MANAGING INVENTORY MODELS FOR RAW MATERIALS OF DIE LUBRICANTS

by

Mr. Win Soontornkitprapai

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

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
Assumption University

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Project Title	Managing Inventory Models for Raw Materials of Die Lubricants
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

Inventory is any stored resource that is used to satisfy a current or a future need, such as raw materials and finished goods. Inventory continues to represent a major use of capital in the supply channel. Excess inventory is costly to store while insufficient inventory may result in loss of market share, which is more costly. Good management of it means keeping it at the lowest possible level consistent with the balance of costs.

There are two questions for inventory policy. First is how much to order and second is when to order. The answers of these questions are determined based upon the relevant factors that encompass setup cost (K), holding cost (h), demand (D), lead time of ordering (L), and etc.

Hanano (Thailand) Co., Ltd. is the case study company that inspires to revise the current inventory system and improve it so that it can serve changes in the future. The focus of this project is on the new inventory models formulation for the fifteen types of raw material of die lubricants. To set the new inventory policy, the combination of gathering the historical data of the relevant factors and applying the concept of deterministic inventory models in operations research to analyze the problem is necessary. Furthermore, Crystal Ball, a Microsoft® Excel add-in that provides the ability to perform a technique for simulating real-world situations involving elements of uncertainty, and CB Predictor, a Microsoft® Excel add-in that provides the ability to forecast, are applied for the calculation.

Finally, the new inventory policy for fifteen types of raw material is suggested. Formulated in the form of Microsoft® Excel, it is easy to use, controllable, flexible to change, as well as, it tends to reduce inventory costs.

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I would like to thank two persons and a firm for their help in the preparation of this project. Without them, this project will not be effectively accomplished.

I was more fortunate than most in that I had the opportunity to know Dr. Aran Namphol, my advisor. He not only taught me about the concept of operations research, but also advised me on the specialty software, Crystal Ball and CB Predictor, for solving the problems. His vision for analyzing and solving the problems in operations research is superb. His guidance and encouragement has led me from the start of the project to its completion. Thank you.

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Last but definitely not least, I wish to express sincere gratitude to Hanano (Thailand) Company Limited. Every one gave me the great cooperation in gathering and providing all necessary data I need. All I can do for my beloved company is to show my integrity of keeping the secrets on commerce, and to do my best in preparing the new inventory policy.

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I. INTRODUCTION

1.1 Foreword

Proper inventory management may be one of the most important functions of management. Tracing several bankruptcies of construction firms and agricultural machinery manufacturers has shown that overstocking was the major contributor to failure (Turban & Meredith 1991).

Despite the fact that excess inventories are costly to store, insufficient inventories may result in loss of market share, which is counted to be more damage. On one hand, a firm can try to reduce costs by reducing on-hand inventory levels. On the other hand, customers become dissatisfied when frequent inventory outages (called stockouts) occur. Thus companies must make the balance between low and high inventory levels. It is very important to managing their inventories.

There are two questions for inventory policy.

(1) How much to order?

(2) When to order?

The research had been done for one of the most famous companies on die lubricants and plunger lubricants, Hanano (Thailand) Co., Ltd., and the author focuses only on the ten models of die lubricant and fifteen types of raw material.

After analyzing the current inventory system of die lubricants with their raw materials and the historical data, it is founded that there are possibilities to improve the current system. The author had studied the current inventory system for die lubricants and their raw materials, new system's requirements, as well as the relevant historical data, such as sales volume (kilogram per month) of each model of die lubricants, possible lead time (day) for ordering each raw material, and etc. Finally, to answer the two questions of inventory policy mentioned above, the new inventory models for raw materials are suggested.

To make it as close to reality as possible and to get most effectiveness from the new inventory policy, forecasting techniques are involved in this project to determine the demand for next period of time.

Moreover, 7 steps of Decision Making Process (AMOS 1981) is applied in this project to show the working processes clearly. New inventory policy formulation is written in Microsoft® Excel and easy to control. The author intends to use "Crystal Ball" software to determine the relevant variables that have probability distributions and hard to determine exactly in a single value.

1.2 Objectives

(1) To study and analyze problem concerning inventory in Hanano (Thailand) Co., Ltd.

(2) To provide the new inventory models on fifteen types of raw materials of die lubricants.

1.3 Scope

This project will focus only on ten models of die lubricants and their raw materials from the case study of Hanano (Thailand) Co., Ltd.

1.4 Deliverables

After finishing the project, the deliverables of the project are the following:

(1) The new inventory policy for fifteen types of raw materials of Hanano (Thailand) Co., Ltd.

(2) The calculation program written in Microsoft® Excel together with Crystal Ball add-in software for determining the relevant data about inventory model.

(3) The project report.

II. LITERATURE REVIEW

2.1 Overview

Inventory is one of the most expensive and important assets to many companies, representing as much as 40 percent of total invested capital (Render & Stair 1982).

Inventory deals with maintaining sufficient stocks of goods (e.g., parts and raw materials) that will ensure a smooth operation of a production system or a business activity. Traditionally, inventory has been viewed by business and industry as a necessary evil: too little of it may cause costly interruptions in the operation of the system, and too much of it can ruin the competitive edge and profitability of the business (Taha 1995). On one hand, a firm can try to reduce costs by reducing on-hand inventory levels. On the other hand, customers become dissatisfied when frequent inventory outages (called stockouts) occur. Thus companies must strike a balance between low and high inventory levels (Render & Stair 1982).

Inventory is any stored resource that is used to satisfy a current or a future need. Raw materials, work-in-process, and finished goods are examples of inventory. Inventory levels for finished goods are a direct function of demand. Once we determine that demand for completed clothes dryers, for example, it is possible to use this information to determine how much sheet metal, paint, electric motors, switches, and other raw materials and work-in-process are needed to produce the finished product (Render & Stair 1982).

Although the type of demand is a principal factor in the design of the inventory model, the following factors may also influence the way the model is formulated (Taha 1995).

(1) Lead times or delivery lags.

When an order is placed, it may be delivered instantaneously, or it may require some time before delivery is effected. The time between the placement of an order and its receipt is called lead time or delivery lag.

(2) Stock replenishment.

Although an inventory system may operate with lead times, the actual replenishment can occur instantaneously or uniformly. Instantaneous replenishment can occur when the stock is purchased from outside sources. Uniform replenishment may occur when the product is manufactured locally within the organization. In general, a system may operate with positive lead time and also with uniform stock replenishment.

(3) Time horizon.

The time horizon defines the period over which the inventory level will be controlled. This horizon may be finite or infinite, depending on the time period over which demand can be forecast reliably.

(4) Number of supply echelons.

An inventory system may consist of several (rather than one) stocking points. In some cases these stocking points are organized such that one point acts as a supply point for others. This type of operation may be repeated at different levels so that a demand point may again become a new supply point. The situation is usually referred to as a multiechelon system.

(5) Number of items.

An inventory system may involve more than one item (commodity). This case is of interest mainly if some kind of interaction exists between the different items. For example, the items may compete for limited floor space or limited total capital.

2.2 Appraisal of Inventories

There are numerous reasons why inventories are present in a supply channel, yet in recent years the holding of inventories has been roundly criticized as unnecessary and wasteful. Consider why a firm might want inventories at some level in their operations, and why they would also want to keep them at a minimum (Ballou 1999).

Reasons for Inventories

Reasons for having inventories relate to customer service or to cost economies indirectly derived from them. Briefly consider some of these (Ballou 1999).

(1) Improve Customer Service

Operating systems usually cannot be designed to economically respond to customer requests for product or services in an instantaneous manner. Inventories provide a level of product or service availability, which, when located in the proximity of the customer, can meet a high customer service requirement. The presence of these inventories to the customer may not only maintain sales but actually increase them.

(2) Reduce Costs

Although holding inventories has a cost associated with it, it can indirectly reduce operating costs in other activities and may more than offset the carrying cost.

First, holding inventories may encourage economies of production by allowing larger, longer, and more level production runs. Production output can be decoupled from the variation in demand requirements when inventories exist to act as buffers between the two.

Second, holding inventories fosters economies in purchasing and transportation. A purchasing department may buy in quantities beyond the firm's immediate needs in order to realize price-quantity discounts. The cost of holding the excess quantities until manner, transportation costs can often be reduced by shipping size results in increased inventory levels that need to be maintained at both ends of the transportation channel. The reduction in transportation costs justifies the carrying of an inventory.

Third, forward buying involves the purchasing of additional quantities of products at a lower current price rather than at higher anticipated future prices. Buying in quantities greater than immediate needs results in a larger inventory than does purchasing in quantities that more closely match immediate requirements. However, if prices are expected to rise in the future, some inventory resulting from forward buying can be justified.

Fourth, variability in the time that it takes to produce and transport goods throughout the operating channel can cause uncertainties that impact on operating costs as well as customer service levels. Inventories are frequently used at many points in the channel to buffer the effects of this variability and, thereby, help to smooth operations.

Fifth, unplanned and unanticipated shocks can befall the logistics system. Labor strikes, natural disasters, surges in demand, and delays in supplies are the types of contingencies against which inventories can afford some protection. Having some inventory at key points throughout the logistics channel allows the system to operate for a period of time while the effort of the shock can be diminished.

Reasons against Inventories

It has been claimed that management's job is much easier having the security of inventories. Criticism for being overstocked is much more defensible than being short of supplies. The major portion of inventory carrying costs is of an opportunity cost nature and, therefore, goes unidentified in normal accounting reports. To the extent that inventory levels have been too high for the reasonable support of operations, the criticism is perhaps deserved (Ballou 1999).

Critics have challenged the holding of inventories along several lines (Ballou 1999).

First, inventories are considered wasteful. They absorb capital that might otherwise be put to better use, such as to improve productivity of competitiveness. Also, they do not contribute any direct value to the products of the firm, although they do store value.

Second, they can mask quantity problems. When quality problems surface, the tendency is to work off existing inventories to protect the capital investment. Correcting quality problems can be slow.

Finally, using inventories promotes an insular attitude about the management of the logistics channel as a whole. With inventories, it is often possible to isolate one stage of the channel from another. The opportunities arising from integrated decision making that considers the entire channel are not encouraged. Without inventories, it is difficult to avoid planning and coordinating across several echelons of the channel at one time.

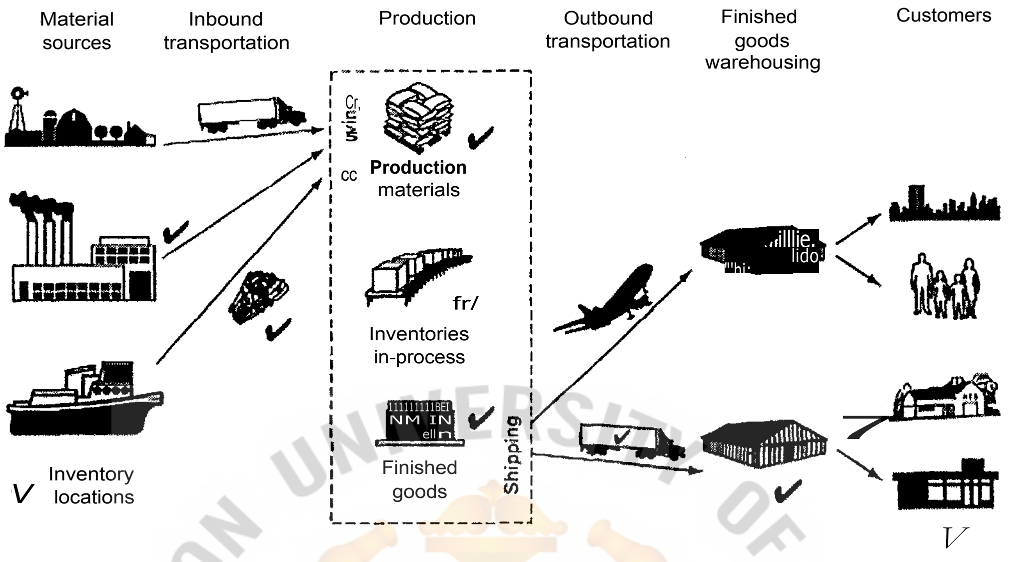


Figure 2.1. Inventories Are Located at Each Echelon of the Supply Channel.

2.3 The Purpose of Inventory

The following is a list of the major reasons for maintaining an inventory (Turban & Meredith 1991):

(1) Protection against fluctuating demand: Inventories are kept to meet peak demand. For example, blood is stored in hospitals in quantities sufficient to meet the needs of a major accident.

(2) Protection against delayed supply: A strike by the supplier's employees is one reason why deliveries may not arrive on time. Lack of material at the supplier level, strikes in the transportation network, or a rainstorm are other possible causes for shortages. Inventories are kept as a buffer that can be used until late deliveries arrive.

(3) Protection against inflation: Inventories are often kept as a hedge against inflation. In this case inventories are built up in anticipation of a price

increase. This speculative practice is especially common in the commodity markets (such as wheat or gold).

(4) Benefits of large quantities: Purchasing large quantities of an item often entitles the buyer to a price discount (lower per unit price). Similarly, in the case of manufacturing of large production lots, the utilization of more efficient automated equipment can be justified by the reduction in the per unit manufacturing cost.

(5) Primary basis for business: Retail operations involving customer perusal and selection require fully stocked shelves and complete inventories.

(6) Savings on ordering cost: Ordering in large quantities reduces the number of times that an order must be placed and processed. Since a fixed cost is associated with placing each order, the fewer times one places an order, the lower the total cost of ordering will be.

(7) Other reasons: Inventories are kept for several other reasons: An inventory may improve the bargaining power of a firm with a supplier (or with its own employees) by making the company less vulnerable to delays or stoppages. Inventories also are kept so that machines can be shut down for overhauls. An inventory of labor is maintained to meet fluctuating production demands in order to reduce hiring, firing, and training costs.

2.4 Inventory Costs

Inventory problems are usually examined from a cost rather than from a profit standpoint. The major types of inventory costs are (Turban & Meredith 1991):

(1) Setup cost (Ordering cost), (K)

Setup cost includes all the necessary expenses of placing orders. It is assumed to be a fixed cost per order; that is, each time an order is placed the same expenses occur regardless of how many units are ordered. Included in the setup cost are the clerical and paperwork expenses of purchasing, inspection, receiving, bookkeeping, and data processing that are directly related to ordering, as well as the expenses of delivery, postage, and the related overhead (such as direct telephone charges). The cost of ordering can be computed by dividing the total annual cost related to ordering by the number of orders processed that year.

(2) Holding cost (Carrying cost), (h)

The expenses of holding or carrying the inventory include such components as:

(a) Cost of capital: The interest paid on the capital invested in inventories or the opportunity cost of doing something else with the money.

(b) Storage: Cost of maintaining the storage space. This includes rental fees, lights, heat, security, and janitorial services.

(c) Storekeeping operations: Expenses such as record-keeping and taking of physical inventory.

(d) Insurance and taxes.

(e) Obsolescence and deterioration of the items stored.

All holding costs are totaled and expressed either in terms of Baht per item per unit time, or in percentage of the value of the inventory.

(3) Shortage cost (Penalty cost)

Shortage costs occur when an item is out of stock and demand is unsatisfied. Depending on the item under consideration, shortage costs may include the following:

(a) In case of raw materials: costs of idled production, spoilage of products of materials, and the cost of placing and fulfilling special expediting orders.

(b) In case of finished goods: cost of "ill will" to the seller (the loss of customers) due to inability to deliver or due to late deliveries. The cost of ill will or the loss of goodwill reflects the anticipated loss of future profits due to customers' dissatisfaction.

(c) In case of replacement parts: costs of idle machines, idle labor, spoilage of materials, and delay in shipment.

(d) In other cases: the shortage of blood or ambulances may cost a life; and a shortage of fire engines may result in excessive damage caused by a fire.

Shortage may be temporary ("back order"), in which case they are eliminated when the supply arrives, or permanent in the sense that sales are lost.

(4) Item cost (Purchasing cost)

Item cost is the price paid for one unit of the commodity under consideration. It is not a direct inventory cost, the items must be eventually procured anyway, but it may be influenced by inventory decisions. For example, ordering large quantities may result in a lower per unit price due to quantity discounts.

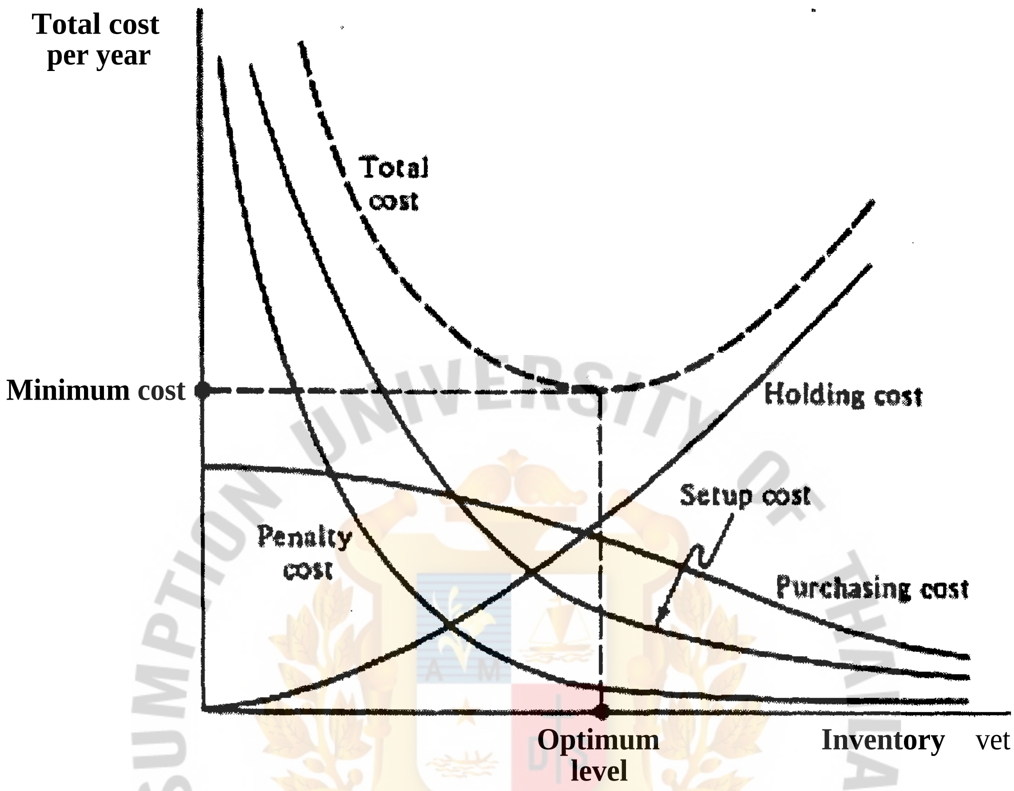


Figure 2.2. The Variation of the Four Cost Components of the General Inventory Model as a Function of the Inventory Level.

2.5 The Economic Order Quantity (EOQ) and the Re-Order Point (ROP)

Basically known as inventory policy, the ultimate objective of any inventory model is to answer two questions (Taha 1997):

(1) How much to order?

(2) When to order?

The answer of the first question is determined by Economic Order Quantity (EOQ) whereas the answer of the second question is determined by Re-Order Point (ROP).

Both EOQ and ROP are normally determined by minimizing the total inventory cost that can be expressed as a function of these two variables. We can summarize the total cost of a general inventory model as a function of its principal components in the following manner (Taha 1997):

$$\begin{pmatrix}\text{Total} \\ \text{inventory} \\ \text{cost}\end{pmatrix} = \begin{pmatrix}\text{Setup} \\ \text{cost}\end{pmatrix} + \begin{pmatrix}\text{Holding} \\ \text{cost}\end{pmatrix} + \begin{pmatrix}\text{Shortage} \\ \text{cost}\end{pmatrix} + \begin{pmatrix}\text{Item} \\ \text{cost}\end{pmatrix}$$

The Economic Order Quantity (EOQ)

The Economic Order Quantity (EOQ) is one of the oldest and most commonly known inventory control techniques. This technique is relatively easy to use, but it does make a number of assumptions (Render & Stair 1982).

Assumptions of the EOQ Model

(1) Demand is known and constant.

(2) The lead time is known and constant.

(3) The receipt of inventory is instantaneous. In other words, the inventory from an order arrives in one batch, at one point in time.

(4) Quantity discounts are not possible.

(5) The only variable costs are Setup cost and Holding cost.

(6) If orders are placed at the right time, shortages can be completely avoided.

The simplest of the inventory models involves constant rate demand with instantaneous order replenishment and no shortage. Let (Taha 1997):

y = Order quantity (number of units)

D = Demand rate (units per unit time)

to = Ordering cycle length (time units)

Using these definitions, the inventory level follows the pattern depicted in Figure 2.3. An order size y units is placed and received instantaneously when the inventory level is zero. The stock is then depleted uniformly at the constant demand rate D. The ordering cycle for this pattern is (Taha 1997):

t_0 D

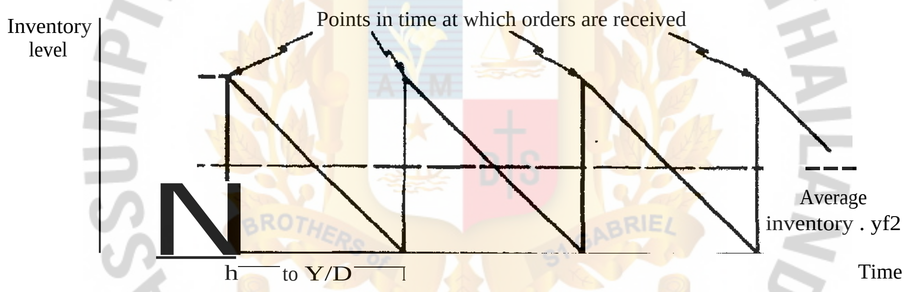


Figure 2.3. The Pattern of EOQ Model.

The resulting average inventory level is given as (Taha 1997)

$$\text{Average inventory level} = \frac{}{2} \text{ units}$$

The cost model requires two cost parameters (Taha 1997).

Setup cost associated with the placement of an order (Baht per order)

Holding cost (Baht per inventory unit per unit time)

The total cost per unit time (TCU) is thus computed as: (Taha 1997).

$$TCU(y) = \text{Setup cost per unit time} + \text{Holding cost per unit time}$$

$$= \frac{\text{Setup cost} + \text{Holding cost per cycle } t_0}{t_0}$$

$$= \frac{K + h\left(\frac{y}{2}\right)t_0}{t_0}$$

$$= \frac{K}{\left(\frac{y}{D}\right)} + h\left(\frac{y}{2}\right)$$

The optimal value of the order quantity y is determined by minimizing TCU(y) with respect to y. Assuming y is continuous, a necessary condition for finding the optimal value of y is: (Taha 1997)

$$\frac{dTCU(y)}{dy} = -\frac{KD}{y^2} + \frac{h}{2} = 0$$

The condition is also sufficient because TCU(y) is convex. The solution of the equation yields the EOQ y* as: (Taha 1997)

$$Y^* = \sqrt{\frac{2KD}{h}}$$

The optimum inventory policy for the proposed model is summarized as: (Taha 1997)

Order $Y^* = \sqrt{\frac{2KD}{h}}$ units every $t_0^* = \frac{y^*}{D}$ time units necessarily the case in general. To account for this situation, we define the effective lead time as (Taha 1997)

$$L_e = L - nt_o^*$$

Where n is the largest integer not exceeding $\frac{L}{t_o^*}$. This result is justified because after n cycles of to* each, the inventory situation acts as if the interval between placing an order and receiving another is L_e. Thus, the Re-Order Point occurs at L_eD units, and the inventory policy can be restated as: (Taha 1997)

Order the quantity y* whenever the inventory level drops to L_eD units.

2.6 Introduction to Forecasting

Forecasting is the general term used to denote the estimation of some unknown variable in the future. All organizations need forecasts for planning purposes. While most applications of forecasting relate to the future demand for goods and services, organizations must also forecast various economic indicators, such as interest rates and production costs, demand for energy, and changes in consumer demographics. Forecasts are necessary inputs to decision models; in particular, they are key building blocks for optimization models, such as inventory model (Camm & Evans 2000).

Forecasting is typically approached in two ways: judgmentally and quantitatively. Many forecasts are obtained by querying "experts," such as field sales managers who may have many years of experience and close relationships with customers that allow them to develop very good estimates of future demand. Fortune magazine publishes a "business confidence index," which is an opinion-based forecast of the future state of the U.S. economy. Judgmental forecasting is useful and often the only alternative for forecasting such things as changes in technology or the demand for unique and innovative products with no prior history (Camm & Evans 2000).

For many forecasts, such as product demand or energy requirements, some type of historical data are usually available. A stream of historical data collected at different points in time is called a time series. You see time series data every day in the daily newspaper; examples are the closing prices of the Dow Jones Industrial Average and daily temperature highs and lows. Most businesses maintain databases of time series data, such as weekly or monthly sales. Working from the assumption that the future will be an extrapolation of the past (which all mutual fund prospectuses are careful not to suggest!), quantitative forecasting methods generate forecasts based on historical time series (Camm & Evans 2000).

Judgmental Forecasting (Subjective or Qualitative Forecasting)

The followings are the examples of judgmental forecasting method:

(1) Field Sales Force

(2) Executive Consensus

(3) Consumer Surveys / Market Research

(4) Outside Opinions

(5) Historical Analogy

(6) Delphi Technique

Time Series Components

A basic approach to analyzing a time series is to assume that it consists of four basic components: trend, seasonal, cyclical, and irregular (Camm & Evans 2000).

(1) Trend is gradual increase or decrease of the time series over a long period of time. For example, the stock market as a whole has exhibited as upward

trend for many decades. The populations of some cities show an upward trend, while others show a downward trend over many years. Trend is often estimated using regression analysis (mentioned later) with time as the independent variable.

(2) A repeating pattern from one year to the next is known as the seasonal component of a time series. For example, products such as hot dogs, cold medicine, air conditioners, and beer typically have demand patterns that vary over the course of a year, but repeat year after year. A seasonal component might also reflect other appropriate time intervals. For example, shopping patterns often exhibit "seasonality" over the course of a week.

(3) A cyclical component of a time series is a longer-term up or down pattern that may vary in length from as few as 2 to 10 years or more. Some examples would be interest rates and housing prices. Cyclical components are usually due to business cycles or the state of the economy.

(4) Finally, the irregular component of a time series is the remaining variation in the series that cannot be described as a trend, cyclical, or seasonal component. These fluctuations are due to random variability, occur over the short term, and are non-repetitive.

This report presents three major techniques for forecasting future changes in the level of a desired variable as a function of time (Taha 1997):

(1) Moving average and weight moving average

(2) Exponential smoothing

(3) Linear regression

Moving Average

Formula

$$F_n = \frac{\sum_{i=1}^{n} D_i}{n}$$

Where

F_n = the forecast for the period n

D_i = the demand in period i

the number of observation periods in the moving average

Moving average generates the forecast by computing a specified number of the most recent data. It calculates for certain periods, for example three or six months, depending on how much the forecaster desires to smoothen the demand figures. This method is useful for the short-term forecast with relatively steady demand, not exhibiting much irregular demand behavior.

There is no exact rule for selecting the moving average base, n. If the variations in the variable remain reasonably constant over time, a large n is recommended. Otherwise, a small value of n is advisable if the variation exhibits changing patterns. In practice, the value of n ranges between 2 and 10.

