753	62	847	15.2	102.7
Instruction book for 5050	C-6010-228	300	30	6.40	3.8	0.1753	62	97	8.2	33.2
Instruction book for 5062	C-6010-229	250	30	5.15	3.8	0.1753	62	89	6.6	27.4
Instruction book for 5080	C-6010-230	200	30	2.46	3.8	0.1753	62	79	3.1	19.8
Instruction book for 50100	C-6010-231	100	30	2.46	3.8	0.1753	62	56	3.1	11.5
Instruction book for 50125	C-6010-232	100	30	2.46	3.8	0.1753	62	56	3.1	11.5
Big Box 12x	C-6010-224	120	30	0.00	1.1	0.1753	62	107	0.0	10.0

Appendix G

The total inventory cost for Group BB



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Biography

My name is Mr. Sarayut Kiatubonpiboon, was born 5th October 1979 at Bangkok. I graduated bachelor's degree in Industrial Engineering, Faculty of Engineering at Thammasat University since 2000. At Thai advance Enterprise Company, this was the first company I worked about one year. Then I moved to YAMAHA motor in Purchasing Engineer position for 2 years in 2003. Nowadays, I work with my family business about Sale position in Jewelry business.



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