Weight Moving Average

Formula

$$F_{„} = > w_1 D,$$

Where

F_n = the forecast for the period n

D_i = the demand in period i

the number of periods in the weight moving average

w_i = the weight for the period i

$0 < w_i < 1$

$w_t = 1$

Like moving average, weight moving average is useful for the short-term forecast with relatively steady demand. To determine the number of periods and the weights assigned to each period, judgmental thinking or trial-and-error can be applied.

Exponential smoothing

Formula

$$F_{t+i} = aD_t + (1 - a)F_t$$

Where

F_t-F_1 = the forecast for the next period

the previous for the current period

D_t = the actual demand in the current period

a smoothing constant, reflecting the weight given to the most recent demand data

$0 < a < 1$

Exponential smoothing technique assumes that the process is constant, the same assumption used in the development of the moving average method. However, it is designed to alleviate a drawback in the moving average method, where the same weight on all the data is used in computing the average. Specifically, exponential smoothing places a larger weight on the most recent observation.

Exponential smoothing is suitable for short-term forecast. The a plays an important part to the forecast. If a equals 0, it means that the forecast doesn't reflect the most recent demand at all. In contrast, if a is set at 1, only the most recent demand is considered. In other words, the higher a is, the more sensitive the forecast will be to recent changes in demand. The lower a is to zero, the forecast will respond more slowly to differences between the actual demand and the forecast demand. Determination of a is subjective and judgmental. In practice, the value of a lies between 0.01 and 0.30.

Linear Regression

Linear Regression relates a dependent variable (e.g., demand) to an independent variable (e.g., time) in a linear equation format.

Formula

$$y = a + bx$$

Where

y	=	the dependent variable
x	=	the independent variable
a	=	the y-intercept, where x = 0
b	=	the slope of the line

The constant a and b are determined from the time series data based on the least-square criterion that seeks to minimize the sum of the square of the differences between the observed and the estimated values.

After some algebraic manipulations, not mentioned in this report, we obtain the following solution:

$$b = \frac{\sum_{i=1}^{n} y_i x_i - n\bar{y}\bar{x}}{\sum_{i=1}^{n} x_i^2 - n\bar{x}^2}$$

$$a = \bar{y} - b\bar{x}$$

Where

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

The equations show that we need to compute b first, from which the value of a can be computed.

We can test how well the linear estimator y* = a + bx fits the raw data by computing the correlation coefficient, r, using the formula

$$r = \frac{\sum_{i=1}^{n} y_i x_i - n\bar{y}\bar{x}}{\sqrt{\left(\sum_{i=1}^{n} x_i^2 - n\bar{x}^2\right)\left(\sum_{i=1}^{n} y_i^2 - n\bar{y}^2\right)}}$$

Where $-1 < r < 1$

If r = ± 1, then a perfect linear fit occurs between x and y. In general, the closer the value of r to 1, the better is the linear fit. A positive r represents a direct relationship while a negative r signifies an inverse relationship. If r = 0, then y and x may be independent. Actually, r = 0 is only a necessary but not sufficient condition for independence, as it is possible for two dependent variables to yield r = 0. Normally, a reasonable fit requires 0.75 r <1

Measuring Forecast Accuracy

The most important thing to remember in forecasting is that no forecast is accurate. However, some forecasts are better than others. For example, in the moving average technique, different values of n will yield different forecasts. There is no way of determining, a priori, the best value of n that provides the best forecasts. A common approach is to simply select different values of n, and determine how well the models would have predicted the historical data by computing a measure of how well the forecasted valued compare to the actual time series. This is referred to as goodness of fit. The forecaster would then use the value of n that provides the best fit (Camm & Evans 2000).

Several goodness-of-fit measures are commonly used. These are based on the forecast error, which, for period n, is the difference between the observed and forecasted value (Camm & Evans 2000):

$$e_t = D_t - F_t$$

(1) Mean Absolute Deviation (MAD)

One popular goodness-of-fit measure is the mean absolute deviation (MAD). This is the average of the absolute value of the errors for each data point for which we have observed and forecasted data. If we have n such data points:

$$MAD = \frac{\sum_{t=1}^{n} |e_t|}{n}$$

(2) Root Mean Square Error (RMSE)

Similar to a standard deviation, a second measure of goodness of fit is root mean square error (RMSE), which is defined as follows:

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n} e_t^2}{n}}$$

(3) Mean Absolute Percentage Error (MAPE)

A third measure of fit is the mean absolute percentage error (MAPE). The percentage error for period t is the difference between the actual and forecasted values divided by the actual value:

$$P_t = 100 \times \frac{D_t - F_t}{D_t}$$

MAPE is the average of these percentage errors:

$$MAPE = \frac{\sum_{t=1} il\, P_{t1}}{n}$$

Which measure of fit one uses is largely a matter of user preference. Note however, that since RMSE uses the square of error, it places more emphasis on large errors than MAD. Also, since MAPE uses percentage errors, it is less appropriate if there are zeros or values close to zero in the data (since dividing by the actual data to get pt will result in very large numbers) (Camm & Evans 2000).

CB Predictor

CB Predictor is a Microsoft® Excel add-in that provides the ability to forecast. This software can determine which method of forecasting is the best (least error) for each series of data. The important indicators to measure the accuracy of forecasting are RMSE, MAD, and MAPE. The forecasting methods available in CB Predictor are shown in Table 2.1.

Table 2.1. The Forecasting Method Gallery available in CB Predictor in Various Events.

	Nonseasonal		Seasonal	
No Trend	Single Moving Average (SMA)	Single Exp. Smoothing (SES)	Seasonal Additive (SNA)	Seasonal Multiplicative (SNM)
Trend	Double Moving Average (DMA)	Double Exp. Smoothing (DES)	Holt-Winters' Additive (HWA)	Holt-Winters' Multiplicative (HWM)

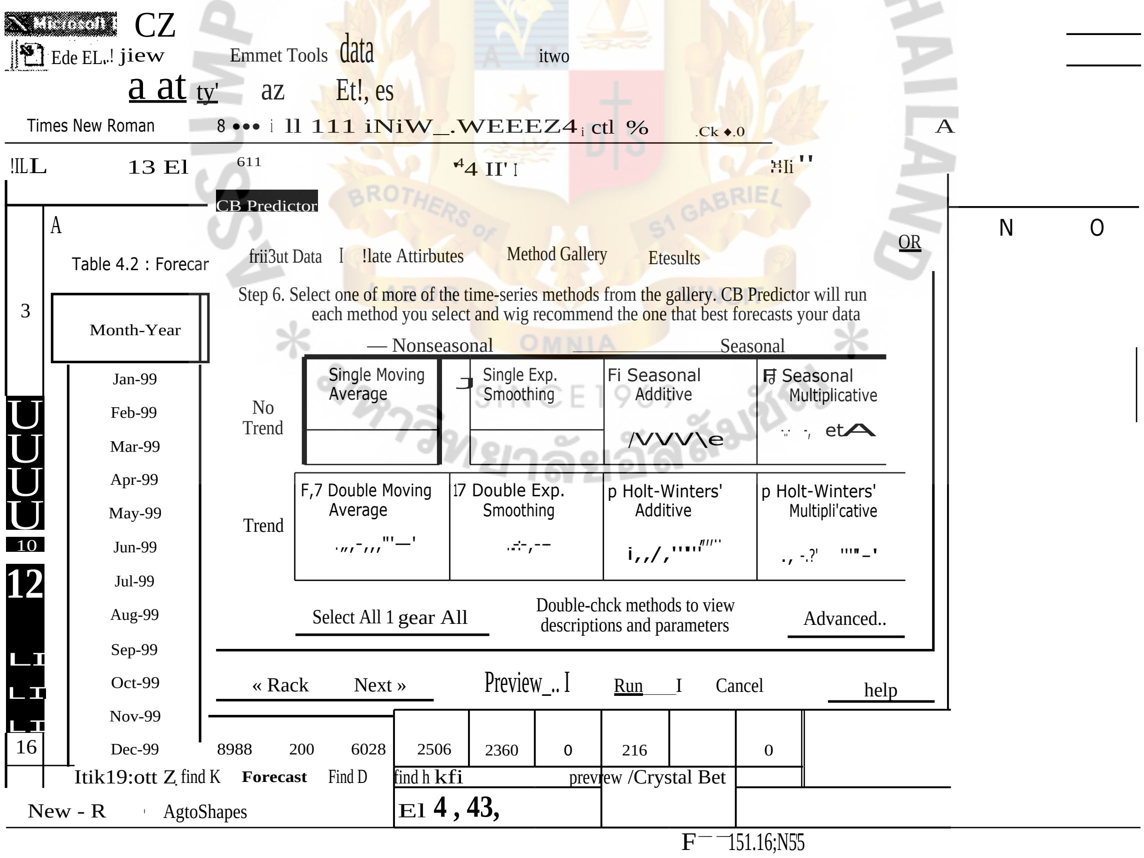


Figure 2.5. The Forecasting Method Gallery Available in CB Predictor.

2.7 Introduction to Crystal Ball

Crystal Ball is a Microsoft® Excel add-in that provides the ability to perform Monte Carlo analysis (a technique for simulating real-world situations involving elements of uncertainty) on spreadsheet models. Users can make better-informed decisions based on the true probability of specific outcomes (Camm & Evans 2000).

The student version of the Crystal Ball software allows a maximum of six assumptions and six forecasts to be defined per model. Available distribution types include uniform, normal, triangular, Poisson, exponential, and custom. One pair-wise correlation can be created per model, there are no overlay charts, simulations are limited to 1,000 trials, and the best fit function can fit a maximum of 100 points to a curve. There is no technical support, except to answer installation questions (Camm & Evans 2000).

To determine EOQ and ROP, the most important criteria for inventory policy, Crystal Ball should be applied since it has potential to solve the problem dealing with parameters that contain probability distributions. In practice, most of variables, such as holding cost (h), lead time (L), and even setup cost (K), cannot be exactly specified in a single value. They would happen in terms of probability distributions. Using Crystal Ball to determine EOQ and ROP makes it easy to get those values as close to reality as possible. Next, the patterns of probability distributions contained in Crystal Ball will be explained (Camm & Evans 2000).

Probability Distributions with Crystal Ball

Probability distributions are important components of many models, particularly those that involve uncertainty and risk. A probability distribution is a description of the possible values that a random variable may assume along with the probability of assuming these values. Discrete distributions describe random variables whose outcomes are finite or countable. Continuous distributions describe random variables having an infinite number of outcomes over some range. We summarize the salient properties of common probability distributions contained in Crystal Ball, which are uniform, normal, triangular, Poisson, exponential, and custom next. Only custom distribution will not be mentioned since it has no pattern (Camm & Evans 2000).

(1) Uniform distribution.

In the uniform distribution, all values between a fixed minimum and maximum value occur with equal likelihood. The uniform distribution is often used when little information is known about a random variable and only its range can be estimated.

(2) Normal distribution.

The familiar bell-shaped normal distribution describes many natural phenomena, such as people's IQs, uncertain inflation rates, or errors in a manufacturing process. The distribution is symmetric about the mean, and the value of the variable is more likely to be close to the mean than far away.

(3) Triangular distribution.

The triangular distribution is characterized by three parameters: minimum, maximum, and most likely value that falls between the minimum and maximum. This distribution is often used when no historical data are available and the parameters can be defined judgmentally.

(4) Poisson distribution.

The Poisson distribution describes the number of times an event occurs in a specified interval, such as the number of telephone calls arriving at a call center or number of defects per inch of a silicon wafer. The number of possible occurrences in any unit of measurement is unlimited, the occurrences are independent, and the average number of occurrences remains constant.

(5) Exponential distribution.

The exponential distribution is widely used to describe events recurring at random times, such as the time between failures of machines or the time between arrivals at a service process. The distribution is not affected by previous events; that is, the future life of a given object has the same distribution, regardless of how long it has existed.

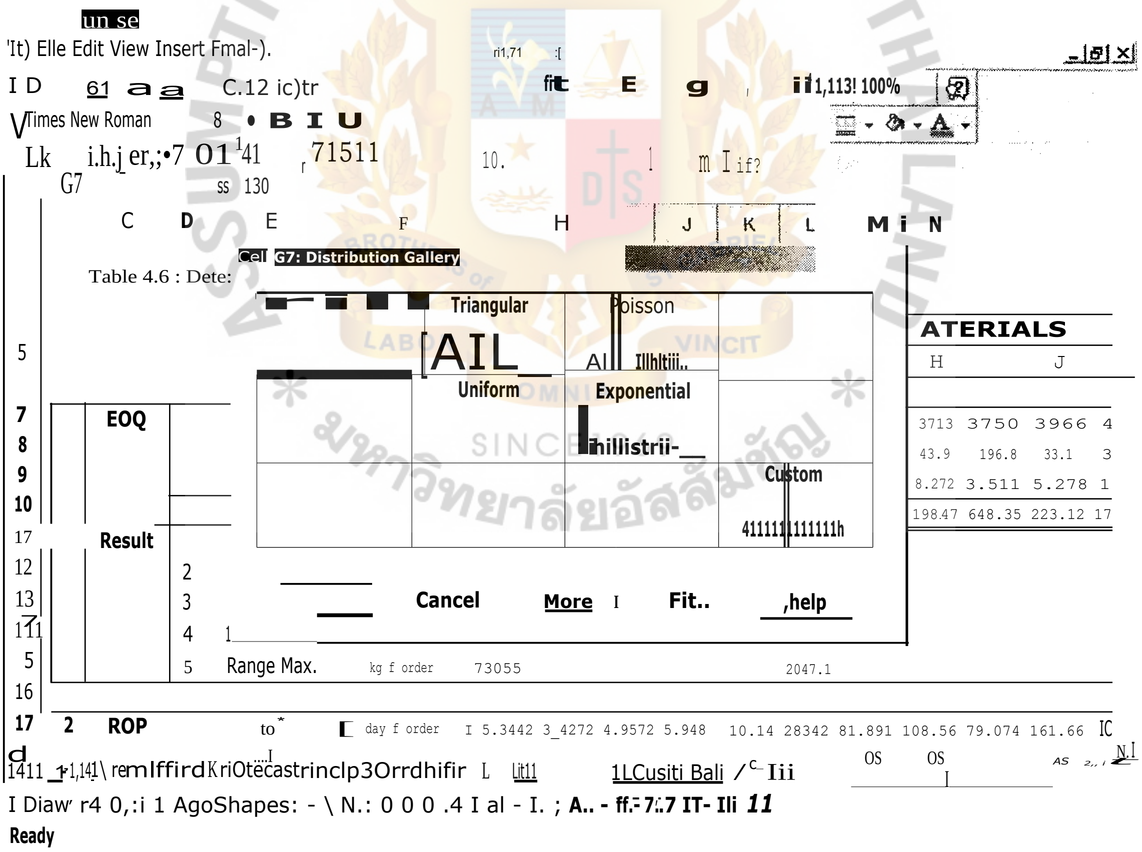


Figure 2.6. Probability Distribution Gallery Available in Crystal Ball.

In Chapter II, all necessary literatures on determining inventory policy, which is the crucial concept of inventory, are explained. The author also explains further in forecasting that is important for determining future demand. To set inventory policy, data must be sufficient and reliable. A case study for this project is determining a new inventory policy of raw materials of die lubricants for Hanano (Thailand) Co., Ltd. All of the relevant data for setting an inventory policy are gathered and compiled, and all of them are shown in the next chapter.

III. CURRENT INVENTORY SYSTEM

Due to the integrity of keeping the commercial secrets of Hanano (Thailand) Co., Ltd., some information presented in this chapter had been changed as properly as they should be. The author intends to keep the highest confidential information including the names, the formula, the sales volumes, and etc., by assuming the new ones instead.

3.1 About Hanano (Thailand) Co., Ltd.

Since the aim of this project is to study and analyze problem concerning inventory in Hanano (Thailand) Co., Ltd., and also, to provide the new inventory models of the raw materials of die lubricants, the author is pleased to introduce the background, management policy, product line, and roughly details about die lubricants of Hanano (Thailand) Co., Ltd. in this project.

Background

Founded in 1989 by Hanano Corporation Japan as a joint venture with Thai Partner, Hanano (Thailand) Co., Ltd. is one of the most famous manufacturers and distributors of Die Lubricant (Mold Release Agent) and Plunger Lubricant for pressure die casting field. For more than ten years Hanano Thailand has been the leading manufacturer and distributor of not only die lubricant and plunger lubricant, but also all kinds of materials and services, and industrial furnaces required for pressure die casting industry. In 2000, Hanano Thailand was relocated at the new factory at Amata Nakorn Industrial Estate, Chonburi, due to the expansion of its business line.

Today, Hanano Thailand Head Office and Factory is located at Amata Nakorn while Bangkok Office is located at 6th floor Nation Tower, Bangna-Trad Road km 5.

Management Policy

(1) To be the best specialist of die and plunger lubricants in pressure die casting industry.

Pressure die casting industry in South East Asian region has been growing up rapidly in accordance with the expansion of automobile market and motorcycle market during the past decade. We are the first manufacturer of die lubricant and plunger lubricant in South East Asian region as we started local production in Samutprakarn Thailand since April 1989, and we have been devoted to raise local contents ratio of our finished products for more than 10 years. Through our continuous research and study on raw materials localization, we achieved very high local contents ratio with keeping fine quality standard exactly as excellent as it is in Japan.

We have strong confidence that we are real professionals and specialists of die lubricant and plunger lubricants and we shall never stop our practice to improve technical know-how and capability to enable all die casters to be satisfied with our products and services.

"A smiling face of a die caster is our best pleasure."

(2) To be the best provider of total engineering service in pressure die casting industry.

We are always making our best effort to grow up not only as one of leading manufacturers and distributors of die lubricants, but also as the best provider of all kinds of materials and services required for pressure die casting industry in South East Asian countries.

Our basic awareness is "we are specialists of pressure die casting work as well as we are specialists of die lubricants and plunger lubricants."

(3) To be the center of "Team Hanano" company network, which contributes to the progress of pressure die casting industry in South East Asian region.

Since 1997, Thailand has become an important manufacturing base of many automobile manufacturers and a main automobile export base to the world market. This change means the real growth of aluminium die casting has started and there is no doubt on its high potentiality in the coming future. Base on this good situation, we are building our international and global working network with our group corporations in Malaysia, Indonesia, and the Philippines. In addition, we are always keeping in touch with most other countries in South East Asian region through international trading both directly and indirectly.

We steadfastly believe that South East Asian market is going to be one united market in the future and our "Team Hanano" network will try our best to construct the beautiful future of the one South East Asian market.

Product Line

(1) Die Lubricants (Mold Release Agents) and Plunger Lubricants for Die Casting

(2) Tools and Factory Utilities

(3) Chemical Products

(4) Industrial Furnaces

The variety of products in pressure die casting industry that Hanano Thailand manufactures and sells make customers satisfied because they can ask Hanano Thailand to provide almost everything involved in die casting that they want. All of the products that Hanano Thailand sells can be categorized into 4 major lines as shown in product line above. Not every product does Hanano Thailand manufacture. Die lubricants, plunger lubricants, and industrial furnaces are the three major products that Hanano Thailand manufactures.

This project concentrates only on die lubricants and their raw materials.

3.2 Data Analysis

The principle data that the author collects are:

(1) The details about die lubricants and their raw materials, including ingredients, sales volumes, and etc.

(2) Internal expenses and external expenses occurred from ordering raw materials each time.

(3) Production time of die lubricants and lead time for delivering raw materials from the source of supplier to Hanano Thailand.

There are 10 models of die lubricant which are commercial, and each of them is mixed by the different types or different ratio from the 15 types of raw material.

The author assumes the names of 15 types of raw material which are:

(1) Raw material type 1: A

(2) Raw material type 2: B

(3) Raw material type 3: C

(4) Raw material type 4: D

(5) Raw material type 5: E

(6) Raw material type 6: F

(7) Raw material type 7: G

(8) Raw material type 8: H

(9) Raw material type 9: I

(10) Raw material type 10: J

(11) Raw material type 11: K

(12) Raw material type 12: L

(13) Raw material type 13: M

(14) Raw material type 14: N

(15) Raw material type 15: 0

Moreover, the author assumes the names of 10 models of die lubricant as well as their ingredients which are:

(1) Model 1: AA

Ingredient

A: 7.4%

B: 6.0%

C: 11.6%

F: 6.0%

N: 0.5%

Etc.: 68.5%

(2) Model 2: BB

Ingredient

A: 13.5%

B: 6.0%

K: 10.0%

N: 0.4%

Etc.: 70.1%

(3) Model 3: CC

Ingredient

C: 21.0%

D: 10.5%

M: 0.1%

N: 0.4%

Etc.: 68.0%

(4) Model 4: DD

Ingredient

A: 22.1%

B: 16.8%

N: 0.6%

Etc.: 60.5%

(5) Model 5: EE

Ingredient

B: 8.0%

D: 15.0%

G: 15.0%

O: 0.5%

Etc.: 61.5%

(6) Model 6: FF

Ingredient

E: 16.0%

I: 2.6%

K: 1.2%

N: 0.4%

Etc.: 79.8%

(7) Model 7: GG

Ingredient

A: 7.0%

B: 21.0%

J: 14.0%

L: 6.0%

N: 0.4%

Etc.: 51.6%

(8) Model 8: HH

Ingredient

A: 5.0%

H: 25.0%

O: 0.4%

Etc.: 69.6%

(9) Model 9: II

Ingredient

A: 5.0%

F: 15.0%

N: 0.4%

Etc.: 79.6%

(10) Model 10: JJ

Ingredient

A: 12.0%

I: 13.0%

K: 10.0%

N: 0.4%

Etc.: 64.6%

The total sales volume (kg / month) for each of product from January 1999 until April 2001 is shown in Table 3.1 next.

Table 3.1. The Total Sales Volume (kg / month) for Each Model of Die Lubricants.

Month-Year	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ
Jan-99	6968	0	1594	2198	1890	0	0	1422	0	0
Feb-99	8598	0	1738	4376	2270	0	90	1350	0	1980
Mar-99	10050	0	2174	2234	2020	0	54	1368	0	810
Apr-99	11268	0	2368	2034	1980	0	36	1242	0	270
May-99	12738	0	1774	1360	1480	0	72	1368	0	360
Jun-99	8686	0	2770	1890	2920	0	0	1332	0	360
Jul-99	7638	0	3818	3476	1840	0	36	3456	0	540
Aug-99	10356	18	4320	2252	2020	0	0	306	0	540
Sep-99	14370	200	2520	3826	2560	0	90	1854	0	810
Oct-99	14482	400	3534	5262	3430	0	108	630	0	360
Nov-99	11800	400	4574	2052	3260	0	288	2466	0	1080
Dec-99	8988	200	6028	2506	2360	0	216	1026	0	756
Jan-00	12652	400	5126	6544	2200	0	288	1404	0	702
Feb-00	13206	54	3706	5998	2520	0	108	1224	0	1098
Mar-00	15056	1000	4124	3286	4200	0	180	1404	1080	1160
Apr-00	13976	1400	4398	6216	2560	200	288	918	0	854
May-00	15098	836	5724	3034	3280	378	0	1286	0	1090
Jun-00	14622	836	6158	6564	2200	740	0	2362	54	890
Jul-00	11566	1326	4198	3216	580	2000	144	398	2580	872
Aug-00	13224	708	4396	5436	540	236	288	72	0	800
Sep-00	11738	1344	1596	2980	200	1532	54	180	1598	400
Oct-00	11742	854	3506	2344	1372	0	180	270	708	1200
Nov-00	11912	1472	1902	6146	3280	0	216	978	36	800
Dec-00	10992	1344	3174	2234	902	738	0	108	2200	400
Jan-01	12030	1196	2938	4328	400	630	270	90	2200	836
Feb-01	13840	2180	4612	2254	800	450	54	0	2200	400
Mar-01	17886	2834	4188	1144	0	1440	270	108	2200	1308
Apr-01	17552	2000	3486	2054	400	1530	72	234	2200	1016

From Table 3.1, the data of sales volume for each of model above is the summation of sales in two packing types; can (18 kg / can) and drum (200 kg / drum). To determine the demand (kg / month) for each of them, all data are plotted into graphs to see the trends of usage (see APPENDIX B).

Hanano Thailand is not only a distributor, but also a manufacturer. In production of die lubricant (batch process), it takes approximately 6 hours (actual time) to produce 1,000 kg in a big reactor tank. It also takes the same amount of production time to produce 200 kg in a small reactor tank. Hanano Thailand has 3 big reactor tanks and 1 small reactor tank. Therefore, managing the raw materials to sufficiently supply to the production is more important than managing the finished goods stock levels.

The forecasting of sales volumes of die lubricants plays an important part to ordering raw materials. All of the sales volumes from Table 3.1 are converted into raw material consumption per month from January 1999 to April 2001, concerning each model's ingredients (see APPENDIX C), and they are also plotted into graph to see the trend (see APPENDIX D).

To determine setup cost (K) at Hanano Thailand, the details that must be considered consist of two major parts;

(1) External expenses (K1)

These expenses involve the costs of delivering raw materials from suppliers to Hanano Thailand, which are transportation cost, service charge, rent, document of ordering, custom formality, and etc.

The author collects these data from Hanano Thailand and describes them in Table 3.2 next. Some data are not authorized to be disclosed and they are replaced by the symbol "xx".

(2) Internal expenses (K2)

These expenses involve the costs of clerical and paperwork, telephone charge, data processing, bookkeeping, and etc. These costs have not been monitored yet. They will be assumed and shown in section 4.3.

Table 3.2. Data of External Expenses (K1) Occurred from Ordering Raw Materials.

R/M	DATE	Q'TY	EXPENSE	COST	AVERAGE
A	-	-	-	0	0
B	-	-	-	0	0
C	-	-	-	0	0
D	-	-	-	0	0
E		-	-	0	0
F	xx/xx/xx	1 drum	1 xx	400	4,182.84
			2 xx	1,300.00	
			3 xx	321	
			4 xx	761.84	
			5 xx	1,400.00	
			TOTAL	4,182.84	
G	xx/xx/xx	5 drums	1 xx	0	3,717.92
			2 xx	1,250.00	
			3 xx	1,081.95	
			4 xx	200	
			5 xx	140.51	
			6 xx	1,050.00	
			7 xx	7.5	
			TOTAL	3,729.96	
	xx/xx/xx	5 drums	1 xx	0	
			2 *xx*	1,250.00	
			3 xx	1,205.88	
			4 xx	200	
			5 xx	1,050.00	
			TOTAL	3,705.88	

Table 3.2. Data of External Expenses (K1) Occurred from Ordering Raw Materials. (continued)

R/M	DATE	Q'TY	EXPENSE		COST	AVERAGE
H	xx/xx/xx	5 drums	1	xx	0	3,583.25
			2	xx	1,250.00	
			3	xx	1,081.95	
			4	xx	200	
			5	xx	140.51	
			6	xx	1,050.00	
			7	xx	7.5	
				TOTAL	3,729.96	
	xx/xx/xx	5 drums	1	xx	0	
			2	xx	1,250.00	
			3	xx	1,205.88	
			4	xx	200	
			5	xx	1,050.00	
				TOTAL	3,705.88	
	xx/xx/xx	5 drums	1	xx	1,250.00	
			2	xx	813.9	
			3	xx	200	
			4	xx	1,050.00	
				TOTAL	3,313.90	
I	-	-	-		0	0
J	xx/xx/xx	2 cans	1	xx	600	3,835.63
			2	xx	735.63	
			3	xx	400	
			4	xx	2,100.00	
				TOTAL	3,835.63	
K	xx/xx/xx	400 kg	1	xx	1,264.98	4,098.74
			2	xx	145.34	
			3	xx	1,518.42	
			4	xx	1,170.00	
				TOTAL	4,098.74	

Table 3.2. Data of External Expenses (K1) Occurred from Ordering Raw Materials. (continued)

R/M	DATE	Q'TY	EXPENSE	COST	AVERAGE
	xx/xx/xx	400 kg	1 xx	1,264.98	
			2 xx	145.34	
			3 xx	1,518.42	
			4 xx	1,170.00	
			TOTAL	4,098.74	
	xx/xx/xx	400 kg	1 xx	1,264.98	
			2 xx	145.34	
			3 xx	1,518.42	
			4 xx	1,170.00	
			TOTAL	4,098.74	
L	-	-	-	0	0
M	-	-	-	0	0
N	-	-	-	0	0
O	-	-	-	0	0

From Table 3.2, raw material A, B, C, D, E, I, L, M, N, and 0 do not contain any detail of external expenses of ordering (K1). It is because suppliers do not charge any cost in ordering each time. They have already charged together with the item costs (purchasing costs). The last column is the mean of all the samples of external expenses presented in Table 3.2, and they are used together with the internal expenses (K2) to determine the total setup cost (K) for each raw material. The internal expenses are described later in section 4.3.

After interviewing with Hanano Thailand, the author concludes the occurrences of production time for die lubricants and occurrences of lead time for ordering raw materials in Table 3.3 and Table 3.4 respectively.

Table 3.3. Occurrences of Production Time for Die Lubricants.

Die Lubricant	Production Time (day)
AA	vary from 1 to 3
BB	vary from 1 to 3
CC	vary from 1 to 3
DD	vary from 1 to 3
EE	vary from 1 to 3
FF	vary from 1 to 3
GG	vary from 1 to 3
HH	vary from 1 to 3
Il	vary from 1 to 3
JJ	vary from 1 to 3

From Table 3.3, the production time for each model of die lubricant takes one day to three days, equally every model. Normally it takes one or two days for production. Taking three days is the emergency case.

Table 3.4. Occurrences of Lead Time for Ordering Raw Materials.

Raw Material	Lead Time (day)
A	vary from 1 to 4
B	vary from 1 to 4
C	vary from 1 to 4
D	vary from 1 to 4
E	7 or 45
F	60 ± 5
G	90 ± 5
H	90 + 5
I	vary from 1 to 3
J	vary from 14 to 21 or 60 + 5
K	vary from 1 to 3
L	vary from 14 to 21 or 60 + 5
M	60 + 5
N	vary from 2 to 7
O	60 + 5

From Table 3.4, since raw materials come from several sources, lead time for ordering them is different. For example, raw material B takes one day to four days for delivery while raw material E takes either seven days (if materials are available at supplier's stock) or forty five days (if materials are not available) for delivery. Raw material J and L take either fourteen days to twenty one days (by air-freight) or sixty days ± 5 days (by sea-freight) for delivery.

The details of probability distribution for each type of raw materials will be considered in section 4.3.

Table 3.5. The Current Inventory Policy for Die Lubricants and Their Raw Materials.

INVENTORY SYSTEM						
DATA : JANUARY - DECEMBER' 2001				HANANO (THAILAND) CO.,LTD.		
ITEM	DESCRIPTION	UNIT	RUNNING AVERAGE	RE-ORDER POINT	QUANTITY ORDER	LEAD TIME (DAY)
1	AA	CAN	267.9	104.0	56 x 2	3
2	AA	DRUM	42.8	17.0	5 x 5	3
3	BB	DRUM	5.0	2.0	5	3
4	CC	CAN	29.9	12.0	56	3
5	CC	DRUM	16.9	7.0	5 x 3	3
6	DD	CAN	90.1	35.0	56	3
7	DD	DRUM	11.4	5.0	5 X 2	3
8	EE	CAN	56.2	22.0	56	3
9	EE	DRUM	1.8	1.0	5	3
10	FF	CAN	40.0	16.0	56	3
11	GG	CAN	8.2	4.0	10	3
12	HH	CAN	14.4	6.0	56	3
13	HH	DRUM	2.0	1.0	5	3
14	II	CAN	6.0	3.0	10	3
15	JJ	CAN	20.0	8.0	56	3
16	JJ	DRUM	4.0	2.0	5	3
17	A	kg	3,058.5	1,738.0	1800	7
18	B	kg	1,984.0	1,128.0	1800	7
19	C	kg	2,606.2	1,481.0	1800	7
20	D	kg	193.0	110.0	960	7
21	E	kg	180.0	414.0	720	45
22	F	kg	1,002.3	2,985.0	2520	60
23	G	kg	193.0	838.0	1440	90
24	H	kg	129.2	561.0	1440	90
25	I	kg	1,200.0	464.0	800	3
26	J	kg	60.2	180.0	180	60
27	K	kg	900.0	BY ORDER	BY ORDER	3
28	L	kg	11.6	35.0	180	60
29	M	kg	7.1	22.0	50	60
30	N	kg	164.3	94.0	140	7
31	**O**	kg	28.5	85.0	108	60

The value of running average, re-order point, order quantity, and lead time described in Table 3.5 can be considered as D, ROP, EOQ, and L consequently.

3.4 Problem Analysis and New System's Requirements

Not only the high costs are counted to be the problem for inventory, but also the manner of operation. The current system of inventory policy for die lubricants and their raw materials has been used for many years. It works smoothly and nothing is wrong. However, Hanano Thailand aspires to revise the current system and improve it so that it can serve changes in the future.

After studying the situation and current manner of operation of inventory system at Hanano Thailand, the author concludes the major problems, which are;

(1) Not gain benefits from the potential significant data that it has.

(2) Not flexible to change.

(3) Has a trend to contain high cost of inventories.

(4) Lack of sharing information throughout other related departments.

This situation is the fact that everyone should realize and feel compelled to change. To solve those problems, the research had been done as well as a new inventory policy had been considered. The current inventory policy for die lubricants and their raw materials should be revised, scrutinized, and improved from time to time.

The new inventory policy should contain the advantages, when compared with the current policy, as the followings:

(1) More flexible, more convenient, and more systematic.

(2) Reduce processing time.

(3) Controllable and easy to use.

(4) Has a trend to reduce inventory costs.

In Chapter IV, all of the data gathered from Hanano Thailand in Chapter III are compiled and calculated to determine a new inventory policy. Some assumptions must be set to smooth the calculation, and they must be as close to reality as possible. Crystal Ball is applied to solve the probability distribution of some parameters, and also, a new program, using Microsoft® Excel, is formulated.

IV. NEW INVENTORY POLICY FORMULATION

The previous chapter defines the background and the current inventory policy of Hanano Thailand, and also, shows the data related to the calculation determining a new inventory policy for die lubricants and their raw materials. This chapter will present how to formulate the new inventory models. The author uses Microsoft® Excel together with its add-in software named Crystal Ball to calculate the optimum EOP and ROP based on some assumptions needed to be set before calculation.

4.1 Setting the Assumptions

To simplify the process of calculation, setting assumptions is needed so that it makes everyone understand in the same direction the concept based on the amount of historical data in hand and their reliabilities as well as the real situation.

The author sets 10 assumptions for determining the new inventory policy, which are;

(1) No shortage is allowed.

Hanano (Thailand) Co., Ltd. has no policy to ignore any customer. Hanano Thailand will supply its products to customers as much as possible, no matter how little customer order is. Based on this concept, shortage cost (penalty cost) shall be ignored.

(2) Raw materials are concerned more than finished goods.

Since Hanano Thailand is a manufacturer, to ensure the smooth production is important (in order to get along with the first assumption; no shortage is allowed). As described in section 3.2: Data Analysis, in production of die lubricant (batch process), it takes approximately 6 hours (actual time) to produce 1,000 kg in a big reactor tank and the same amount of production time to produce 200 kg in a small reactor tank. Hanano

Thailand has 3 big reactor tanks and 1 small reactor tank. Therefore, managing the raw materials to ensure the smooth production is more important than managing the finished goods stock level. As long as the raw materials are in hand, the production will be fine.

(3) The new inventory policy is suggested only for the 15 types of raw materials.

According to the previous assumption, we pay attention to the raw materials more than the die lubricant itself since the root of high costs of inventory comes from buying raw materials over actual needs. The more raw materials we buy, the higher costs we take. Once the materials are in hand, they can be stocked by either keeping them as their original packing or transforming them into finished goods, packing in can (18 kg) and drum (200 kg). No matter which way they are kept, rarely will their shelf-life and their holding costs (h) be effected. Sooner or later, they will be transformed into die lubricants.

The EOQ and the ROP of raw materials will be determined type by type (shown in section 4.4: New Inventory Policy).

(4) No storage limitation is concerned.

Some advanced formula for determining EOQ pay attention to the constraint of storage limitation. But it is nothing to do with the case of Hanano Thailand since its new factory, finished construction in 2000, has enough space available for keeping either finished goods (die lubricants) or their raw materials.

(5) No price discount for raw materials is concerned.

The size of the order of raw materials does not effect the price. The details of the minimum order or minimum packing for each raw material is described in section 4.4.

(6) Determining the demand for each type of raw materials (D) is based on forecasting the sales volumes of die lubricants in Table 3.1.

To determine demand for each raw material which is a necessary variable for calculation EOQ for raw materials, there are two ways of forecasting. The first is forecasting the sales volumes for each die lubricant, based on the data in Table 3.1 and APPENDIX B, then breakdown into ingredient composition to determine the raw material consumption later (see examples in APPENDIX C). Another is directly forecasting the demand for each raw material based on the historical data, after breakdown into each ingredient composition already, shown as in the graphs in APPENDIX D.

Forecasting the future demand for either finished goods or raw materials may give the results which are not much different, but it does not make any sense to forecast demand of raw materials instead of forecasting demand of products. The important fact that should be known is how much products will be sold next month, not how much raw materials will be bought. Once the forecasting of products are known, they can be converted into raw material quantities anyway. CB Predictor is applied to forecast the sales volumes of each model of die lubricant.

(7) Determining setup cost (K) is based on data in Table 3.2.

There are other cases of ordering raw materials that are not shown in Table 3.2. For the cases shown in Table 3.2, they are most likely to happen in real situation. Based on these data, together with other conditions described in section 4.3, the author can determine the setup cost for each raw material.

Determining holding cost (h) is based on the cost per unit (Baht per kg) of each raw material, by considering the two components which are the cost of capital and storage of raw materials.

It is hardly likely that holding cost can be calculated accurately. There are too many conditions to be considered. According to section 2.4: Inventory Costs, there are five major conditions in considering holding costs; cost of capital, storage, storekeeping operations, insurance and taxes, and obsolescence and deterioration. Storekeeping operations and obsolescence and deterioration can be ignored due to the situation at Hanano Thailand. Taxes are involved in the item costs (purchasing costs), and shown in APPENDIX C as cost per unit of each raw material. Cost of capital and storage are the major constraints for determining the holding costs for each raw material (see more details in section 4.3).

Since the real sunk cost is incurred from buying raw materials, not from producing finished goods, the calculation of holding costs is done only for raw materials in order to avoid the overlapping of cost determination.

Lead time (L) of ordering raw materials is based on Table 3.4.

It is not exactly known how many days it takes for delivery materials from suppliers to Hanano Thailand. Table 3.4 shows the occurrences of mostly possible situation for delivery of raw materials. After discussion with Hanano Thailand, the author concludes the probability distributions of lead time for each raw material in section 4.3.

(10) Probability distribution of all variables are set based on the available historical data.

Because it is difficult to determine the real pattern of probability distribution for any variable, setting probability distribution of all variables, by using Crystal Ball, is determined by combining the idea of several persons who have strong experience working at Hanano Thailand. The author collects those ideas and compiles them into probability distribution forms as close to those ideas and historical data as possible.

4.2 Steps for New Inventory Model Formulation

The author applies the concept of 7 steps of Decision Making Process to solve the problem and to make it step-by-step, which are;

(1) Recognize the problem.

As explained in section 3.4, the current inventory system at Hanano Thailand has no problem. However, traditionally, inventory has been viewed by business and industry as a necessary evil (Taha 1995). A firm might want inventories at some level in their operations, and they would also want to keep them at a minimum. Like Hanano Thailand, despite the fact that there is no problem caused by operation, no one can deny that the existing high costs of inventories does not count to be a problem. The current inventory policy for die lubricants and their raw materials should be revised, scrutinized, and improved from time to time. Not only the high costs that are counted to be the problem, but also the manner of operation. A new contemporary system should be considered.

(2) Define the problem.

In section 3.4, the problem that probably occurred from using the current inventory system is defined.

(a) Not gain benefits from the high potential significant data that it has.

(b) Not flexible to change.

(c) Has a trend to contain high cost of inventories

(d) Lack of sharing information throughout other related departments.

(3) Obtain relevant data.

In chapter III, the author gathers all of the relevant data needed for determining a new inventory policy, and also, discusses with several experienced persons at Hanano Thailand to compile those data as properly as possible.

(4) Evaluate and analyze data.

This step needs a tool to analyze or process the significant data collected from the third step. Each data must be accurately processed by the suitable method. In chapter II, the author describes the necessary tools for processing those data. For example, the EOQ and the ROP equations for determining an inventory policy, CB Predictor for determining forecasting techniques of the future demands, Crystal Ball for handling the data that has probability distributions.

(5) Formulate the model.

The new inventory models for raw materials are formulated based on the combination of the available historical data and the theories. In this project, the new models will be determined by the EOQ and ROP.

(6) Implement the model.

Once the new models are formulated, they have to be implemented by substituting all relevant parameters. The author simulates those models for Hanano Thailand consideration. For using them in real situation, Hanano Thailand is the only one who makes the decision, as well as adjusting them to its need.

(7) Review the model and evaluate the result.

The results are the new inventory policy of raw materials for Hanano Thailand. They can be compared with the current policies to evaluate the proper models. All results are shown in section 4.4: New Inventory Policy, and evaluated in section 5.1: Conclusion and 5.2: Recommendation.

From the 7 steps mentioned above, the author has already finished step 1, step 2, and step 3 already. Next he will continue step 4, step 5, step 6, and step 7 consequently.

4.3 Determine the Relevant Data

This section includes the determining of setup cost (K), demand (D), holding cost (h), and lead time (L) in order to substitute in the EOQ and ROP equations as well as to be applied with Crystal Ball in section 4.4 later.

Determine setup cost (K)

From section 3.2, to determine setup cost (K) at Hanano Thailand, the details that must be considered consist of two major parts; external expenses (K1) and internal expenses (K2).

(1) External expenses.

These expenses involve the costs of delivering raw materials from suppliers to Hanano Thailand, which are transportation cost, service charge, rent, document of ordering, custom formality, and etc. The mean of K1 are shown in Table 3.2.

(2) Internal expenses.

These expenses involve the costs of clerical and paperwork, telephone charge, data processing, bookkeeping, and etc. Since these costs have not been monitored yet, the author discussed with Hannao Thailand and assumed these costs. The details of internal expenses for each raw material are shown in Table 4.1 next.

For calculation example, the purchaser's salary is assumed to be 24,000 Baht / month, which is 1,000 Baht / day (1 month = 24 working days). There are approximately 10 ordering jobs per day. So the labor expense for the internal expense is 100 Baht / order.

From Table 4.1, generally, setup cost is varied slightly. Based upon the observation of situation and historical data, the probability distribution of setup costs is uniform, equally to every raw material, with ± 10%.

Table 4.1. Determine Setup Cost (K) for Each Raw Material.

Details	Units	Raw Material														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1 External expenses																
Mean (from Table 3.2)	฿ / order	0	0	0	0	0	4183	3718	3583	0	3836	4099	0	0	0	0
2 Internal expenses																
paperwork	฿ / order	10	10	10	10	10	10	10	10	0	10	10	10	10	10	10
telephone charge	฿ / order	20	20	20	20	20	20	20	20	0	20	20	20	20	20	20
labor	฿ / order	100	100	100	100	100	100	100	100	1250	100	100	100	100	100	100
other expenses	฿ / order	0	0	0	0	0	0	0	0	2500	0	0	0	0	0	0
Sum	฿ / order	130	130	130	130	130	130	130	130	3750	130	130	130	130	130	130
Total setup cost	฿ / order	130	130	130	130	130	4313	3848	3713	3750	3966	4229	130	130	130	130

Determine Demand (D)

According to the sixth assumption in section 4.1; determining the demand for each type of raw materials (D) is based on forecasting the sales volumes of die lubricants, there are two parts of analysis. The first part is forecasting the sales volumes of die lubricant, and the second is determining demand of the raw materials based on those sales volumes.

Table 4.2 shows the forecasting for the sales volumes of die lubricants applying CB Predictor to determine which method of forecasting should be used, referred to Table 2.1, as well as to determine the forecast values. From Table 4.2, the period 1 to period 6 are assumed to be May 2001 to October 2001, but the actual sales in those periods will not be shown to compare with the forecast. Selecting "n" for each model is up to the decision of Hanano Thailand. The sales volume in period 1 is the representative for the demand of die lubricants which will be used for calculation next. The forecasting reports for all of the die lubricants are shown in APPENDIX E.

Once those sales volumes are forecasted, they are input to the Table 4.3 to convert to raw materials demand. In general, the demand is varied normally. The assumption for probability distribution for demands (D) is set as normal, equally to every raw material, with standard deviation (SD) 10% of the mean.

Table 4.2. Forecasting the Sales Volumes for Each Model of Die Lubricants, Applying CB Predictor.

Month-Year	AA (kg)	BB (kg)	CC (kg)	DD (kg)	EE (kg)	FF (kg)	GG (kg)	HH (kg)	II (kg)	JJ (kg)
Jan-99	6968	0	1594	2198	1890	0	0	1422	0	0
Feb-99	8598	0	1738	4376	2270	0	90	1350	0	1980
Mar-99	10050	0	2174	2234	2020	0	54	1368	0	810
Apr-99	11268	0	2368	2034	1980	0	36	1242	0	270
May-99	12738	0	1774	1360	1480	0	72	1368	0	360
Jun-99	8686	0	2770	1890	2920	0	0	1332	0	360
Jul-99	7638	0	3818	3476	1840	0	36	3456	0	540
Aug-99	10356	18	4320	2252	2020	0	0	306	0	540
Sep-99	14370	200	2520	3826	2560	0	90	1854	0	810
Oct-99	14482	400	3534	5262	3430	0	108	630	0	360
Nov-99	11800	400	4574	2052	3260	0	288	2466	0	1080
Dec-99	8988	200	6028	2506	2360	0	216	1026	0	756
Jan-00	12652	400	5126	6544	2200	0	288	1404	0	702
Feb-00	13206	54	3706	5998	2520	0	108	1224	0	1098
Mar-00	15056	1000	4124	3286	4200	0	180	1404	**1080**	1160
Apr-00	13976	1400	4398	6216	2560	200	288	918	0	854
May-00	15098	836	5724	3034	3280	378	0	1286	0	1090
Jun-00	14622	836	6158	6564	2200	740	0	2362	54	890
Jul-00	11566	1326	4198	3216	580	2000	144	398	2580	872
Aug-00	13224	708	4396	5436	540	236	288	72	0	800
Sep-00	11738	1344	1596	2980	200	1532	54	180	1598	400
Oct-00	11742	854	3506	2344	1372	0	180	270	708	1200
Nov-00	11912	1472	1902	6146	3280	0	216	978	36	800
Dec-00	10992	1344	3174	2234	902	738	0	108	2200	400
Jan-01	12030	1196	2938	4328	400	630	270	90	0	836
Feb-01	13840	2180	4612	2254	800	450	54	0	4600	400
Mar-01	17886	2834	4188	1144	0	1440	270	108	0	1308
Apr-01	17552	2000	3486	2054	400	1530	72	234	1400	1016
Period 1	**17552**	**2214**	**3724**	**2735**	**430**	**798**	**144**	**171**	**1149**	**792**
Period 2	**17552**	**2364**	**3724**	**2735**	**430**	**798**	**144**	**171**	**1149**	**792**
Period 3	**17552**	**2513**	**3724**	**2735**	**430**	**798**	**144**	**171**	**1149**	**792**
Period 4	**17552**	**2663**	**3724**	**2735**	**430**	**798**	**144**	**171**	**1149**	**792**
Period 5	**17552**	**2812**	**3724**	**2735**	**430**	**798**	**144**	**171**	**1149**	**792**
Period 6	**17552**	**2962**	**3724**	**2735**	**430**	**798**	**144**	**171**	**1149**	**792**
Method	SMA	DES	SES	SES	SES	SMA	SES	SMA	SES	SMA
n	28	22	28	28	28	14	28	6	15	28

Table 4.3. Determine the Demand for Each Raw Material Based on the Forecasting of Sales Volumes of Die Lubricants.

				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
AA	Ingredient		%	7.4	6.0	11.6			6.0								0.5		68.5	100.0
	Forecast	17552	kg / month	1298.8	1053.1	2036.0	0.0	0.0	1053.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.8	0.0	12023.1	17552.0
BB	Ingredient		%	13.5	6.0									10.0			0.4		70.1	100.0
	Forecast	2214	kg / month	298.9	132.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	221.4	0.0	0.0	8.9	0.0	1552.0	2214.0
CC	Ingredient		%			21.0	10.5									0.1	0.4		68.0	100.0
	Forecast	3724	kg / month	0.0	0.0	782.0	391.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	14.9	0.0	2532.3	3724.0
DD	Ingredient		%	22.1	16.8												0.6		60.5	100.0
	Forecast	2735	kg / month	604.4	459.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.4	0.0	1654.7	2735.0
EE	Ingredient		%		8.0		15.0			15.0								0.5	61.5	100.0
	Forecast	430	kg / month	0.0	34.4	0.0	64.5	0.0	0.0	64.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	264.5	430.0
FF	Ingredient		%					16.0				2.6		1.2			0.4		79.8	100.0
	Forecast	798	kg / month	0.0	0.0	0.0	0.0	127.7	0.0	0.0	0.0	20.7	0.0	9.6	0.0	0.0	3.2	0.0	636.8	798.0
GG	Ingredient		%	7.0	21.0								14.0		6.0		0.4		51.6	100.0
	Forecast	144	kg / month	10.1	30.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.2	0.0	8.6	0.0	0.6	0.0	74.3	144.0
HH	Ingredient		%	5.0							25.0							0.4	69.6	100.0
	Forecast	171	kg / month	8.6	0.0	0.0	0.0	0.0	0.0	0.0	42.8	0.0	0.0	0.0	0.0	0.0	0.0	0.7	119.0	171.0
II	Ingredient		%	5.0					15.0								0.4		79.6	100.0
	Forecast	1149	kg / month	57.5	0.0	0.0	0.0	0.0	172.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	914.6	1149.0
JJ	Ingredient		%	12.0								13.0		10.0			0.4		64.6	100.0
	Forecast	792	kg / month	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.0	0.0	79.2	0.0	0.0	3.2	0.0	511.6	792.0

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	2373	1710	2818	456	128	1225	65	43	124	20	310	9	4	139	3	20283	x
2	Buffer	%	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	x
3	Demand D	kg / month	**3085**	**2223**	**3663**	**592**	**166**	**1593**	**84**	**56**	**161**	**26**	**403**	**11**	**5**	**181**	**4**	**26368**	x
4	Cost per unit	฿ / kg	73	250	73	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	660	674.33	0.8	x
5	Estimated Cost	฿ / month	225226	555776	267435	171731	38840	265524	31582	18388	22586	5533	17573	1748	329	119652	2484	21094	**1,765,500**

Determine Holding Cost (h)

According the to eight assumption in section 4.1; determining holding cost (h) is based on the cost per unit (Baht per kg) of each raw material, by considering the two components which are the cost of capital and storage of raw materials. Those two components are considered by estimation.

To determine the cost of capital, the calculation is based on the interest rate and the opportunity cost. The interest rate of loaning, is approximately 8% per year (Krung Thai Bank on September, 2001). The opportunity cost is estimated at 10% per year (Hanano Thailand judgement). By flat rate, it is equal to 18% divided by 12 months, which is 1.5% per month. Despite the fact that there is sufficient area at factory of Hanano Thailand to keep stocks, the storage is still considered as 1% per month. This estimation is based on the judgemental estimation of Hanano Thailand. Thus, the total components for holding cost are estimated at 2.5% per month.

Table 4.4 shows the calculation of holding costs for raw materials. Generally, holding cost is not much varied. Note that holding costs are not set by the probability distribution due to the potential limitation of student version of Crystal Ball (only six assumptions are allowed). So, holding cost will be determined as a single value.

Table 4.4. Determine Holding Cost (h) for Each Raw Material.

Details	Units	Raw Material														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1 Cost per unit																
cost (included VAT)	฿ / kg	73.00	250.00	73.00	290.00	234.00	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68.00	660.00	674.33
2 Considered components																
- cost of capital	% / month	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
- storage	% / month	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sum	% / month	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Holding cost	฿ / kg / month	1.825	6.250	1.825	7.250	5.850	4.167	9.416	8.272	3.511	5.278	1.090	3.891	1.700	16.500	16.858

Determine Lead Time (L)

To determine the probability distribution of lead time for each raw material, there are two possible distributions; Custom and Uniform. From the Table 4.5, the probability distributions of raw material A, B, C, D, E, I, K, N are set as custom while the probability distributions of raw material F, G, H, M, O are set as uniform. Raw material J and L has probability distribution either 14 to 21 days or 60 ± 5 days, but the probability occurrance of 14 to 21 days is only 5%. Therefore, the custom distribution between 14 to 21 days should be ignored and only the uniform distribution at 60 ± 5 days should be considered.

Since Hanano Thailand does not want to take a risk of shortage, the value of lead time assigned into ROP equation will be the pessimistic view. After that, the ROP value calculated by the ROP equation will be compared with the ROP calculated by applying Crystal Ball.

Table 4.5. Determine the Probability Distribution of Lead Time for Each Raw Material.

Condition	Units	Raw Material														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1 Custom distribution																
(1) occurance	day	1	1	1	1	5 - 7	-	-	-	1	14 - 21	1	14 - 21	-	2 - 3	-
probability	-	0.1	0.1	0.1	0.1	0.8				0.1	0.05	0.1	0.05		0.2	
(2) occurance	day	2	2	2	2	45				2	60	2	60		4 - 5	
probability	-	0.2	0.2	0.2	0.2	0.2				0.4	0.95	0.4	0.95		0.4	
(3) occurance	day	3	3	3	3					3		3			6 - 7	
probability	-	0.3	0.3	0.3	0.3					0.5		0.5			0.4	
(4) occurance	day	4	4	4	4											
probability	-	0.4	0.4	0.4	0.4											
Total Relative Prob.	-	1	1	1	1	1	0	0	0	1	1	1	1	0	1	0
2 Uniform distribution																
(1) occurance	day	-	-	-	-	-	60	90	90	-	60	-	60	60	-	60
(2) distribution range (+/-)	day						5	5	5		5		5	5		5
3 None distribution																
(1) Most likely happen	day	4	4	4	4	7	60	90	90	2	60	2	60	60	5	60
(2) Pessimistic view	day	4	4	4	4	45	65	95	95	3	65	3	65	65	7	65

4.4 New Inventory Policy

After determining all relevant data needed for calculation of the inventory policy, all of them are substituted in the equation of EOQ and ROP. Table 4.6 shows the calculation of EOQ and ROP for raw material type A and type B, as well as the results analyzed by Crystal Ball. Note that only six assumptions are allowed in the student version of Crystal Ball.

Table 4.7 shows the final results of inventory policy for all raw materials. The frequency charts of EOQ and ROP calculated by Crystal Ball are illustrated in APPENDIX F.

Table 4.8 is the new inventory policy compared with the current policy and other interesting and necessary information for Hanano Thailand.

Table 4.6. Determine EOQ and ROP for Raw Material A and B, Analyzing by Crystal Ball.

		Details		'et		A			;Li	7	E-4		CA 0.5				N	O
,-1	CY O W		$ / order	130	131)	130	130	130	4313	3848	3713	3750	3966	4229	130	130	130	130
			kg / month	3085.3	2223 I	3663.5	592.2	166.0	1593.1	83.9	55.6	160.8	26.2	403.2	11.2	4.8	181.3	3.7
			$ / kg / month	1.825	6.250	1.825	7.250	5.850	4.167	9.416	8.272	3.511	5.278	1.090	3.891	1.700	16.500	16.858
		Y	0)	66198	304.11	722.44	145.73	85.89	1816.06	261.79	223.37	586.12	198.46	1769.28	27.40	27.21	53.45	7.54
	CG	1 Mean	0)	661.54	304.68													
		2 Median	0)	659.71	304.44													
		3 SD	.	36.76	17.77													
		4 Range Min.	0)	548.92	247.25													
		5 Range Max.	0)	773.32	359.81													
N	O 4	*	day/order	5.15726	3.28305	4.73281	5.90614	12.419	27.3586	74.9296	96.4621	87.4693	181.744	105.307	58.5419	134.895	7.07569	49.1044
			day		4	4	4 •	45	65	95	95	3	65	3	65	65	7	65
				0	1	0	0	3	2	1	0	0	0	0	1	0	0	1
		a)	day	4	0.71695	4	4	7.74298	10.2828	20.0704	95	3	65	3	6.45812	65	7	15.8956
		LeD	0)	514.213	66.4102	610.582	98.696	53.5504	682.565	70.1211	219.984	20.1026	70.98	50.4036	3.0224	13.1116	52.8763	2.44011
		ny*+LeD	0)	.514.213	370.517	610.582	98.696	311.22	4314.68	331.906	219.984	20.1026	70.98	50.4036	30.42	13.1116	52.8763	9.97804
	al C4	1 Mean	0)	384.87	280.56													
		2 Median	0)	396.56	290													
		3 SD	.	134.57	97.18													
		4 Range Min.	a)	90.76	66.53													
		5 Range Max.	0)	644.55	476.67													

Final Results of EOQ and ROP for Each Raw Material, Analyzing by Crystal Ball.

	Unit															
[illegible]	$ / order	130	130	130	130	130	4313	3848	3713	3750	3966	4229	130	130	130	130
[illegible]	kg / month	3085.28	2223.10	3663.49	592.18	165.98	1593.11	83.85	55.58	160.82	26.21	403.23	11.23	4.84	181.29	3.68
[illegible]	$ / kg / month	1.825	6.250	1.825	7.250	5.850	4.167	9.416	8.272	3.511	5.278	1.090	3.891	1.700	14	[illegible]
[illegible]	kg / order	662.98	304.11	722.44	145.73	85.89	1816.06	261.79	223.37	586.12	198.46	1769.28	27.40	27.21	53.45	7.54
[illegible]	[illegible]	661.54	304.68	718.88	145.49	85.94	1808.06	261.43	223.39	585.18	198.11	1759.66	27.37	27.11	53.36	7.54
[illegible]	[illegible]	659.71	304.44	719.30	145.36	86.00	1807.92	261.44	223.92	584.49	198.24	1763.47	27.37	27.16	53.33	7.53
[illegible]	.	36.76	17.77	41.77	8.51	4.85	106.17	15.14	12.97	34.32	11.13	108.94	1.62	1.58	3.23	0.44
[illegible]	[illegible]	548.92	247.25	588.19	119.97	71.02	1488.87	206.16	165.43	454.69	162.71	1434.40	21.03	21.68	42.98	5.82
[illegible]	[illegible]	773.32	359.81	844.24	177.45	99.43	2158.91	310.01	267.36	705.50	231.56	2109.97	31.90	31.80	62.38	8.81
[illegible]	day / order	5.16	3.28	4.73	5.91	12.42	27.36	74.93	96.46	87.47	181.74	105.31	58.54	134.90	7.08	49.10
[illegible]	day	4	4	4	4	45	65	95	95	3	65	3	65	65	7	[illegible]
		0	i	0	0	3	2	1	0	0	0	0	1	0	0	1
[illegible]	day	4.00	0.72	4.00	4.00	7.74	10.28	20.07	95.00	3.00	65.00	3.00	6.46	65.00	7.00	15.90
[illegible]	[illegible]	514.21	66.41	610.58	98.70	53.55	682.57	70.12	219.98	20.10	70.98	50.40	3.02	13.11	52.88	2.44
[illegible]	[illegible]	514.21	370.52	610.58	98.70	311.22	4314.68	331.91	219.98	20.10	70.98	50.40	30.42	13.11	52.88	9.98
[illegible]	[illegible]	384.87	280.56	456.28	74.37	97.87	3978.74	315.20	208.84	16.14	65.51	40.07	28.10	12.04	36.69	9.22
[illegible]	[illegible]	396.56	290.00	475.44	77.54	43.42	3972.22	314.58	208.88	16.39	65.36	40.41	28.09	12.03	36.33	9.20
[illegible]		134.57	97.18	161.05	25.52	110.66	449.66	32.60	22.58	4.77	7.12	12.07	3.14	1.32	12.17	1.03
[illegible]	[illegible]	90.76	66.53	110.85	19.40	24.97	2717.86	208.16	123.14	4.78	45.64	12.19	17.23	6.78	12.19	5.81
[illegible]	[illegible]	644.55	476.67	787.86	130.35	390.32	5708.61	459.86	281.33	26.79	90.15	67.51	36.48	15.70	63.17	12.76

Table 4.8. The New Inventory Policy.

Details	Unit																
1. How much to order																	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Current quantity order	kg / order	1800	1800	1800	960	720	2520	1440	1440	800	180	-	180	50	140	108	
Minimum order	kg / order	200	100	200	100	181.4	180	180	180	-	18	-	200	25	20	17	
2. When to order																	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Current re-order point	kg	1738	1128	1481	110	414	2985	838	561	464	180	-	35	22	94	85	
Current stock	kg	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	
3. Additional details																	
Lead time (most likely)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Lead time (pessimistic)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
New forecast (D)	kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Current forecast (D)	kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Cost (included VAT)	[illegible]	73.00	250.00	73.00	290.00	234.00	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68.00	660.00	674.33	
New Total Cost	/ month	225,226	555,776	267,435	171,731	38,840	265,524	31,582	18,388	22,586	5,533	17,573	1,748	329	119,652	2,484	1,744,405

From Table 4.8, the new inventory policy tends to contain inventory costs less than the current policy. For example, let's consider raw material A in Table 4.8. The current forecast for its demand per month is 3,058 kg and the new forecast, included 30% buffer, is 3,085 kg (normal distribution with SD = 308.5). In spite of the fact that those forecast values are close to each other, their inventory policies are much different. The EOQ (kg / order) of the current policy and the new policy is 1,800 and 662 respectively, and also, the ROP (kg) of the current policy and the new policy is 1,738 and 385 consequently. Both EOQ and ROP of the current policy are higher than the new policy, thus it makes the inventory costs of the current policy higher than the new policy also.

The costs in this case are actually holding costs. The different cost between current inventory and new inventory can be roughly calculated, however, the calculation must be performed under the same conditions, such as demand, lead time, and etc. In general, if demand (kg / month) of one model is expected to be higher than another is, then the value of EOQ and ROP will be higher too. Likewise, if lead time (day) of one model is expected to be longer than another is, then the value of ROP will be higher as well.

Table 4.9 shows the calculation of estimated holding cost of current policy and new policy for raw material A. From section 2.5: The EOQ and the ROP, the average inventory can be determined by $\frac{Y}{2}$ units. So the average inventory level of the current policy and the new policy will be $\frac{1{,}800\text{kg}}{2}$ and $\frac{662}{2}$ kg, which are 900 kg and 331 kg consequently. After the average inventory levels (kg) are determined, they are multiplied by their holding costs (Baht / kg / month). The results will be the estimated holding costs (Baht / month) of raw material A. Since the holding cost of the current inventory policy is not revealed, it is assumed to apply the holding cost of the new policy, which is 1.825 Baht / kg / month.

The estimated holding costs (Baht / month) of the current policy and the new policy for raw material A are 1,643 and 604 respectively. The different cost is 1,039 Bahts / month. The result implies that, for raw material A, Hanano Thailand can save 1,039 Bahts / month if the new inventory policy is applied in stead of the current policy.

However, applying the new inventory policy in real situation will probably be confronted by some irregular or unpredictable factors that may cause the inventory policy fail, such as shortage problem. It is very important to carefully consider the most suitable inventory policy of raw materials for Hanano (Thailand) Co., Ltd. by considering the new inventory policy, the current policy, the additional information, as well as the current situation together.

Table 4.9 Estimated Holding Costs of the Current Policy and the New Policy for Raw Material A.

Relevant Data	Unit	Inventory Policy for Raw Material A	
		Current	New
Setup cost	$ / order	?	130 ± 13
Demand	kg / month	3,058	3,085
Holding cost	$ / kg / month	?	1.825
Lead time	day	7	1 (prob. = 0.1) 2 (prob. = 0.2) 3 (prob. = 0.3) 4 (prob. = 0.4)
EOQ (y*)	kg / order	1,800	662
ROP (LeD)	kg	1,738	385
Avg. Inventory (y*/2)	kg	900	331
Estimated holding cost	$ / month	1,643	604

V. CONCLUSIONS AND RECOMMENDATIONS

From the previous Chapter, the new inventory policy has been already determined, and it is compared with the current one. Table 4.8 completely shows the necessary information about inventory of raw materials of die lubricants for management decision. It is the final result of this project. However, it will be reviewed in this Chapter again so that the project reaches its completeness.

5.1 Conclusions

Inventory deals with maintaining sufficient stocks of goods (e.g., raw materials) that will ensure a smooth operation of a production system or a business activity. Traditionally, inventory has been viewed by business and industry as a necessary evil: too little of it may cause costly interruptions in the operation of the system, and too much of it can ruin the competitive edge and profitability of the business (Taha 1995). Therefore, managing the balance between low and high inventory levels is very important to a firm.

Basically known as inventory policy, the ultimate objective of any inventory model is to answer two questions:

(1) How much to order?

(2) When to order?

The answer of the first question is determined by Economic Order Quantity (EOQ) whereas the answer of the second question is determined by Re-Order Point (ROP).

Hanano (Thailand) Co., Ltd. is the case study for this project. Its famous product is die lubricants. Ten models of die lubricant and fifteen types of raw material are considered. The new inventory policy is suggested only for the fifteen types of raw materials since they are the actual inventory costs, not finished goods. Another reason is that Hanano Thailand is concerned with ensuring the sufficient raw materials for the production more than managing the stock levels of finished goods. Despite the fact that Hanano Thailand has the current inventory policy that works smoothly, it still aspires to revise the current system and improve it so that the system can serve changes in the future.

The new inventory policy for raw materials depends upon the EOQ and ROP while both of them depend upon the relevant historical data. The process of gathering the relevant data for determining EOQ and ROP is done under the real situation. There are four major components for determining EOQ and ROP; setup cost (K), demand (D), holding cost(h), and lead time(L). The combination of the actual historical data and the estimation based on experience is the standard for determining those components in order to make them as close to reality as possible. Once they are determined, their values are not totally in the forms of single value. They are mostly defined in the probability distribution. The Microsoft® Excel add-in that provides the ability to perform a technique for simulating real-world situations involving elements of uncertainty, Crystal Ball is applied to handle those four factors to determine the optimal EOQ and ROP.

The new inventory policy for fifteen types of raw material is suggested. It is formulated in the form of Microsoft® Excel. It is easy to use, controllable, flexible to change, moreover, it tends to reduce inventory costs.

Since the accuracy of the demand forecasting is the crucial indicator to measure how good the inventory policy is, CB Predictor is utilized in forecasting the demands to get the best results (least error). It is the Microsoft® Excel add-in that provides the ability to perform forecasting techniques. The major indicators that measure the accuracy of forecasting are RMSE, MAD, and MAPE.

Eventually, the new inventory policy, the current policy, the additional information, as well as the current situation should be considered together to determine the most suitable inventory policy of raw materials for Hanano (Thailand) Co., Ltd.

5.2 Recommendations

After this project is finished, many things still should be reviewed for further study. This section emphasizes on the recommendation about future project to enhance the new inventory model later.

There are two significant topics that will be discussed, which are;

(1) Inventory Policy for Die Lubricants

This project suggests only the new inventory policy for the fifteen types of raw material. For the ten models of die lubricant, suggesting the guideline for new inventory models formulation is noticeable.

According to the concept of inventory policy; how much to order? (determine EOQ), and when to order? (determine ROP). When applied to die lubricant production, the concept will be changed, which are; how much to produce?, and when to produce?

Hardly did EOQ of die lubricant is determined. It has a constraint about the production. Hanano Thailand has 3 big reactor tanks with production capacity 1,000 kg / batch, and 1 small reactor tank with capacity 200 kg / batch. To reach the economical production quantity, the production should run at the maximum capacity of reactor tank (1,000 kg for big tank and 200 kg for small tank) for each batch. Therefore, EOQ (y*) of die lubricants is probably assumed to be 1,000 kg or 200 kg depending on which tank is used.

Another important thing that should be considered is about the unit of measuring. The inventory model formulation of raw materials is different from the model formulation of die lubricants in that the unit measured for raw materials is standard in "kilogram (kg)" while the unit measured for die lubricants must be packing in "can" and "drum". Packing in can contains 18 kg and packing in drum contains 200 kg. Once the demand of each model of die lubricants is forecasted, they must be separated in can and drum. For example, the forecast of die lubricant "AA" is 17,552 kg / month. It may come from the sales of 364 cans (6,552 kg) plus 55 drums (11,000 kg). The important thing is how the sales volumes of die lubricant packing in cans and drums are determined. APPENDIX B shows the sales volume of each model of die lubricants from January 1999 to April 2001 breakdown in can, drum, and total. These data are significant in forecasting the sales volumes of die lubricants packing in can and drum.

After the EOQ (y*) and demand (D) are known, ROP of each model of die lubricants can be estimated.

(2) Forecasting

The accuracy of the demand forecasting is the crucial indicator to measure how good the inventory policy is. Forecasting the demands lower than actual needs may cause shortage problems which is very dangerous, and forecasting the demands higher than actual needs can make high costs of inventory. Thus, forecasting close to the right needs is the best way to manage inventory, not just to make high buffer demands or to determine every variable within the pessimistic view. Despite the fact that CB Predictor is utilized in forecasting the demands to get the best results (least error), there is no guarantee that the results will be closer to the actual demands than the results from other methods of forecasting or even from judgmental thinking. However, applying CB Predictor as a standard of forecasting the demand is counted to be the better starting point, which can be revised later, than assuming any forecasting technique without standard.

In this project, the author sets the assumption about determining the demand of raw materials by forecasting from the sales volume of die lubricants. In the future, forecasting should be done for both sales volume of die lubricants and consumption of raw materials. Then both results should be compared to determine which way of forecasting is better. Furthermore, the techniques of forecasting should be varied and reviewed later to compare which one is the most suitable technique (least error) for each model of die lubricant and for each type of raw material.

APPENDIX A

GLOSSARY OF TERMS AND KEY EQUATIONS

(3) The effective lead time

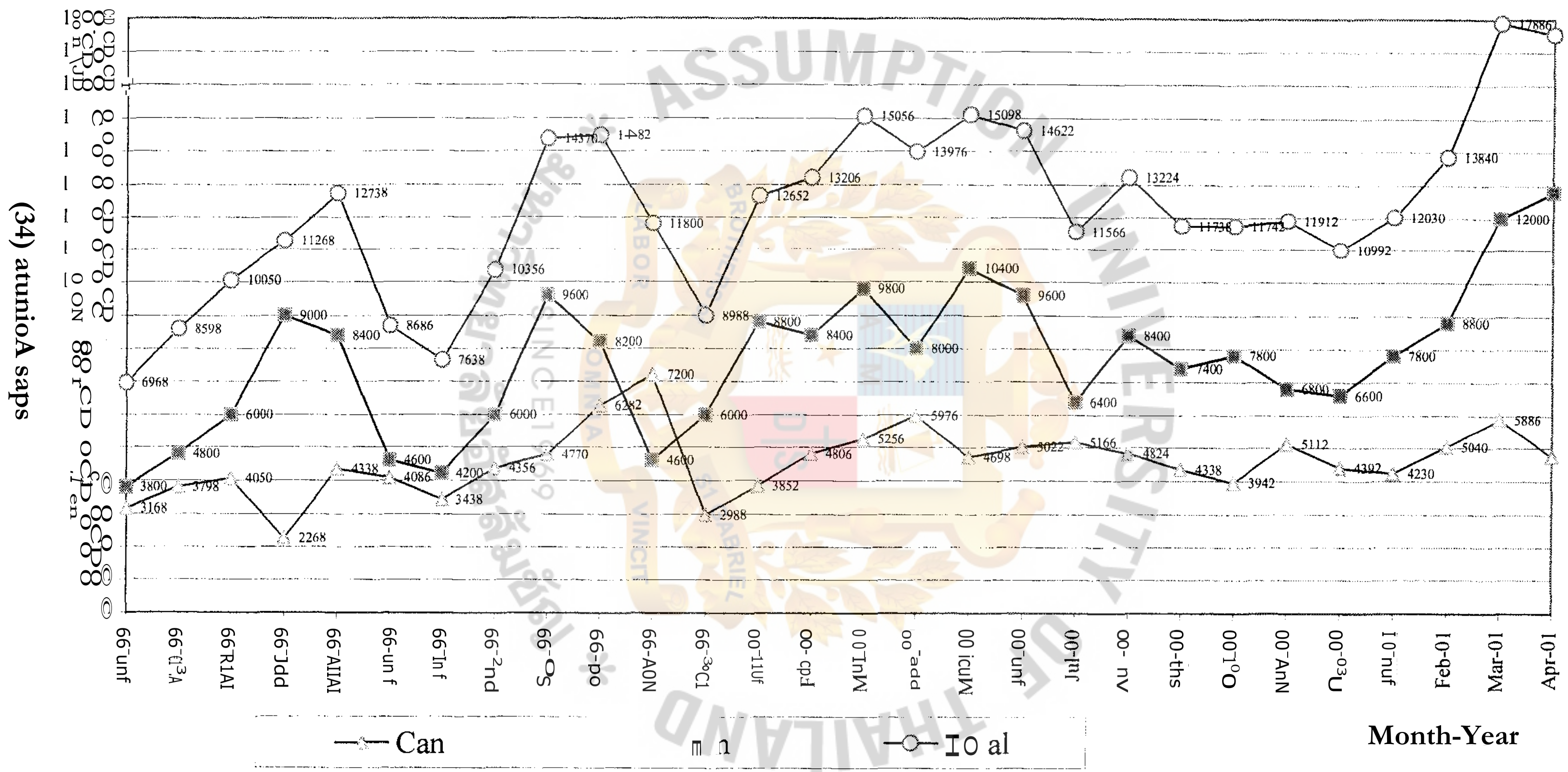
$$L_{e,} = L - nt_{o} \ast$$

(4) The ROP = Le x D

APPENDIX B

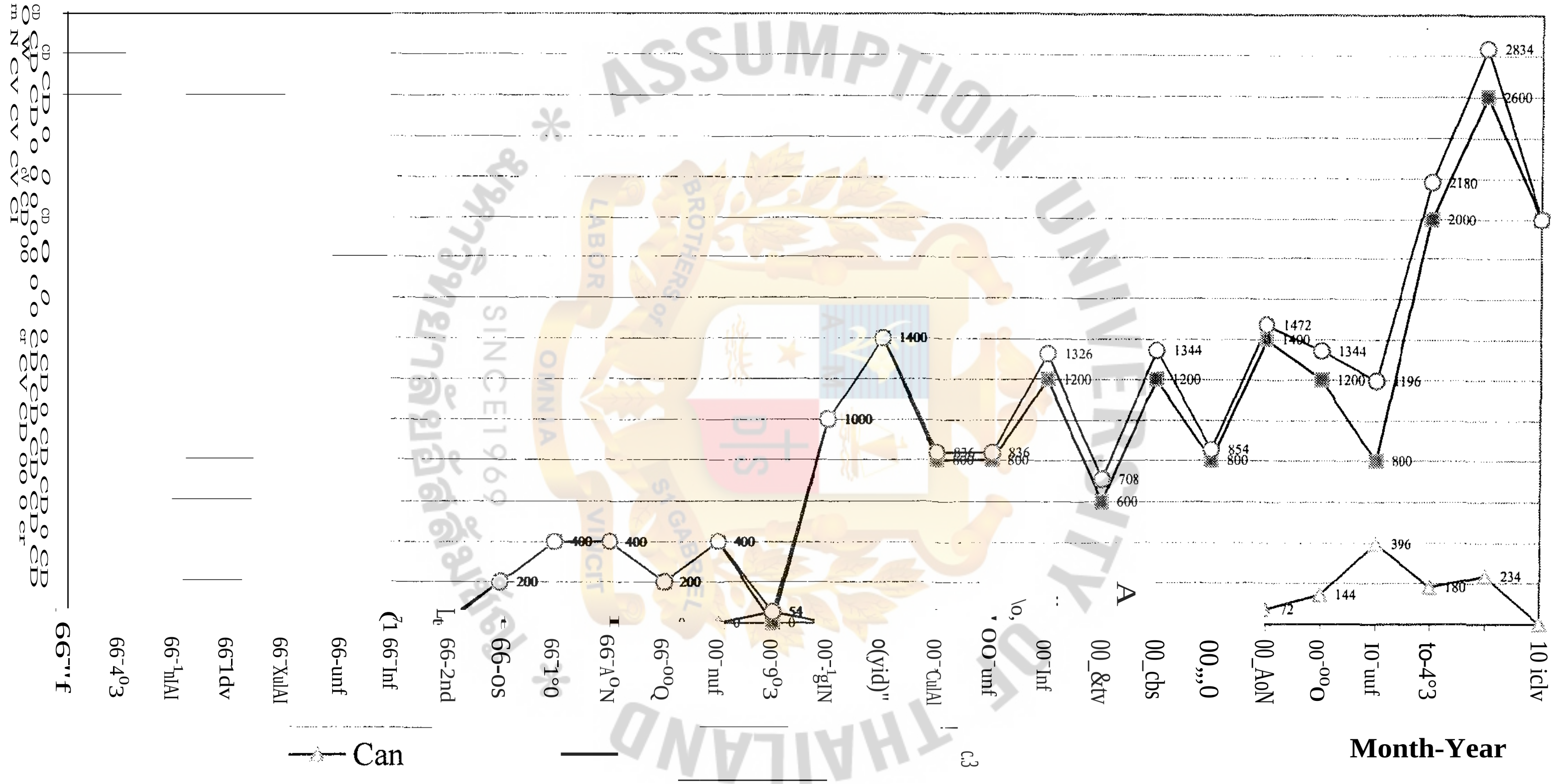
TREND OF USAGE DIE LUBRICANTS

Trend of Usage "AA" from January 1999 to April 2001

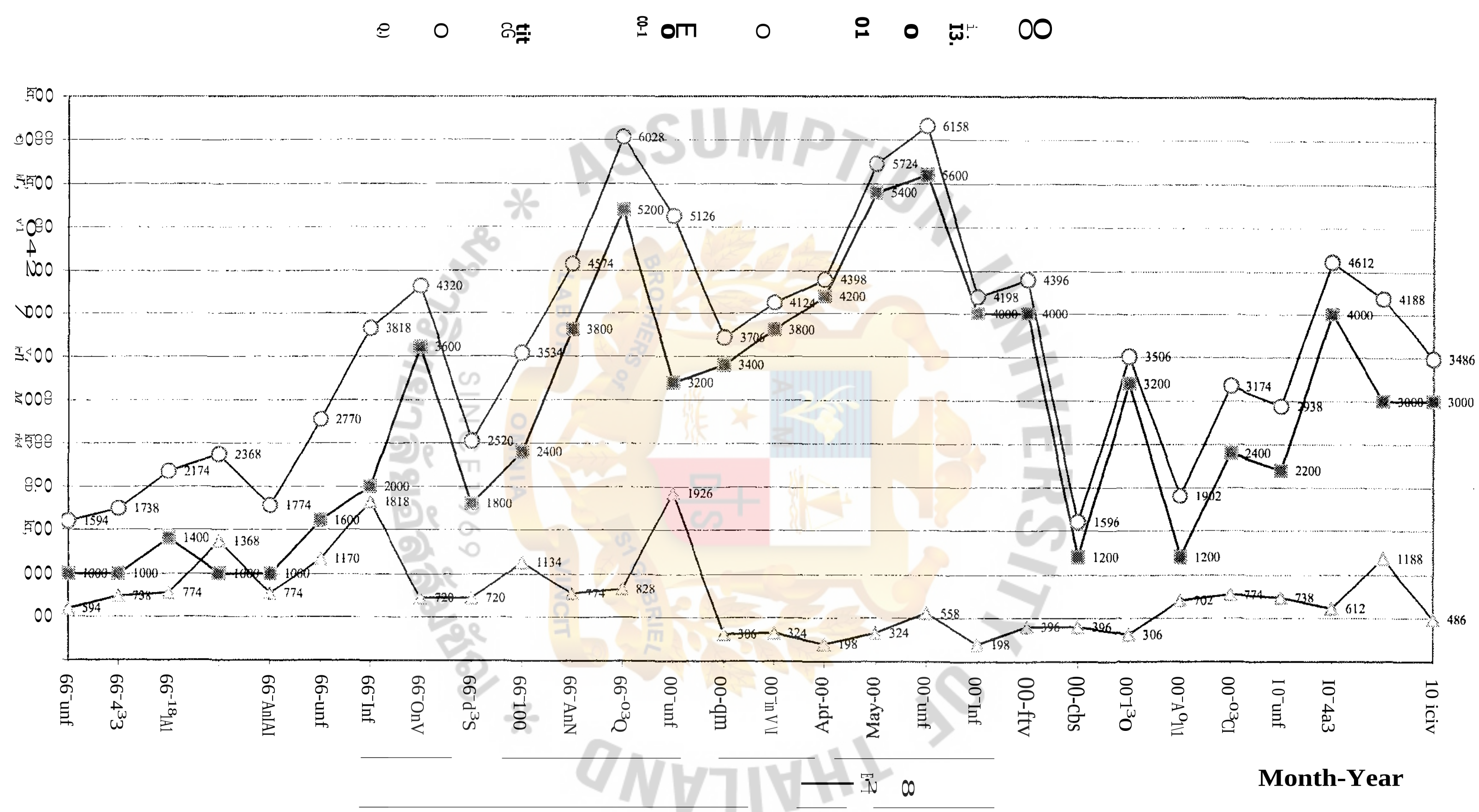


Trend of Usage "AA".

Trend of Usage "BB" from January 1999 to April 2001



Trend of Usage "BB".



Trend of Usage "CC".

Trend of Usage "DD" from January 1999 to April 2001

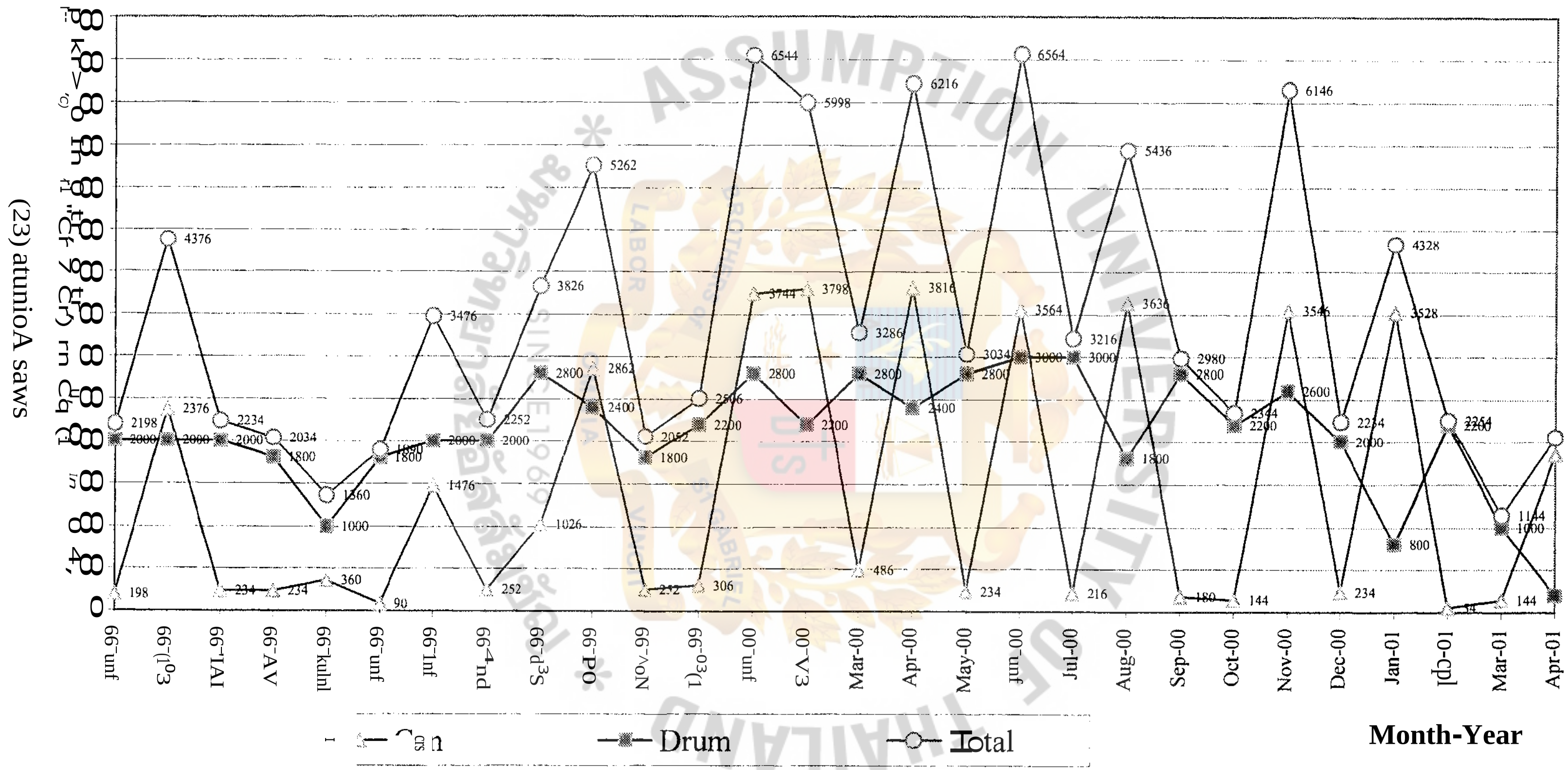
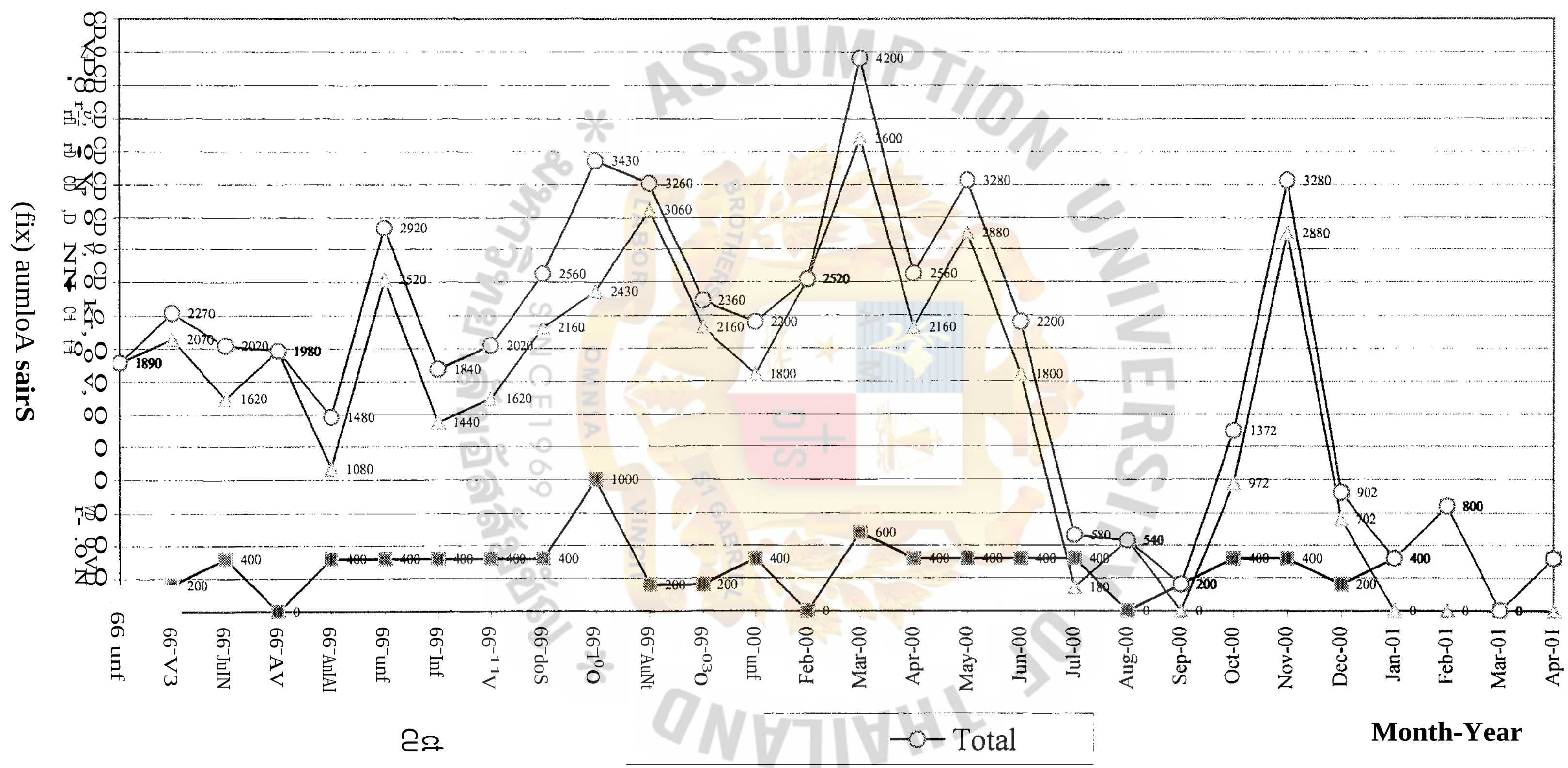


Figure B.4. Trend of Usage "DD".

Trend of Usage "EE" from January 1999 to April 2001



Trend of Usage "EE".

Trend of Usage "FF" from January 1999 to April 2001

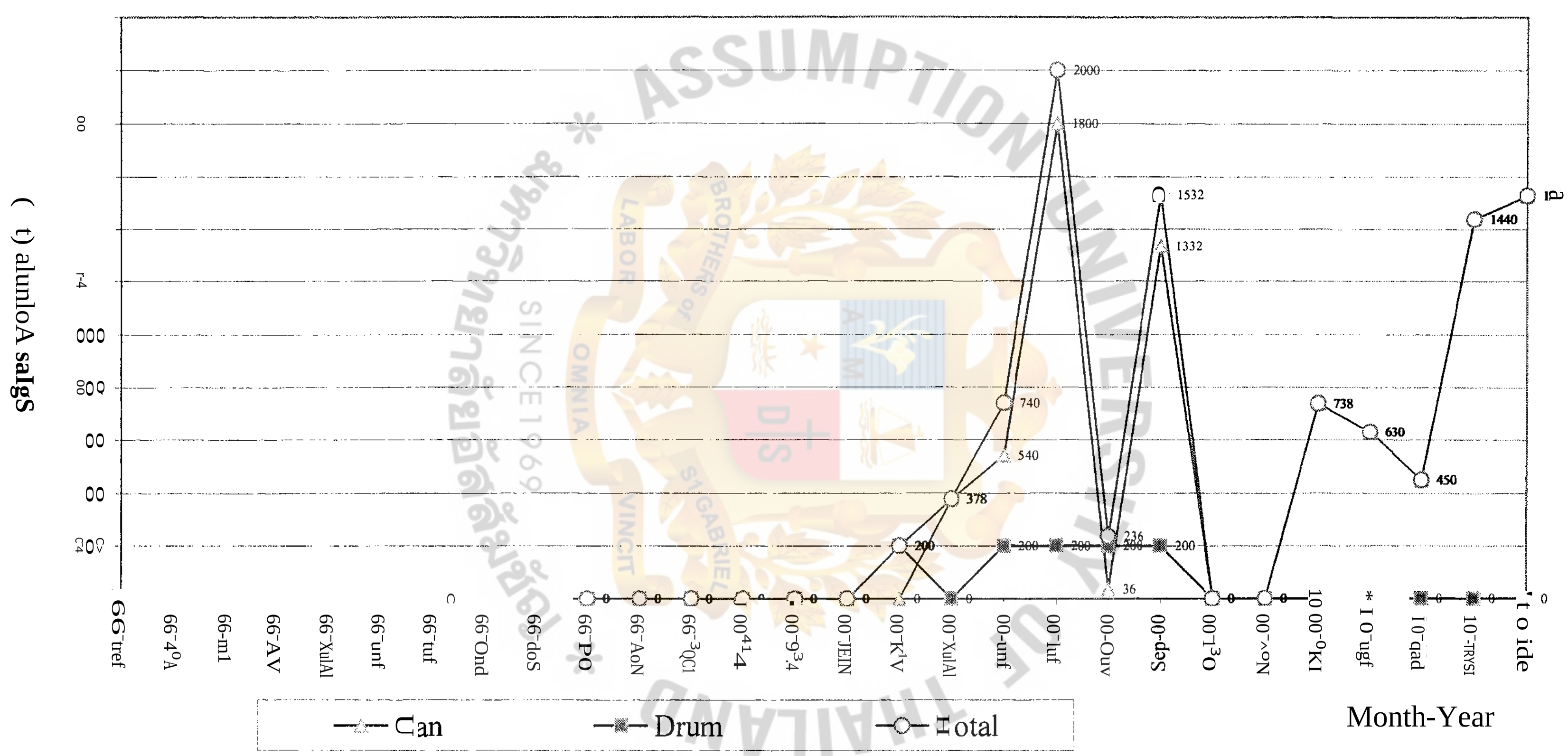


Figure B.6. Trend of Usage "FF".

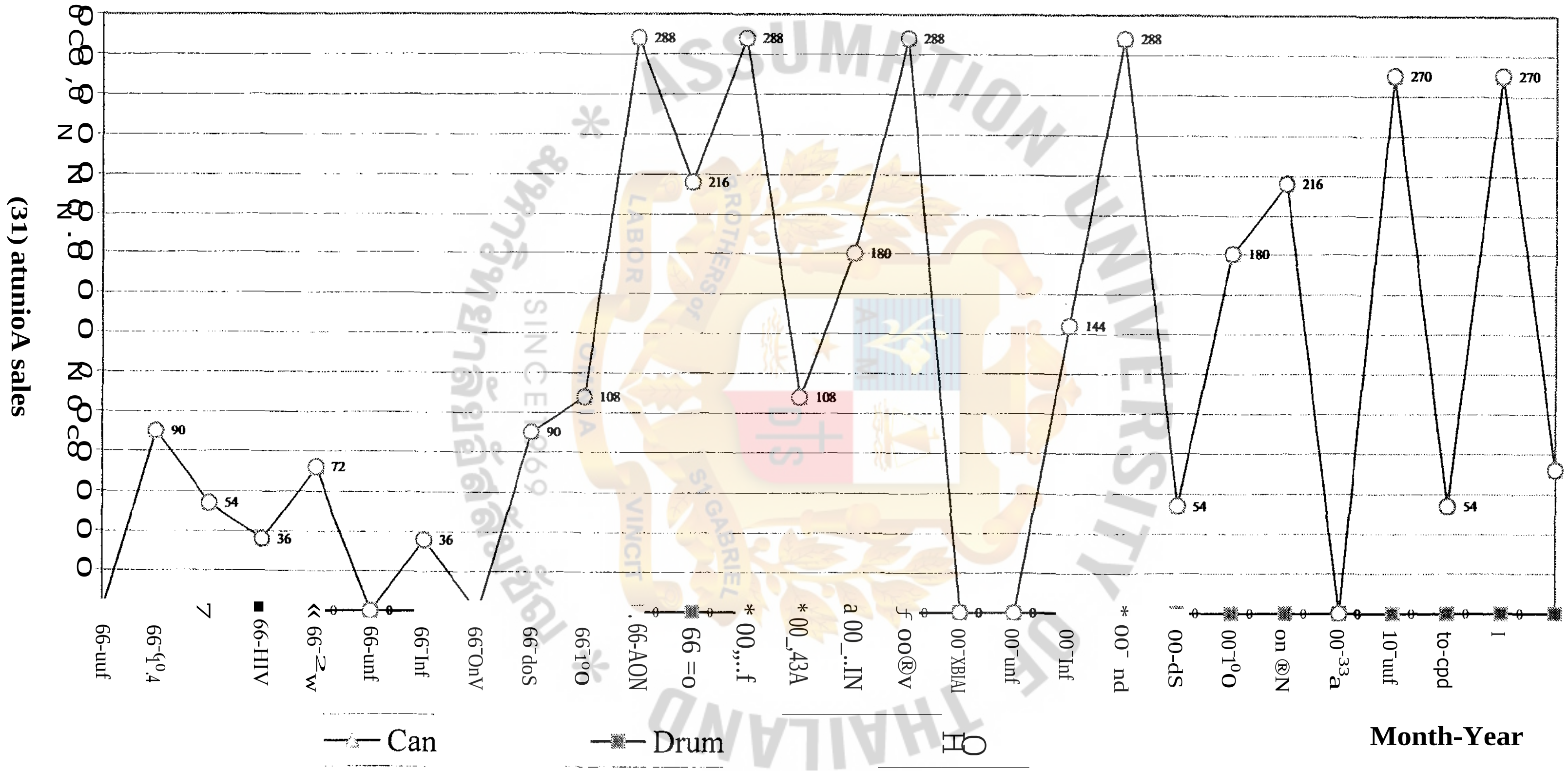
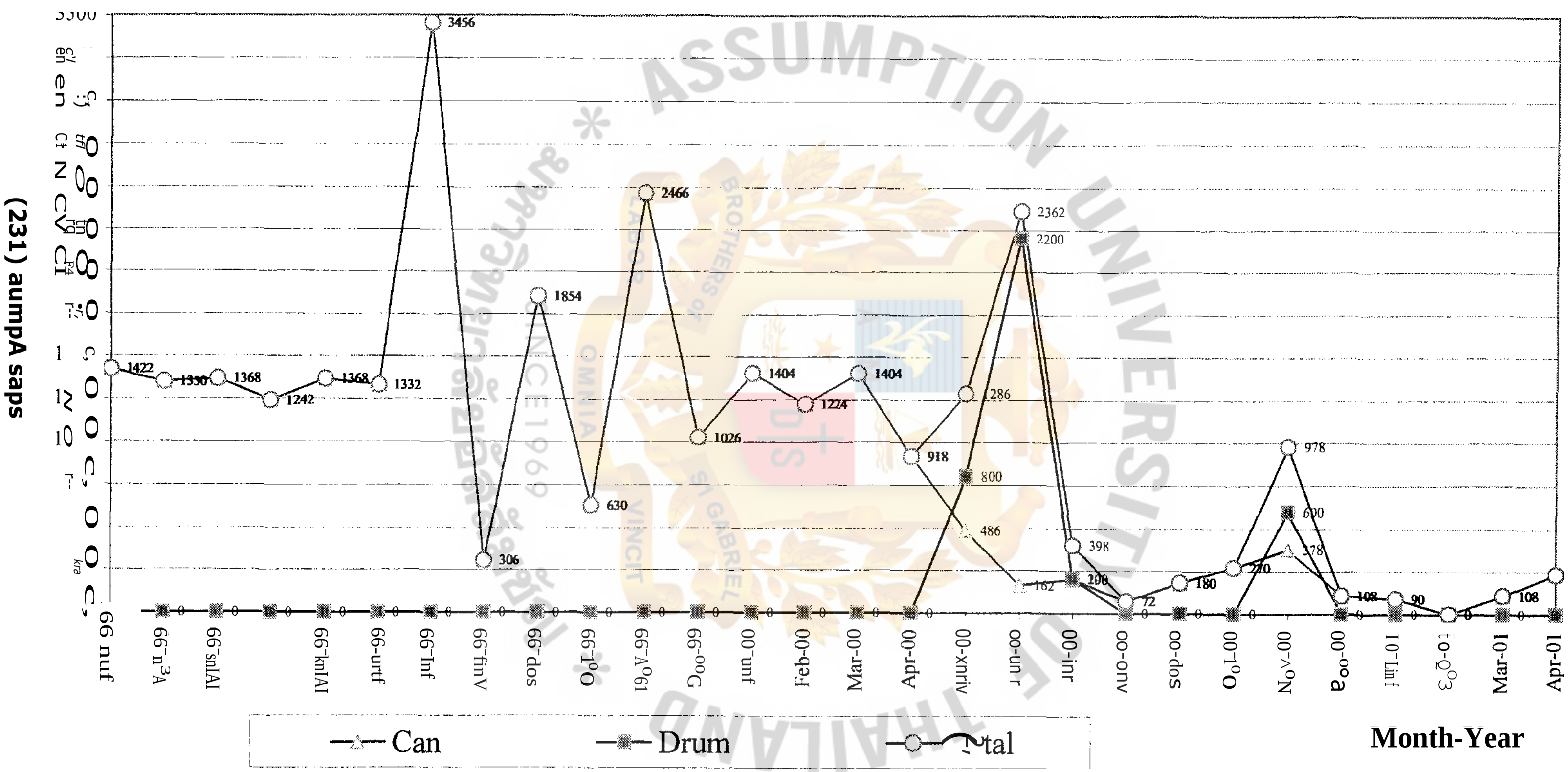


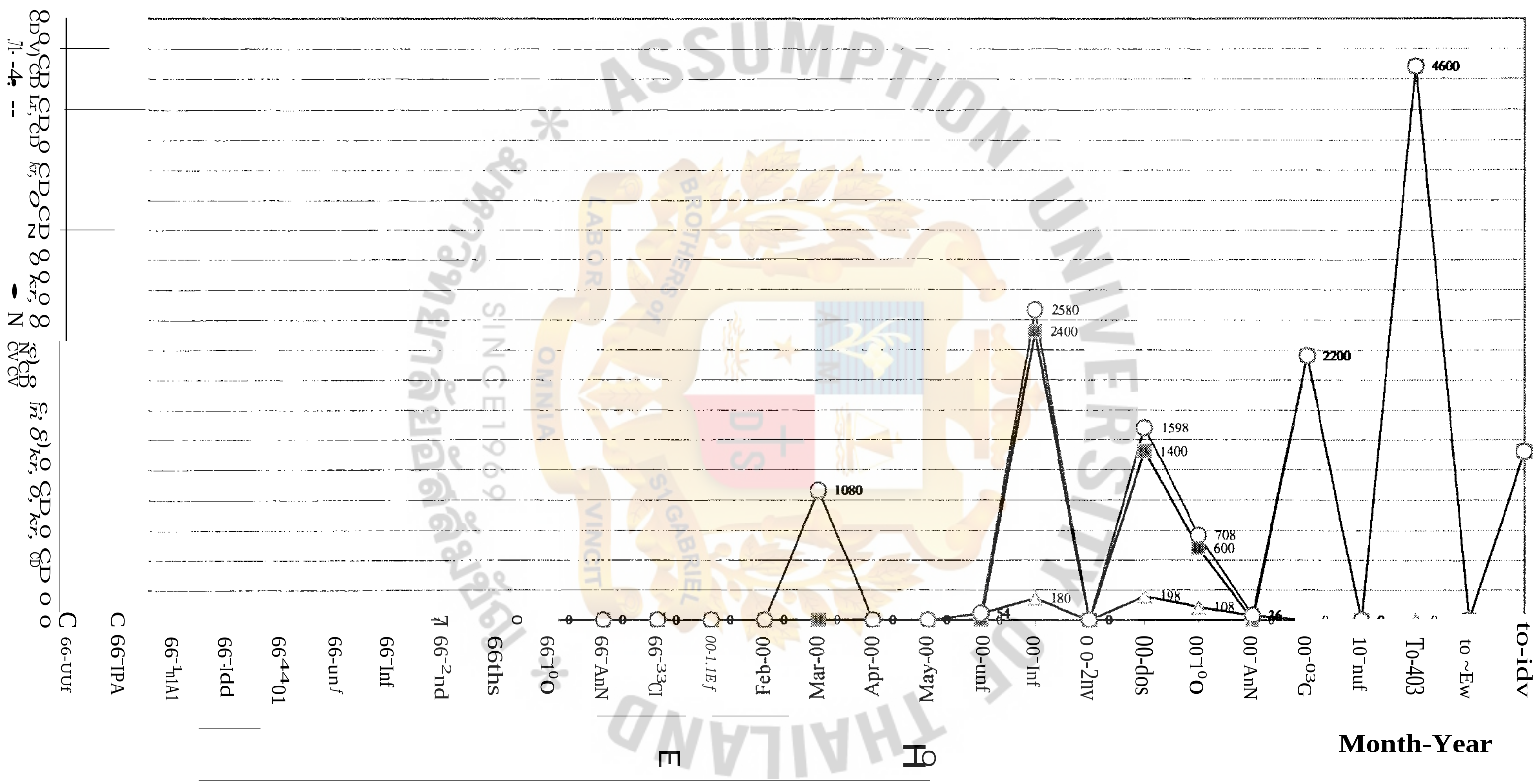
Figure B.7. Trend of Usage "GG".

Trend of Usage "HH" from January 1999 to April 2001



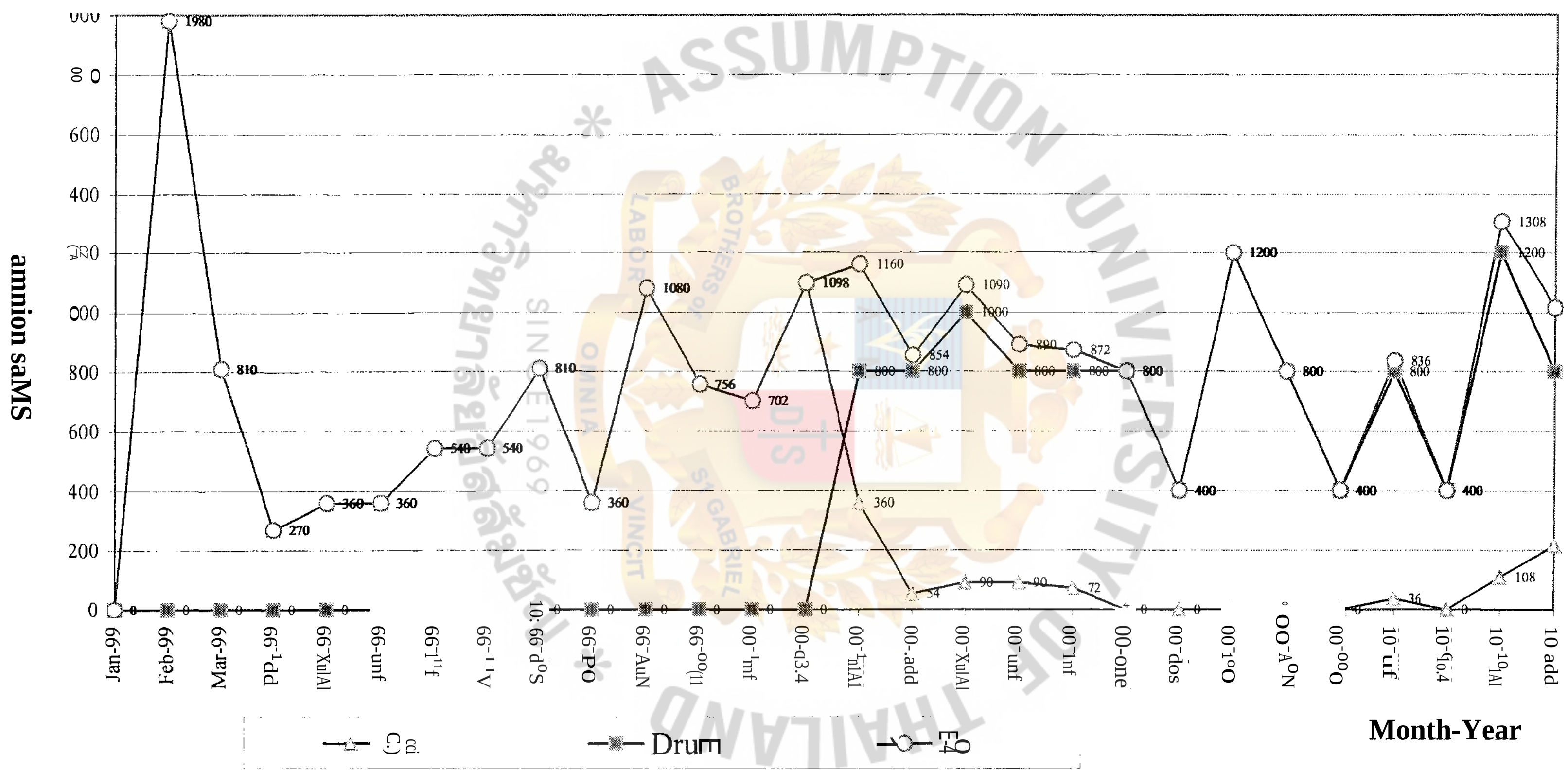
Trend of Usage "1-IH".

Trend of Usage "II" from January 1999 to April 2001



Trend of Usage "II".

Trend of Usage "JJ" from January 1999 to April 2001



Trend of Usage "JJ".

APPENDIX C

DETERMINING RAW MATERIALS CONSUMPTION PER MONTH FROM JANUARY 1999 TO APRIL 2001

Table C.1. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in January 1999.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	6968 kg / month	515.63	418.08	808.29	0.00	0.00	418.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.84	0.00	4773.08	6968.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	100.00
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	1594 kg / month	0.00	0.00	334.74	167.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.59	6.38	0.00	1083.92	1594.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	2198 kg / month	485.76	369.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	1329.79	2198.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	1890 kg / month	0.00	151.20	0.00	283.50	0.00	0.00	283.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.45	1162.35	1890.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ingredient		5.00							25.00							0.40	69.60	[illegible]
	Demand	1422 kg / month	71.10	0.00	0.00	0.00	0.00	0.00	0.00	355.50	0.00	0.00	0.00	0.00	0.00	0.00	5.69	989.71	[illegible]
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	100.00
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	TOTAL
1	Sum	kg / month	1072	939	1143	451	0	418	284	356	0	0	0	0	2	[illegible]	[illegible]	9339	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	[illegible]	x
3	[illegible]	kg / month	[illegible]	[illegible]	[illegible]	541	0	[illegible]	[illegible]	427	0	0	0	0	2	[illegible]	18	9339	x
4	Cost per unit	[illegible] / kg	73	250	78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.44	211.11	43.58	155.62	[illegible]	660	674.33	[illegible]	x
5	Estimated Cost	[illegible] / month	93950	281563	100129	156903	0	[illegible]	[illegible]	141145	0	0	0	0	130	43088	12250	7471	[illegible]

Table C.2. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in February 199[illegible]

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
[illegible]	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	8598 kg / month	636.25	515.88	997.37	0.00	0.00	515.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.99	0.00	5889.63	8598.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	100.00
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00
[illegible]	Ingredient				[illegible]	[illegible]									[illegible]	[illegible]		[illegible]	100.00
	Demand	1738 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1738.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	4376 kg / month	967.10	735.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.26	0.00	2647.48	4376.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2270 kg / month	0.00	181.60	0.00	340.50	0.00	0.00	340.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.35	1396.05	2270.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	90 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	1350 kg / month	67.50	0.00	0.00	0.00	0.00	0.00	0.00	337.50	0.00	0.00	0.00	0.00	0.00	0.00	5.40	939.60	1350.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	1980 kg / month	237.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	257.40	0.00	198.00	0.00	0.00	7.92	0.00	1279.08	1980.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	[illegible]	1452	1362	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	18	198	[illegible]	2	84	[illegible]	13380	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	[illegible] Demand	kg / month	2298	1742	1635	[illegible]	0	[illegible]	[illegible]	[illegible]	309	[illegible]	238	[illegible]	2	101	20	[illegible]	x
4	[illegible] unit	[illegible]	73	250	[illegible]	[illegible]	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	660	674,33	0.8	x
5	Estimated Cost	[illegible]	167732	435464	119342	182001	0	103178	153899	133998	43379	3192	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,444,855

[illegible] Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in March 1999.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
*	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	10050 kg / month	743.70	603.00	1165.80	0.00	0.00	603.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.25	0.00	6884.25	10050.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]				[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68,00	100.00
	Demand	2174 kg / month	0.00	0.00	456.54	228.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.17	8.70	0.00	1478.32	2174.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	[illegible]
	Demand	2234 kg / month	493.71	375.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.40	0.00	1351.57	[illegible]
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2020 kg / month	0.00	161.60	0.00	303.00	0.00	0.00	303.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.10	1242.30	2020.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	54 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	1368 kg / month	68.40	0.00	0.00	0.00	0.00	0.00	0.00	342.00	0.00	0.00	0.00	0.00	0.00	0.00	5.47	952.13	1368.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	810 kg / month	97.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	105.30	0.00	81.00	0.00	0.00	3.24	0.00	523.26	810.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	[illegible]	kg / month	140	[illegible]	1022	[illegible]	0	[illegible]	[illegible]	342	105	[illegible]	[illegible]	3	2	[illegible]	10	[illegible]	x
2	[illegible]	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	[illegible]	kg / month	[illegible]	1382	[illegible]	[illegible]	0	724	364	410	126	[illegible]	[illegible]	4	3	[illegible]	[illegible]	12460	x
4	[illegible]	[illegible] / kg	78	250	73	[illegible]	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	680	[illegible]	[illegible]	x
5	Estimated Cost	[illegible]	123235	345376	142117	184882	0	120602	136950	135785	17746	[illegible]	4236	[illegible]	177	[illegible]	12601	[illegible]	1,296,234

Table C.4. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in April 1999.

No.	Item		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	11268 kg / month	833.83	676.08	1307.09	0.00	0.00	676.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.34	0.00	7718.58	11268.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	100.00
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00
[illegible]	Ingredient	%			21.00	10.50									0.10	0.40		68.00	100.00
	Demand	2368 kg / month	0.00	0.00	497.28	248,64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.37	9.47	0.00	1610.24	2368.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	2034 kg / month	449.51	341.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.20	0.00	1230.57	2034.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	1980 kg / month	0.00	158.40	0.00	297.00	0.00	0.00	297.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.90	1217.70	1980.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	36 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	1242 kg / month	62.10	0.00	0.00	0.00	0.00	0.00	0.00	310.50	0.00	0.00	0.00	0.00	0.00	0.00	4.97	864.43	1242.00
[illegible]	Ingredient	%	[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	270 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	270.00

No.	Item	Unit	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	[illegible]	kg / month	[illegible]	[illegible]	[illegible]	546	[illegible]	[illegible]	297	[illegible]	35	[illegible]	[illegible]	2	2	[illegible]	15	[illegible]	x
2	[illegible]	%	20	20	[illegible]	20	[illegible]	[illegible]	[illegible]	20	[illegible]	20	20	20	20	20	[illegible]	[illegible]	x
3	[illegible]	kg / month	[illegible]	[illegible]	2165	[illegible]	0	811	356	373	[illegible]	[illegible]	32	[illegible]	3	[illegible]	18	[illegible]	x
4	[illegible]	[illegible]	73	[illegible]	73	290	234	166.67	376.65	330.86	140.44	211.11	43,58	155.62	[illegible]	660	674.33	[illegible]	x
[illegible]	Estimated Cost	[illegible] / month	120920	355126	158063	189883	0	135219	134238	123278	5915	[illegible]	1412	40	193	62758	12031	[illegible]	[illegible]

[illegible] C.5. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in May 1999.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	[illegible]
[illegible]	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	12738 kg / month	942.61	764.28	1477.61	0.00	0.00	764.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.69	0.00	8725.53	12738.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient				21.00	10.50									0,10	0.40		68,00	100.00
	Demand	1774 kg / month	0.00	0.00	372.54	186.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	7.10	0.00	1206.32	1774.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	[illegible]
	Demand	1360 kg / month	300.56	228.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.16	0.00	822.80	[illegible]
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61,50	[illegible]
	Demand	1480 kg / month	0.00	118.40	0.00	222.00	0.00	0.00	222.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.40	910,20	[illegible]
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	72 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	1368 kg / month	68.40	0.00	0.00	0.00	0.00	0.00	0.00	342.00	0.00	0.00	0.00	0.00	0.00	0.00	5.47	952.13	1368.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	360 kg / month	43.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.80	0.00	36.00	0.00	0.00	1.44	0.00	232.56	360.00

			A	B	C	D	[illegible]	[illegible]	[illegible]	H	I	J	K	[illegible]	[illegible]	N	O	Etc.	[illegible]
1	Sum	kg / month	1360	1126	1850	408	0	[illegible]	222	[illegible]	[illegible]	10	[illegible]	4	2	[illegible]	10	[illegible]	x
2	Buffer	%	20	[illegible]	[illegible]	20	[illegible]	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	[illegible]	[illegible]	20	[illegible]	x
3	[illegible]	kg / month	1632	[illegible]	[illegible]	490	0	917	266	410	[illegible]	12	43	0	[illegible]	[illegible]	10	12887	x
[illegible]	[illegible] unit	[illegible]	[illegible]	[illegible]	78	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	660	674.33	[illegible]	x
[illegible]	Estimated Cost	[illegible]	119120	337884	162073	142078	0	152859	100340	135785	7887	2554	1883	[illegible]	145	63894	[illegible]	[illegible]	1,248,032

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in June 1999.

No.	Item	Quantity	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
/	Ingredient		7.40	6.00	11.60			6.00								0.50		68,50	[illegible]
	Demand	8686 kg / month	642.76	521.16	1007.58	0.00	0.00	521.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.43	0.00	5949.91	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient				[illegible]	[illegible]									[illegible]	[illegible]		[illegible]	100.00
	Demand	2770 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2770.00
[illegible]	Ingredient		22.10	16.80												0.60		60,50	100.00
	Demand	1890 kg / month	417.69	317.52	0.00	0.00	0.00	0.00	0.00	0.00	0,00	0.00	0.00	0.00	0.00	11.34	0.00	1143.45	1890.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2920 kg / month	0.00	233.60	0.00	438.00	0.00	0.00	438.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.60	1795.80	2920.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								4		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	[illegible]
	Demand	1332 kg month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	360 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	360.00

No.	Item	Unit	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	1170	1072	160	[illegible]29	0	[illegible]21	438	[illegible]	[illegible]	0	36	0	[illegible]	67	20	11332	x
2	Buffer	%	20	20	20	20	20	20	[illegible]	20	20	[illegible]	20	20	20	20	20	0	x
3	[illegible]	kg / month	1404	1287	1[illegible]07	[illegible]075	0	[illegible]25	526	400	5[illegible]	0	43	0	3	81	[illegible]4	11932	x
4	[illegible] unit	[illegible]	78	250	73	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	0	660	674.33	0 8	x
5	Estimated Cost	[illegible] month	102514	321684	139221	253640	0	104234	197967	132212	[illegible]887	0	10[illegible]	0	226	5[illegible]294	1612[illegible]	00 6	1,[illegible]

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in July 1999.

			A	B	C	D	E	F	G	H		J	K	L	M	N	O	Etc.	Total
1	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	7638 kg / month	565.21	458.28	886.01	0.00	0.00	458.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.19	0.00	5232.03	7638.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	3818 kg / month	0.00	0.00	801.78	400.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.82	15.27	0.00	2596.241	3818.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	3476 kg / month	768.20	583.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.86	0.00	2102.98	3476.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	1840 kg / month	0.00	147.20	0.00	276.00	0.00	0.00	276.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.20	1131,60	1840.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	36 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0.40	69.60	[illegible]
	Demand	3456 kg / month	172.80	0.00	0.00	0.00	0.00	0.00	0.00	864.00	0.00	0.00	0.00	0.00	0.00	0.00	13.82	2405.38	[illegible]
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	540 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	540.00

			A	B	C	D	E	F	G	H		J	K	L	M	N	O	Etc.	Total
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]				[illegible]	[illegible]	[illegible]	x
			[illegible]	[illegible]			[illegible]			[illegible]		[illegible]		[illegible]	[illegible]	[illegible]			
	[illegible]	[illegible]		[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]									[illegible]	660	674,33	[illegible]	x
[illegible]	Estimated Cost	[illegible]	137841	359102	147850	235558	0	91658	124746	343036	[illegible]			[illegible]	312	60685	[illegible]		[illegible]

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in August 1999.

No.			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	10356 kg / month	766.34	621.36	1201.30	0.00	0.00	621.36	0.00	0.00	0.00	0.0D	0.00	0.00	0.00	51.78	0.00	7093.86	10356.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	[illegible]
	Demand	18 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	4320 kg ! month	0.00	0.00	907.20	453.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.32	17.28	0.00	2937.60	4320.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	[illegible]
	Demand	2252 kg / month	497.69	378.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.51	0.00	1362.46	[illegible]
[illegible]	Ingredient	9".		8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2020 kg / month	0.00	161.60	0.00	303.00	0.00	0.00	303.00	0.00	0,00	0.00	0.00	0.00	0.00	0.00	10.10	1242.30	2020.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	100.00
	Demand	306 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	306.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	540 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	540.00

No.		Unit	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	[illegible]	kg / mo [illegible]	188	1102	[illegible]	757	0	021	303	77	70	0	56	0	4	05	11	13211	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	Demand	kg / month	1616	1395	2530	908	0	[illegible]	[illegible]	92	[illegible]	0	67	0	5	[illegible]	14	13211	x
4	Cost per unit	[illegible]	73	250	[illegible]	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.02	88	660	674.33	[illegible]	x
5	Estimated Cost	฿ / mo [illegible]	117959	348713	184704	263297	0	124274	136950	30373	11831	0	2918	0	358	[illegible]	9108	[illegible]	1,308,268

Table C.9. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in September 1999.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	[illegible]
/	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.01
	Demand	14370 kg / month	1063.38	862.20	1666.92	0.00	0.00	862.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	71.85	0.00	9843.45	14370.00
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	100.00
	Demand	200 kg / month	27.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.80	0.00	140.20	200.00
O	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	2520 kg month	0.00	0.00	529.20	264.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	10.08	0.00	1713.60	2520.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	3826 kg / month	845.55	642.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.96	0.00	2314.73	3826.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2560 kg / month	0.00	204.80	0.00	384.00	0.00	0.00	384.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.80	1574,40	2560.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	90 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0.40	69.60	[illegible]
	Demand	1854 kg / month	92.70	0.00	0.00	0.00	0.00	0.00	0.00	463.50	0.00	0.00	0.00	0.00	0.00	0.00	7.42	1290.38	[illegible]
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ingredient	%	[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	100.0
	Demand	810 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	810.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	2132	1741	2196	649	0	862	384	464	105	13	101	5	3	109	20	17446	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	Demand D	kg / month	2559	2089	2635	778	0	1035	461	556	126	15	121	6	3	131	24	17446	x
4	Cost per unit	฿ / kg	73	250	73	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	660	674.33	0.8	x
5	Estimated Cost	฿ / month	186774	522200	192380	225713	0	172443	173560	184024	17746	3192	5282	1008	206	86555	16359	13957	1,801,400

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in October 1999.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	14482 kg / month	1071.67	868.92	1679.91	0.00	0.00	868.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.41	0.00	9920.17	14482.00
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	100.00
	Demand	400 kg / month	54.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	0.00	0.00	1.60	0.00	280.40	400.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	3534 kg / month	0.00	0.00	742.14	371.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.53	14.14	0.00	2403.12	3534.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	5262 kg / month	1162.90	884.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.57	0.00	3183.51	5262.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	3430 kg / month	0.00	274.40	0.00	514.50	0.00	0.00	514.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.15	2109.45	3430.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	100,00
	Demand	108 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	108.00
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	630 kg / month	31.50	0.00	0.00	0.00	0.00	0.00	0.00	157.50	0.00	0.00	0.00	0.00	0.00	0.00	2.52	438.48	630.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	360 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	360.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	[illegible]	2371	2074	2422	[illegible]	0	[illegible]	[illegible]	158	47	15	8	8	4	122	20	18623	x
2	[illegible]	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	Demand	[illegible]	2845	2489	2906	[illegible]	0	1043	817	[illegible]	50	18	91	8	4	146	[illegible]	[illegible]	x
4	[illegible] unit	[illegible]	78	20	78	280	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	88	660	674.33	[illegible]	x
5	Estimated Cost	[illegible]	207685	622205	212172	308178	0	173787	232544	62533	[illegible]	[illegible]	3974	1210	288	96299	15917	[illegible]	[illegible]

C.11. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in November 1999.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	[illegible]
[illegible]	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	11800 kg / month	873.20	708.00	1368.80	0.00	0.00	708.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.00	0.00	8083.00	11800.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	100.00
	Demand	400 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	400.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	4574 kg / month	0.00	0.00	960.54	480.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.57	18.30	0.00	3110.32	4574.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	2052 kg / month	453.49	344.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.31	0.00	1241.46	2052.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	3260 kg / month	0.00	260.80	0.00	489.00	0.00	0.00	489.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.30	2004.90	3260.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	100.00
	Demand	288 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	288.00
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	2466 kg / month	123.30	0.00	0.00	0.00	0.00	0.00	0.00	616.50	0.00	0.00	0.00	0.00	0.00	0.00	9.86	1716.34	2466.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	1080 kg / month	129,60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	140.40	D.00	108.00	0.00	0.00	4.32	0.00	697.68	1080.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	[illegible]
1	[illegible]	kg / month	1654	1398	[illegible]	969	0	[illegible]	489	[illegible]	140	40	148	17	[illegible]	[illegible]	[illegible]	[illegible]	x
2	Buffer	%	20	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]	20	20	20	[illegible]	0	x
3	Demand	kg / month	[illegible]	1678	[illegible]	[illegible]	0	850	[illegible]	[illegible]	[illegible]	48	[illegible]	[illegible]	5	110	31	17283	x
4	Cost per unit	[illegible]	[illegible]	250	78	[illegible]	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	660	674.33	0.8	x
5	Estimated Cost	[illegible] / month	144869	419405	204050	337306	0	[illegible]	[illegible]	[illegible]	[illegible]	10214	[illegible]	3227	373	76571	21172	13826	1,869,805

[illegible]12. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in December 1999.

No.			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	[illegible]
[illegible]	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	[illegible]
	Demand	8988 kg / month	665.11	539.28	1042.61	0.00	0.00	539.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.94	0.00	6156.78	[illegible]
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	100.00
	Demand	200 kg / month	27,00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.80	0.00	140.20	200.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	6028 kg / month	0.00	0.00	1265.88	632.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.03	24.11	0.00	4099.04	6028.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	2506 kg / month	553.83	421.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.04	0.00	1516.13	2506.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2360 kg / month	0.00	188.80	0.00	354.00	0.00	0.00	354.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.80	1451.40	2360.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	216 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0,40	69.60	100.00
	Demand	1026 kg / month	51.30	0.00	0.00	0.00	0.00	0.00	0.00	256.50	0.00	0.00	0.00	0.00	0.00	0.00	4.10	714.10	1026.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	756 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	756.00

			A	[illegible]	C	O	[illegible]	[illegible]	[illegible]	H	I	J	K	L	[illegible]	N	O	Etc.	To'al
1	[illegible]	kg / month	1403	12[illegible]	[illegible]	9[illegible]	[illegible]	[illegible]	[illegible]	25[illegible]	98	[illegible]	[illegible]	1[illegible]	0	0	18	14677	x
2	[illegible]fer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	[illegible] D	kg / month	18[illegible]	1448	[illegible]	1184	0	[illegible]	[illegible]	[illegible]	118	[illegible]	115	18	[illegible]	107	1[illegible]	14877	x
4	[illegible] unit	[illegible]	78	250	73	290	234	160 [illegible]	[illegible]	[illegible]	0.44	211.11	43.58	155.62	68	[illegible]	[illegible]	08	x
5	Estimated Cost	[illegible] month	122910	361934	202224	343455	0	107858	160001	101839	1[illegible]563	7661	4999	2420	492	70311	[illegible]	11742	1,527,278

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
[illegible]	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	[illegible]
	Demand	12652 kg / month	936.25	759.12	1467.63	0.00	0.00	759.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.26	0.00	8666.62	[illegible]
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	100.00
	Demand	400 kg / month	54.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	0.00	0.00	1.60	0.00	280.40	400.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	5126 kg / month	0.00	0.00	1076.46	538.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13	20.50	0.00	3485.68	5126.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	6544 kg / month	1446.22	1099.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.26	0.00	3959.12	6544,00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2200 kg / month	0.00	176.00	0.00	330.00	0.00	0.00	330.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	1353.00	2200.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	288 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	1404 kg / month	70.20	0.00	0.00	0.00	0.00	0.00	0.00	351.00	0.00	0.00	0.00	0.00	0.00	0.00	5.62	977.18	1404.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	702 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	[illegible]	kg / month	2611	2119	[illegible]	[illegible]	0	759	330	351	[illegible]	40	110	[illegible]	[illegible]	129	[illegible]	[illegible]	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	[illegible]	kg / month	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	421	110	48	[illegible]	21	6	154	20	[illegible]	x
4	Cost per unit	[illegible]	78	250	78	[illegible]	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	660	674.33	[illegible]	x
5	Estimated Cost	฿ / month	228730	635698	222862	302144	0	151827	149153	139358	[illegible]	[illegible]	[illegible]	3227	418	101842	13446	[illegible]	1,995,522

Table C.14. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in February 2000.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
[illegible]	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	13206 kg / month	977.24	792.36	1531.90	0.00	0.00	792.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.03	0.00	9046.11	13206.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	[illegible]
	Demand	54 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	3706 kg / month	0.00	0.00	778.26	389.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.71	14.82	0.00	2520.08	3706.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	5998 kg / month	1325.56	1007.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.99	0.00	3628.79	5998.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2520 kg / month	0.00	201.60	0.00	378.00	0.00	0.00	378.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.60	1549,80	2520.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg i month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	108 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	100.00
	Demand	1224 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1224.00
	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	1098 kg / month	131,76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	142.74	0.00	109.80	0.00	0.00	4.39	0.00	709.31	1098.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	2511	[illegible]	[illegible]	[illegible]	0	792	078	306	143	[illegible]	115	8	4	122	[illegible]	18400	x
2	Buffer	%	[illegible]	20	[illegible]	[illegible]	20	20	[illegible]	20	20	20	20	20	20	[illegible]	20	0	x
3	Demand	kg / month	[illegible]	2433	[illegible]	921	[illegible]	[illegible]	454	367	[illegible]	[illegible]	138	[illegible]	4	146	21	[illegible]	x
4	Cost per unit	[illegible] / kg	[illegible]	250	78	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	[illegible]	[illegible]	[illegible]	x
5	Estimated Cost	[illegible] / month	219930	608263	202370	266961	0	158475	170848	121492	24056	[illegible]	[illegible]	1210	302	96531	14158	14720	[illegible]

Table C.15. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in March 2000.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	T
*	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	15056 kg / month	1114.14	903.36	1746.50	0.00	0.00	903.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.28	0.00	10313.36	15056.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	100.00
	Demand	1000 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1000.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	[illegible]
	Demand	4124 kg / month	0.00	0.00	866.04	433.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.12	16.50	0.00	2804.32	[illegible]
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	3286 kg / month	726.21	552.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.72	0.00	1988.03	3286.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	4200 kg / month	0.00	336.00	0.00	630.00	0.00	0.00	630.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.00	2583.00	4200.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	100.00
	Demand	180 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	180.00
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	100.00
	Demand	1404 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1404.00
[illegible]	Ingredient		5.00					15.00								0.40		79.60	100.00
	Demand	1080 kg / month	54.00	0.00	0.00	0.00	0.00	162.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,32	0.00	859.68	1080.00
	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	1160 kg / month	139.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	150.80	0.00	116.00	0.00	0.00	4.64	0.00	749.36	1160.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	2251	1008	[illegible]	1008	0	1085	[illegible]	351	101	[illegible]	218	11	[illegible]	125	27	[illegible]	x
2	Buffer	%	20	[illegible]	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	[illegible]	kg / month	2702	2287	3135	1270	0	1278	[illegible]	[illegible]	101	30	259	18	5	100	82	21009	x
4	[illegible] per unit	[illegible]	[illegible]	250	[illegible]	[illegible]	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	660	674.33	[illegible]	x
5	Estimated Cost	[illegible]	197218	566762	228858	369931	0	213076	284747	139358	25414	[illegible]	11296	2017	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in April 2000.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	13976 kg / month	1034.22	838.56	1621.22	0.00	0.00	838.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.88	0.00	9573.56	13976.00
	Ingredient	%	13.50	6.00									10.00			0.40		70,10	100.00
	Demand	1400 kg / month	189.00	84.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	140.00	0.00	0.00	5.60	0.00	981.40	1400.00
	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	4398 kg / month	0.00	0.00	923.58	461.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40	17.59	0.00	2990.64	4398.00
	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	6216 kg month	1373.74	1044.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.30	0.00	3760.68	6216.00
	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2560 kg ! month	0.00	204.80	0.00	384.00	0.00	0.00	384.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.80	1574.40	2560.00
	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	200 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200.00
	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	288 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	918 kg / month	45.90	0.00	0.00	0.00	0.00	0.00	0.00	229.50	0.00	0.00	0.00	0.00	0.00	0.00	3.67	638.93	918.00
	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ingredient		12.00								13.00		10.00			0.40		64.60	[illegible]
	Demand	854 kg / month	102.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	111.02	0.00	85.40	0.00	0.00	3.42	0.00	551.68	[illegible]

			A	B	C	[illegible]	[illegible]	F	[illegible]	H	I	J	K	L	M	N	O	Etc.	Total
1	[illegible]	[illegible] month	[illegible]	2282	2545	848	32	539	884	[illegible]	118	40	[illegible]	17	4	136	16	20380	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	[illegible]	x
3	Demand	kg / month	[illegible]	[illegible]	3054	1015	38	1008	[illegible]	275	139	[illegible]	288	21	[illegible]	188	20	[illegible]	x
4	[illegible] per unit	[illegible] / kg	78	250	[illegible]	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	660	674.33	[illegible]	x
5	Estimated Cost	[illegible] month	242258	669638	222924	294335	8986	167715	173560	91119	19586	10214	11913	3227	359	107503	[illegible]	[illegible]	[illegible]

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in May 2000.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	15098 kg / month	1117.25	905.88	1751.37	0.00	0.00	905.8B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.49	0.00	10342.13	15 098.00
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	100.00
	Demand	836 kg / month	112.86	50.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.60	0.00	0.00	3.34	0.00	586.04	836.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	5724 kg / month	0.00	0.00	1202.04	601.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.72	22.90	0.00	3892.32	5724.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	3034 kg / month	670.51	509.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.20	0.00	1835.57	3034.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	3280 kg / month	0.00	262.40	0.00	492.00	0.00	0.00	492.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.40	2017.20	3280.00
[illegible]	Ingredient						16.00				2.60		1.20			0.40		79.80	100.00
	Demand	378 kg / month	0.00	0.00	0.00	0.00	60.48	0.00	0.00	0.00	9.83	0.00	4.54	0.00	0.00	1.51	0.00	301.64	378.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100.00
	Demand	1286 kg / month	64.30	0.00	0.00	0.00	0.00	0.03	0.00	321.50	0.00	0.00	0.00	0.00	0.00	0.00	5.14	895.06	1286.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	1090 kg / month	130.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	141.70	0.00	109.00	0.00	0.00	4.36	0.00	704.14	1090.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	[illegible]	kg / month	2096	1728	[illegible]	1883	60	906	492	322	102	0	197	0	0	126	[illegible]	[illegible]	×
2	Buffer	%	20	[illegible]	20	20	20	20	20	20	20	20	20	28	20	20	20	0	×
3	Demand D	kg / month	[illegible]	2074	3544	1312	[illegible]	108	[illegible]	386	182	0	237	0	[illegible]	101	26	20574	×
4	Cost / unit	[illegible]	73	[illegible]	[illegible]	[illegible]	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	660	674.33	[illegible]	×
5	Estimated Cost	[illegible] / month	183586	518446	258719	380371	16983	181180	222374	127646	25537	0	18809	0	467	99638	17433	16459	2,059,147

Table C.18. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in June 2000.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
/	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	14622 kg / month	1082.03	877,32	1696.15	0.00	0.00	877.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73.11	0.00	10016,07	14622.00
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	[illegible]
	Demand	836 kg / month	112.86	50.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.60	0.00	0.00	3.34	0.00	586.04	[illegible]
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	6158 kg / month	0.00	0.00	1293.18	646.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.16	24.63	0.00	4187.44	6158.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	6564 kg / month	1450.64	1102.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.38	0.00	3971.22	6564.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	2200 kg / month	0.00	176.00	0.00	330.00	0.00	0.00	330.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	1353.00	2200,00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	740 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	740.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	100.00
	Demand	2362 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2362.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	100.00
	Demand	54 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54.00
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	890 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	2873	2206	2989	977	118	885	330	591	135	0	181	0	6	147	20	22966	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	Demand D	kg / month	3448	2647	3587	1172	142	1063	396	709	162	0	218	0	7	177	25	22966	x
4	Cost per unit	฿ / kg	73	250	73	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	660	674.33	0.8	x
5	Estimated Cost	฿ / month	251686	661870	261865	339853	33247	177088	149153	234447	22741	0	9491	0	502	116587	16546	18373	2,293,451

Table [illegible]. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in July 2000.

No.			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	11566 kg / month	855.88	693.96	1341.66	0.00	0.00	693.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.83	0.00	7922.71	11566.00
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	100.00
	Demand	1326 kg / month	179.01	79.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	132.60	0.00	0.00	5.30	0.00	929.53	1326.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	4198 kg / month	0.00	0.00	881.58	440.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.20	16.79	0.00	2854.64	4198.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	3216 kg / month	710.74	540.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.30	0.00	1945.68	3216.00
[illegible]	Ingredient			8.00		15.00			15.00							0.50		61.50	100.00
	Demand	580 kg / month	0.00	46.40	0.00	87.00	0.00	0.00	87.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.90	356.70	580.00
[illegible]	Ingredient						16.00				2.60		1.20			0.40		79.80	100.00
	Demand	2000 kg / month	0.00	0.00	0.00	0.00	320.00	0.00	0.00	0.00	52.00	0.00	24.00	0.00	0.00	8.00	0.00	1596.00	2000.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	144 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		5.00							25.00						0.40		69.60	100.00
	Demand	398 kg / month	19.90	0.00	0.00	0.00	0.00	0.00	0.00	99.50	0.00	0.00	0.00	0.00	0.00	0.00	1.59	277.01	398.00
[illegible]	Ingredient		5.00					15.00								0.40		79.60	100.00
	Demand	2580 kg / month	129.00	0.00	0.00	0.00	0.00	387.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.32	0.00	2053,68	2580.00
[illegible]	Ingredient		12.00								13.00		10.00			0.40		64,60	100.00
	Demand	872 kg / month	104.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.36	0.00	87.20	0.00	0.00	3.49	0.00	563.31	872.00

			A	[illegible]	[illegible]	D	E	F	G	H	I	J	K	L	[illegible]	N	O	Etc.	Total
1	Sum	kg / month	[illegible]	[illegible]	2223	[illegible]	[illegible]	1081	87	100	185	20	[illegible]	[illegible]	4	122	4	[illegible]	x
2	Safer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	[illegible]	kg / month	2411	[illegible]	2668	633	[illegible]	1297	[illegible]	[illegible]	198	24	[illegible]	[illegible]	5	146	5	18574	x
4	Cost per unit	[illegible]	73	250	78	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	660	674.33	[illegible]	x
5	Estimated Cost	฿ / month	[illegible]	[illegible]	[illegible]	83671	89856	216196	39322	39505	27868	510	12750	1613	343	96312	[illegible]	[illegible]	[illegible]

Table C.20. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in August 2000.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
*	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	[illegible]
	Demand	13224 kg / month	978.58	793.44	1533.98	0.00	0.00	793.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.12	0.00	9058,44	[illegible]
[illegible]	Ingredient		[illegible]	0.00									0.00			0.40		[illegible]	100.00
	Demand	708 kg / month	[illegible]	[illegible]	0.00	0.00	0.00	0.00	[illegible]	0.00	0.00	0.00	[illegible]	[illegible]	0.00	[illegible]	0.00	[illegible]	708.00
[illegible]	Ingredient				21.00	10,50									0.10	0.40		68.00	100.00
	Demand	4396 kg / month	0.00	0.00	923.16	461.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40	17.58	0.00	2989.28	4396.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	5436 kg / month	1201,36	913.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.62	0.00	3288.78	5436.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	540 kg / month	0.00	43.20	0.00	81.00	0.00	0.00	81.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70	332.10	540.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			0.40		[illegible]	100.00
	Demand	236 kg / month	0.00	[illegible]	0.00	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]	0.00	[illegible]	0.00	[illegible]	[illegible]	0.00	[illegible]	236.00
[illegible]	Ingredient	%	7.00	21.00								14.00		6.00		0.40		51.60	100.00
	Demand	288 kg / month	20.16	60.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.32	0.00	17.28	0.00	1.15	0.00	148.61	288.00
[illegible]	Ingredient		[illegible]							[illegible]							0.40	[illegible]	[illegible]
	Demand	72 kg / month	0.00	[illegible]	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]	0.00	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]					[illegible]								0.40		[illegible]	[illegible]
	Demand	0 kg / month	0.00	[illegible]	0.00	0.00	[illegible]	0.00	0.00	0.00	[illegible]	0.00	[illegible]	0.00	0.00	0.00	[illegible]	[illegible]	0.00
[illegible]	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	800 kg / month	96.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	104.00	0.00	80.00	0.00	0.00	3.20	0.00	516.80	800.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	[illegible]	[illegible]	2395	185	2457	543	38	793	81	18	110	40	154	17	4	124	8	17089	x
2	[illegible] Her	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	[illegible]	[illegible]	2884	2223	2949	851	45	952	97	22	132	40	104	21	0	149	4	17088	x
4	[illegible] unit	[illegible]	73	250	[illegible]	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	660	674.33	00	x
5	Estimated Cost	฿ / [illegible]	209826	555854	215246	188818	10603	158691	[illegible]	7147	10561	10214	8084	3227	359	98 8	2410	18 55	1,0[illegible]826

Table C.21. Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in September 2000.

			A	B	C	D	E	F	O	H	I	J	K	L	M	N	O	Etc.	Total
[illegible]	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	11738 kg / month	868.61	704.28	1361.61	0.00	0.00	704.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.69	0.00	8040.53	11738.00
[illegible]	Ingredient		13.50	6.00									10,00			0.40		70.10	100.00
	Demand	1344 kg / month	181.44	80.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	134.40	0.00	0.00	5.38	0.00	942.14	1344.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	1596 kg / month	0.00	0.00	335.16	167.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	6.38	0.00	1085.28	1596.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	2980 kg / month	658.58	500.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.88	0.00	1802,90	2980.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	200 kg / month	0.00	16.00	0.00	30.00	0.00	0.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	123.00	200.00
[illegible]	Ingredient						16.00				2.60		1.20			0.40		79.80	100.00
	Demand	1532 kg / month	0.00	0.00	0.00	0.00	245.12	0.00	0.00	0.00	39.83	0.00	18.38	0.00	0.00	6.13	0.00	1222.54	1532.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	54 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	100.00
	Demand	180 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	180.00
[illegible]	Ingredient		5.00					15.00								0.40		79.60	100.00
	Demand	1598 kg / month	79.90	0.00	0.00	0.00	0.00	239.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.39	0.00	1272.01	1598.00
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	400 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	400.00

			A	B	O	D	E	[illegible]	[illegible]	H	I	J	K	L	M	N	O	Etc.	[illegible]
1	Sum	kg / month	1849	1313	1697	198	245	944	30	45	[illegible]	[illegible]	198	3	[illegible]	108	2	[illegible]	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	[illegible]	[illegible]	20	0	x
3	[illegible]	kg / month	2219	1575	2036	237	[illegible]	1133	36	54	110	[illegible]	231	4	[illegible]	123	2	[illegible]	x
[illegible]	Cost per unit	[illegible]	73	250	73	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	68	660	674.33	[illegible]	x
[illegible]	Estimated Cost	[illegible] month	162000	393870	148637	68758	68830	188800	13559	[illegible]	[illegible]	[illegible]	[illegible]	60	130	81311	1392	11920	[illegible]

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	11742 kg / month	868.91	704.52	1362.07	0.00	0.00	704.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.71	0.00	8043.27	11742.00
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	[illegible]
	Demand	854 kg / month	115.29	51.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.40	0.00	0.00	3.42	0.00	598.65	[illegible]
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	3506 kg / month	0.00	0.00	736.26	368.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.51	14.02	0.00	2384.08	3506.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	[illegible]
	Demand	2344 kg / month	518.02	393.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.06	0.00	1418,12	[illegible]
[illegible]	Ingredient			8.00		15,00		15.00									0.50	61.50	100.00
	Demand	1372 kg / month	0.00	109.76	0.00	205.80	0.00	0.00	205.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.86	843.78	1372.00
[illegible]	Ingredient		[illegible]				[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	100.00
	Demand	180 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	180.00
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	100.00
	Demand	270 kg / month	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	270.00
[illegible]	Ingredient		5.00					15.00								0.40		79.60	100.00
	Demand	708 kg / month	35.40	0.00	0.00	0.00	0.00	106.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.83	0.00	563.57	706.00
JJ	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	1200 kg / month	144.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	156.00	0.00	120.00	0.00	0.00	4.80	0.00	775.20	1200.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	1708	[illegible]	2098	574	0	811	20	68	158	25	20	11	4	[illegible]	8	1490	x
2	Buffer	%	20	20	20	20	20	20	28	20	20	20	20	20	20	20	20	0	x
[illegible]	[illegible] mand	kg / month	[illegible]	[illegible]	[illegible]	889	0	[illegible]	247	[illegible]	187	30	246	13	4	118	18	14907	x
4	[illegible]	฿ / kg	73	280	73	290	[illegible]	[illegible]	[illegible]	[illegible]	0.44	211.11	43.58	155.62	88	660	674.33	[illegible]	x
[illegible]	Estimated Cost	[illegible] / month	149596	389134	183814	199728	0	[illegible]	0	[illegible]	[illegible]	8884	10742	2017	286	[illegible]	[illegible]	11926	[illegible]

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in November 2000.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	[illegible]
[illegible]	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	11912 kg / month	881.49	714.72	1381.79	0.00	0.00	714.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.56	0.00	8159.72	11912.00
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	100.00
	Demand	1472 kg / month	198.72	88.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	147.20	0.00	0.00	5.89	0.00	1031.871	1472.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	1902 kg / month	0.00	0.00	399.42	199.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90	7.61	0.00	1293.36	1902.00
[illegible]	Ingredient		[illegible]	[illegible]												[illegible]		[illegible]	100.00
	Demand	6146 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6146.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.061
	Demand	3280 kg / month	0.00	262.40	0.00	492.00	0.00	0.00	492.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.40	2017.20	3280.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	100.00
	Demand	216 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	216.00
[illegible]	Ingredient		5.00							25.00							0.40	69.60	100,00
	Demand	978 kg / month	48.90	0.00	0.00	0.00	0.00	0.00	0.00	244.50	0.00	0.00	0.00	0.00	0.00	0.00	3.91	680.69	978.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	100.00
	Demand	36 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36.00
[illegible]	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	800 kg / month	96.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	104.00	0.00	80.00	0.00	0.00	3.20	0.00	516.80	800.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	234	166.67	376.65	330.86	140.44	21	43.58	155.62	[illegible]	660	674.33	[illegible]	
	Estimated Cost	[illegible]	227786	642998	156034	240715	0	144027	222374	97074	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	155	90399	[illegible]	[illegible]

Table C.24. Deteimine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in December 2000.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	[illegible]
	Demand	10992 kg / month	813.41	659.52	1275.07	0.00	0.00	659.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	54.96	0.00	7529.52	[illegible]
[illegible]	Ingredient		13.50	6.00									10.00			0.40		70.10	[illegible]
	Demand	1344 kg / month	181.44	80.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	134.40	0.00	0.00	5.38	0.00	942.14	[illegible]
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	3174 kg / month	0.00	0.00	666.54	333.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.17	12.70	0.00	2158.32	3174.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	[illegible]
	Demand	2234 kg / month	493.71	375.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.40	0.00	1351.57	[illegible]
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	902 kg / month	0.00	72.16	0.00	135.30	0.00	0.00	135.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.51	554.73	902.00
[illegible]	Ingredient						[illegible]				[illegible]		[illegible]			[illegible]		[illegible]	100.00
	Demand	738 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	738.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	[illegible]
	Demand	108 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ingredient		5.00					15.00								0.40		79.60	100.00
	Demand	2200 kg / month	110.00	0.00	0.00	0.00	0.00	330.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.80	0.00	1751.20	2200.00
	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	400 kg / month	48.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52.00	0.00	40.00	0.00	0.00	1.60	0.00	258.40	400.00

			A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	H	I	J	K	L	M	N	[illegible]	Etc.	Total
1	[illegible]	kg / month	[illegible]	[illegible]	1942	469	118	90	135	27	71	0	[illegible]	0	[illegible]	10	5	15210	x
2	Buffer	[illegible]	20	20	20	20	20	[illegible]	20	20	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]	20	0	x
[illegible]	Dem[illegible]	kg / month	[illegible]	[illegible]	[illegible]	562	142	1187	182	[illegible]	[illegible]	[illegible]	220	0	4	120	[illegible]	[illegible]	x
4	[illegible] unit	[illegible]	73	[illegible]	[illegible]	[illegible]	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	660	674.33	[illegible]	x
[illegible]	Estimated Cost	฿ / month	144712	356290	170085	163062	33157	197908	61153	[illegible]	[illegible]	0	[illegible]	0	259	79032	3999	[illegible]	1,254,125

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in January 2001.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	
/	Ingredient		7.40	6.00	11.60			6.00								0.50		68.50	100.00
	Demand	12030 kg / month	890.22	721.80	1395.48	0.00	0.00	721.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.15	0.00	8240.55	12030.00
[illegible]	Ingredient		[illegible]	[illegible]									[illegible]			[illegible]		[illegible]	[illegible]
	Demand	1196 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	2938 kg / month	0.00	0.00	616.98	308.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.94	11.75	0.00	1997.84	2938.00
[illegible]	Ingredient		22.10	16.80												0.60		60.50	[illegible]
	Demand	4328 kg / month	956.49	727.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.97	0.00	2618.44	[illegible]
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	400 kg / month	0.00	32.00	0.00	60.00	0.00	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	246.00	400.00
[illegible]	Ingredient						16.00				2.60		1.20			0.40		79.80	100.00
	Demand	630 kg / month	0.00	0.00	0.00	0.00	100.80	0.00	0.00	0.00	16.38	0.00	7.56	0.00	0.00	2.52	0.00	502.74	630.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	100.00
	Demand	270 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	270.00
[illegible]	Ingredient		[illegible]							[illegible]							[illegible]	[illegible]	100.00
	Demand	90 kg / month	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	90.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	[illegible]
	Demand	0 kg / month	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		12.00								13.00		10.00			0.40		64.60	100.00
	Demand	836 kg / month	100.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	108.68	0.00	83.60	0.00	0.00	3.34	0.00	540.06	836.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	[illegible]	[illegible]	2012	[illegible]	101	722	[illegible]	28	125	[illegible]	211	[illegible]	3	110	2	[illegible]	
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	
3	Demand	kg / month	[illegible]	[illegible]	[illegible]	442	121	866	[illegible]	27	[illegible]	45	[illegible]	[illegible]	4	132	[illegible]	[illegible]	x
4	Cost per unit	฿ / kg	78	250	78	290	28	[illegible]	[illegible]	[illegible]		[illegible]	43.58	155.62	[illegible]	660	674.33	[illegible]	x
5	Estimated Cost	฿ / month	186753	482809	176291	128235	28305	144363	27119	8933	21076	[illegible]	[illegible]	3025	240	[illegible]	1810	12149	1,328,607

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
*	**Ingredient**		7.40	6.00	11.60			6.00								0.50		68.50	[illegible]
	Demand	13840 kg / month	1024.16	830.40	1605.44	0.00	0.00	830.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.20	0.00	9480.40	[illegible]
8 8	Ingredient		13.50	6.00									10.00			0.40		70,10	100.00
	Demand	2180 kg / month	294.30	130.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	218.00	0.00	0.00	8.72	0.00	1528.18	2180.00
8	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	4612 kg / month	0.00	0.00	968.52	484.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.61	18.45	0.00	3136.16	4612.00
8	Ingredient		22.10	16.80												0.60		60.50	100.00
	Demand	2254 kg / month	498.13	378.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.52	0.00	1363.67	2254.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	800 kg / month	0.00	64.00	0.00	120.00	0.00	0.00	120.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	492.00	800.00
[illegible]	Ingredient						16.00				2.60		1.20			0.40		79.80	100.00
	Demand	450 kg / month	0.00	0.00	0.00	0.00	72.00	0.00	0.00	0.00	11.70	0.00	5.40	0.00	0.00	1.80	0.00	359.10	450.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	54 kg / month	[illegible]	11.84	0.00	0.00	0.00	0.00	0.00	0.00	00	[illegible]	0.00	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]
[illegible]	Ingredient		5.00							[illegible]							[illegible]	[illegible]	100.00
	Demand	0 kg / month	0.00		0.00	0.00	0.00	0	0.00	0.00		0.00	0.00	[illegible]	0.00	0	0.00	[illegible]	0.00
II	Ingredient		5.00					15.00								0.40		79.60	100.00
	Demand	4600 kg / month	230.00	0.00	0.00	0.00	0.00	690.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40	0.00	3661.60	4600.00
JJ	Ingredient		[illegible]								13.00		10.00			[illegible]		[illegible]	100.00
	Demand	400 kg / month	48.00	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00	[illegible]	0.00	0.00	[illegible]		[illegible]	400.00

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Sum	kg / month	[illegible]	1415	2574	604	72	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	0	132	4	[illegible]	x
2	Buffer	%	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0	x
3	[illegible]	kg / month	[illegible]	[illegible]	[illegible]	725	[illegible]	1824	144	0	70	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	x
4	[illegible] unit	[illegible]	73	250	78	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	660	674.33	0.8	x
5	Estimated Cost	[illegible] month	183818	424564	225479	210282	20218	304086	54238	0	10735	[illegible]	[illegible]	[illegible]	376	104471	3237	[illegible]	1,574,044

Determine the Demand for Each Raw Material Based on the Actual Sales Volume of Die Lubricants in April 2001.

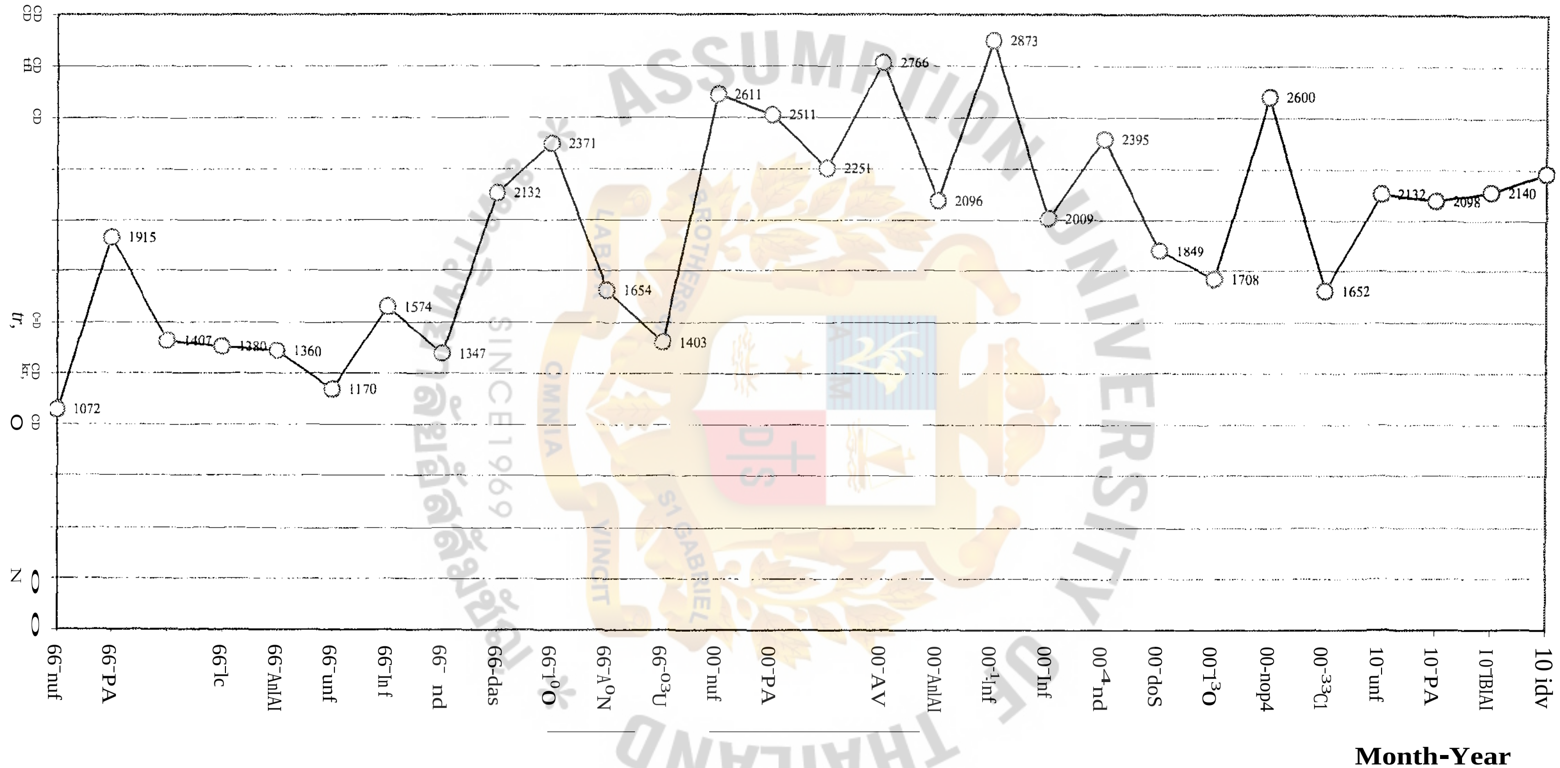
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Etc.	Total
1	Ingredient		7.40	6.00	11.60			6.00								0.50		68.501	100.001
	Demand	17552 kg / month	1298.85	1053,12	2036.03	0.00	0.00	1053.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	87.76	0.00	12023.12	17552.00
[illegible]	Ingredient		13,50	6.00									10.00			0.40		70.10	100.00
	Demand	2000 kg / month	270.00	120.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00	0.00	0.00	8.00	0.00	1402.00	2000.00
[illegible]	Ingredient				21.00	10.50									0.10	0.40		68.00	100.00
	Demand	3486 kg / month	0.00	0.00	732.06	366.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.49	13.94	0.00	2370.48	3486.00
[illegible]	Ingredient		[illegible]	[illegible]												[illegible]		[illegible]	100.00
	Demand	2054 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2054.00
[illegible]	Ingredient			8.00		15.00			15.00								0.50	61.50	100.00
	Demand	400 kg / month	0.00	32.00	0.00	60.00	0.00	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	246.00	400.00
[illegible]	Ingredient						16.00				2.60		1.20			0.40		79.80	100.00
	Demand	1530 kg / month	0.00	0.00	0.00	0.00	244.80	0.00	0.00	0.00	39.78	0.00	18.36	0.00	0.00	6.12	0.00	1220.94	1530.00
[illegible]	Ingredient		[illegible]	[illegible]								[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
	Demand	72 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ingredient		[illegible]							[illegible]						[illegible]	[illegible]	[illegible]	100.00
	Demand	234 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	234.00
[illegible]	Ingredient		[illegible]					[illegible]								[illegible]		[illegible]	100.00
	Demand	1400 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1400.00
[illegible]	Ingredient		[illegible]								[illegible]		[illegible]			[illegible]		[illegible]	[illegible]
	Demand	1016 kg / month	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

			A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	G	H	I	J	K	L	M	N	O	[illegible]	[illegible]
1	[illegible]	[illegible]	2231	[illegible]	2768	426	245	[illegible]	60	59	172	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	x
2	Buffer	%	[illegible]	20	20	20	20	20	20	[illegible]	[illegible]	20	20	[illegible]	20	20	[illegible]	0	x
3	[illegible]	[illegible]	[illegible]	[illegible]	3322	[illegible]	294	[illegible]	72	[illegible]	206	12	[illegible]	[illegible]	4	166	[illegible]	[illegible]	x
4	[illegible] unit	[illegible]	73	250	73	290	234	166.67	376.65	330.86	140.44	211.11	43.58	155.62	[illegible]	660	674.33	0.8	x
[illegible]	Estimated Cost	[illegible]	195474	469594	242485	148258	68740	252629	27119	23226	28963	2554	16733	807	284	109375	[illegible]	16381	1,604,998

APPENDIX D

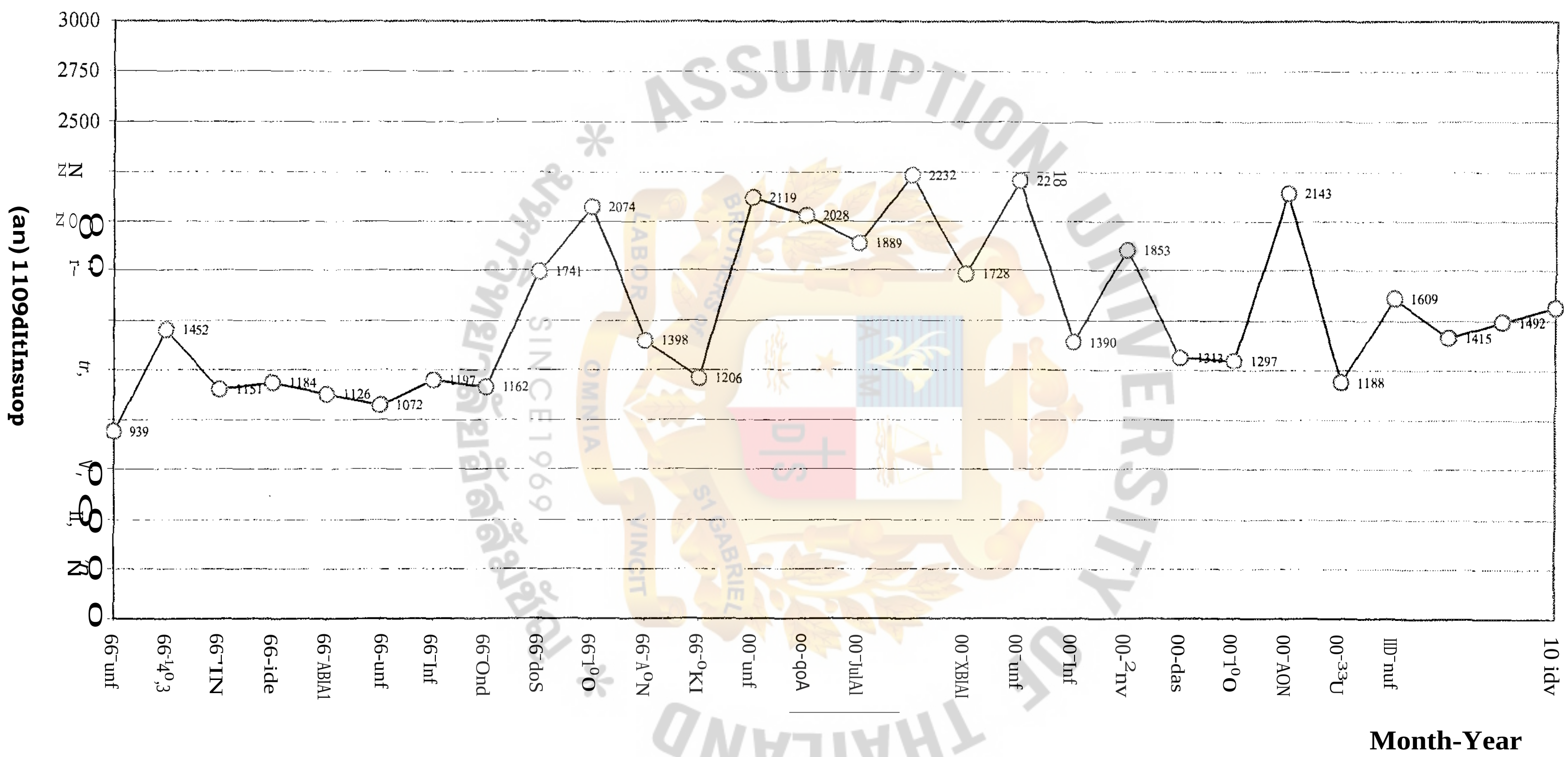
TREND OF USAGE RAW MATERIALS

Trend of Usage "A" from January 1999 to April 2001



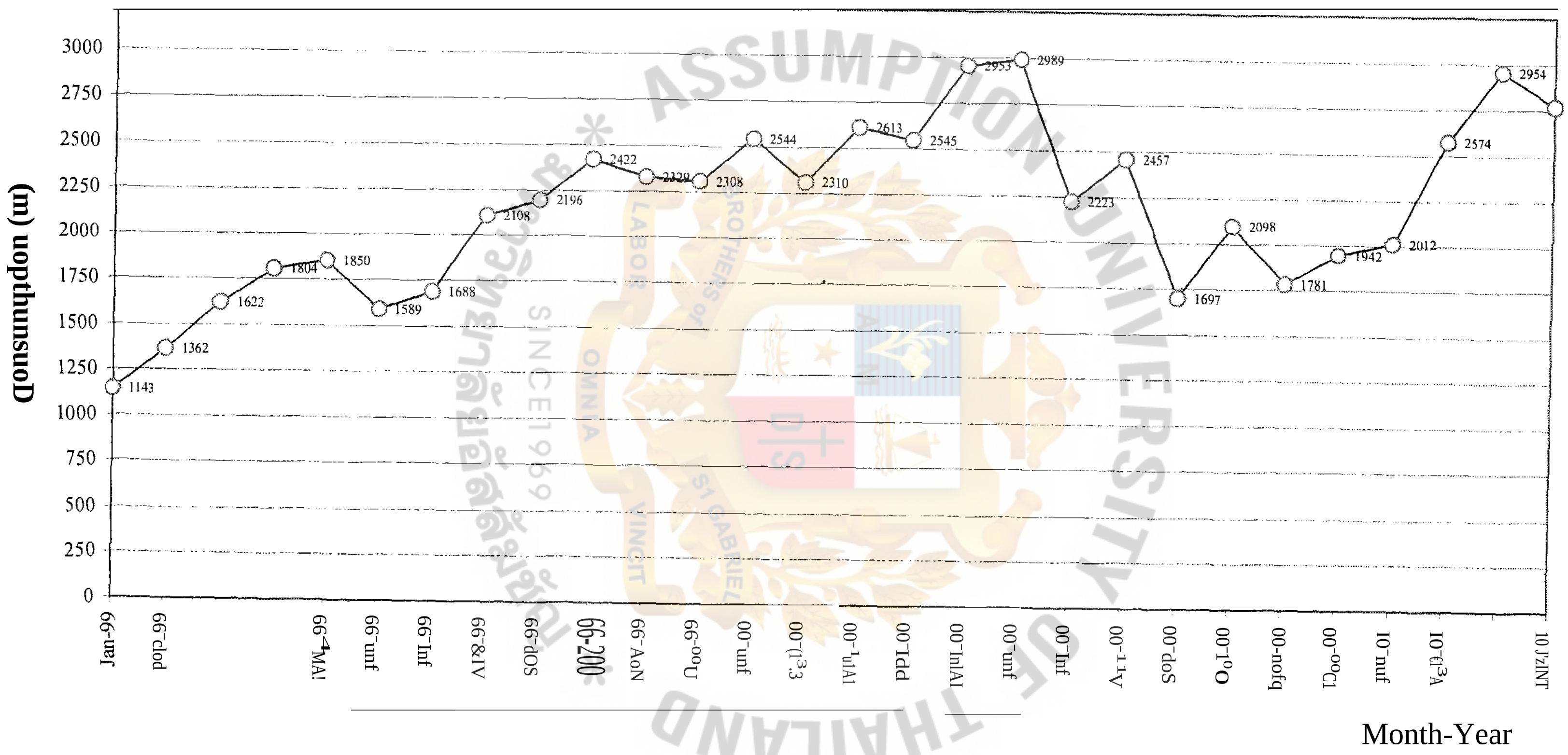
Trend of Usage "A".

Trend of Usage "B" from January 1999 to April 2001



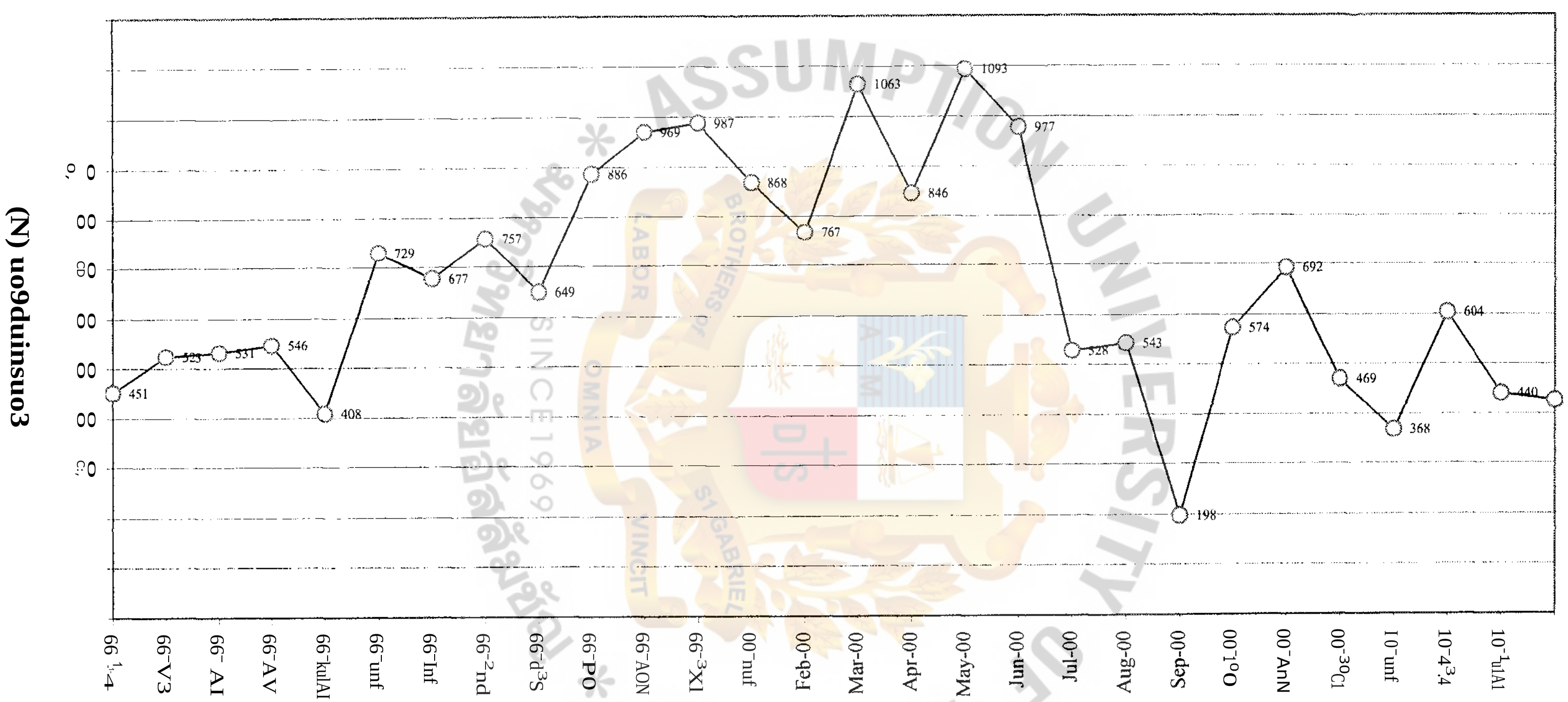
Trend of Usage "B".

Trend of Usage "C" from January 1999 to April 2001



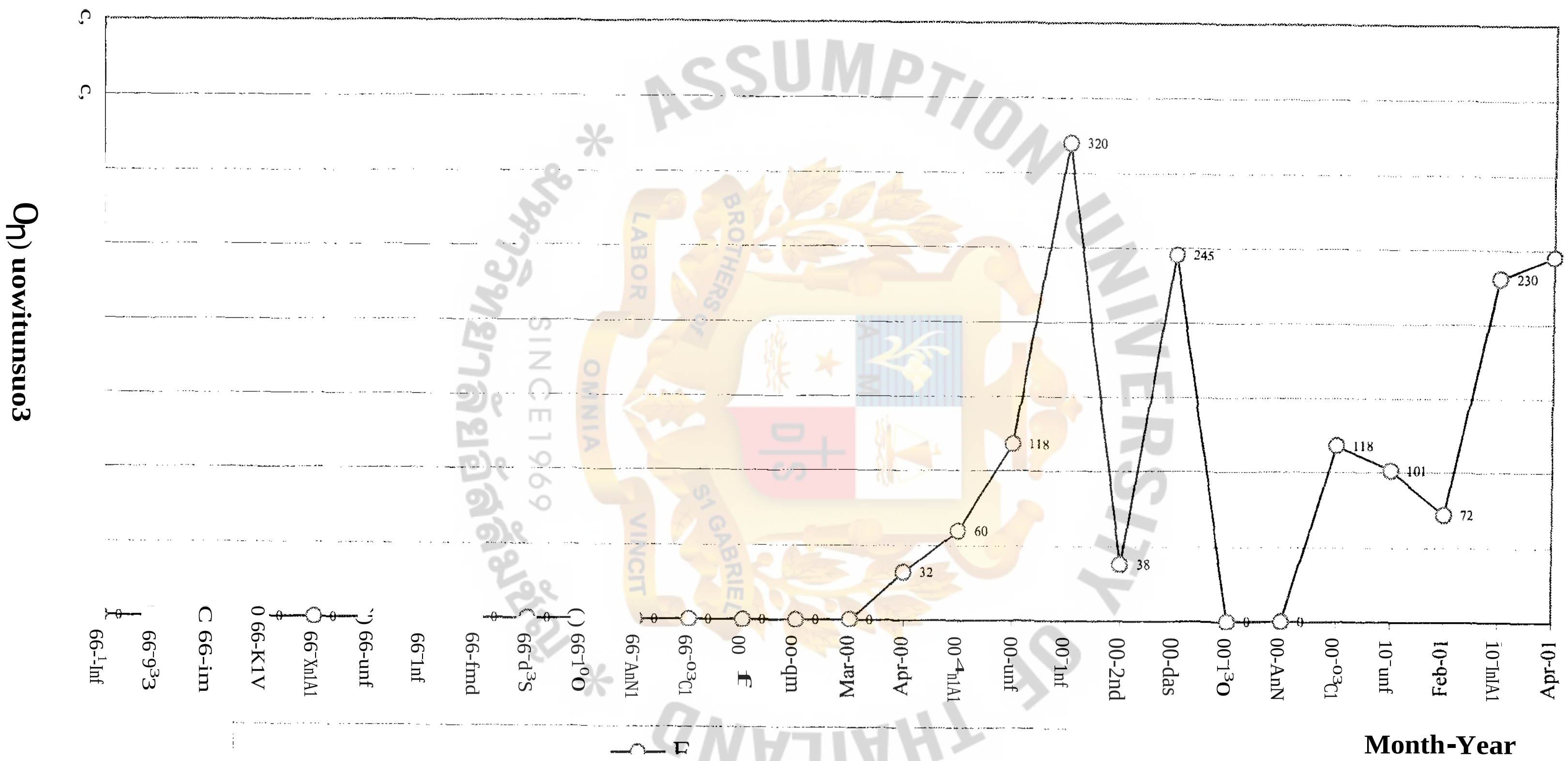
Trend of Usage "C".

Trend of Usage "D" from January 1999 to April 2001



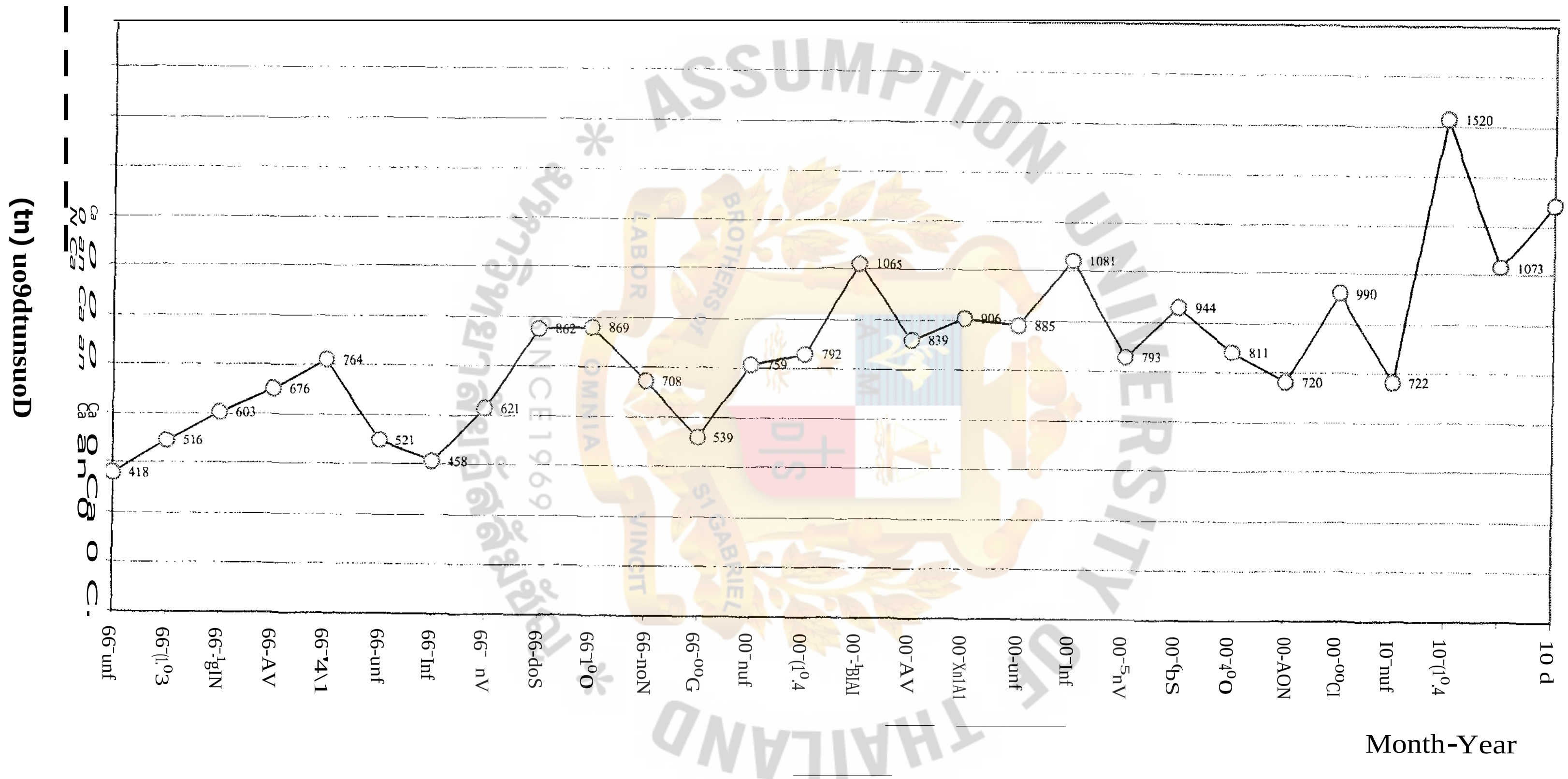
Trend of Usage "D".

Trend of Usage "E" from January 1999 to April 2001



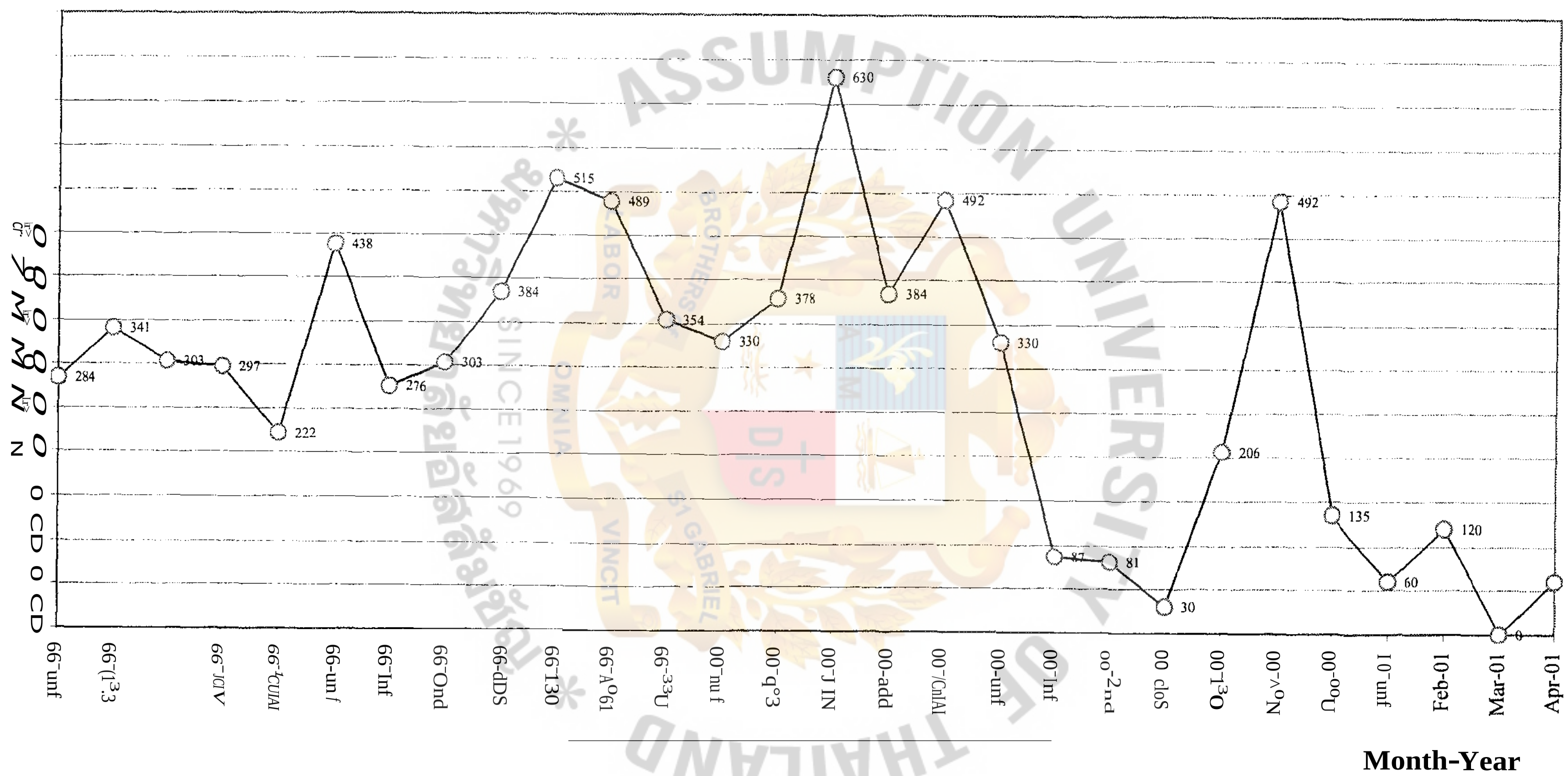
Trend of Usage "E".

Trend of Usage "F" from January 1999 to April 2001

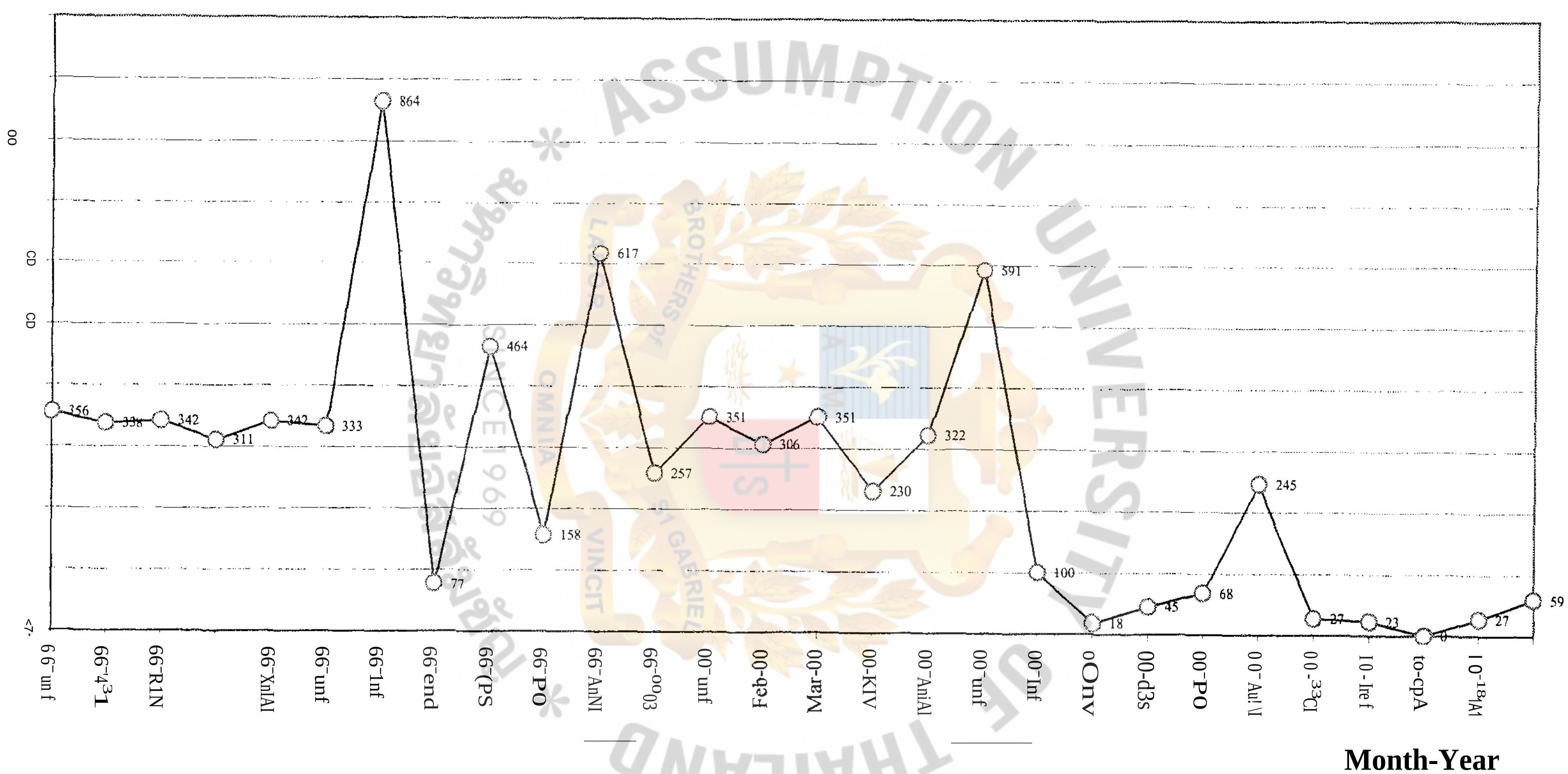


Trend of Usage "F".

Trend of Usage "G" from January 1999 to April 2001



Trend of Usage "G".



Trend of Usage "H".

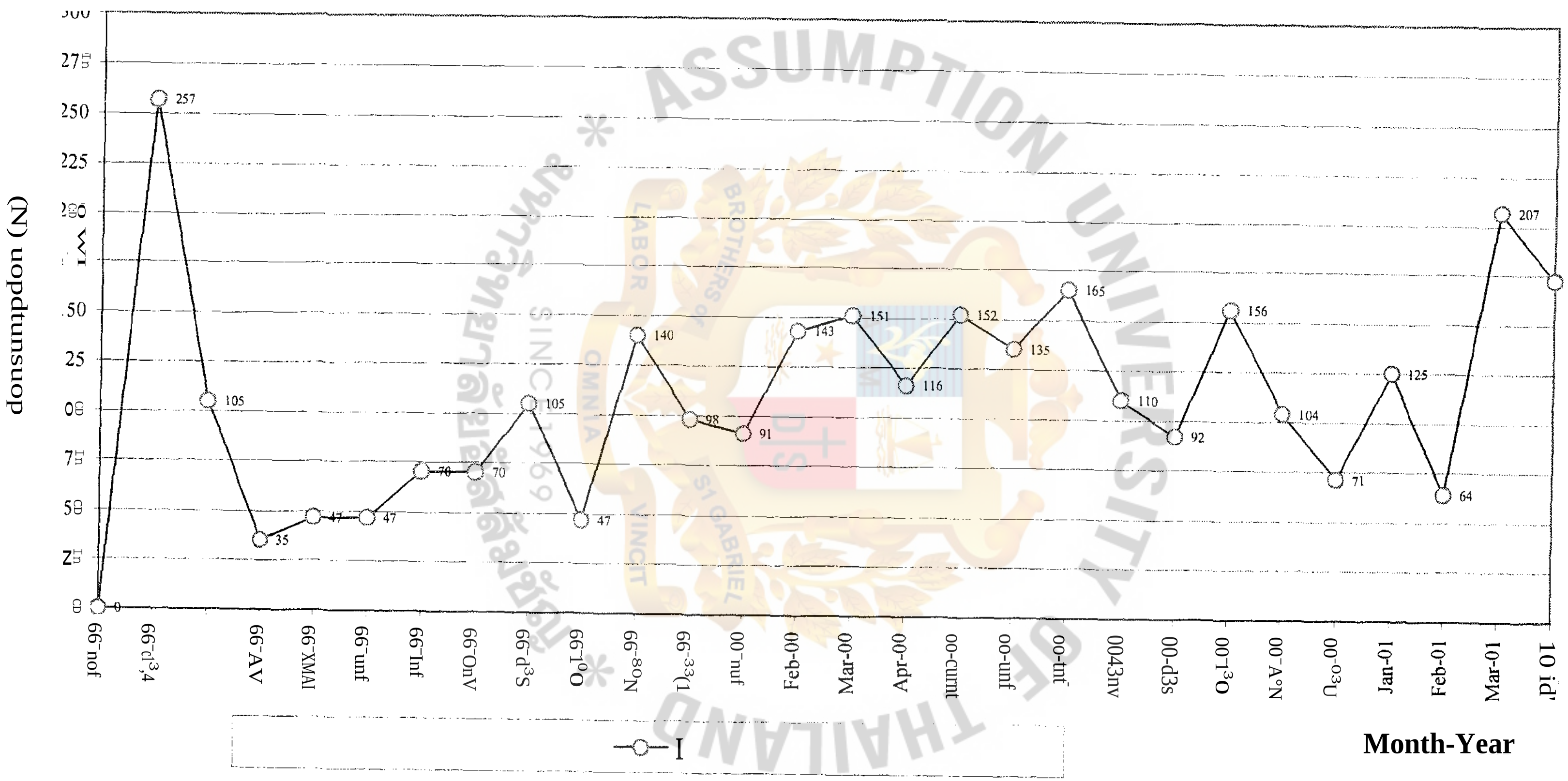
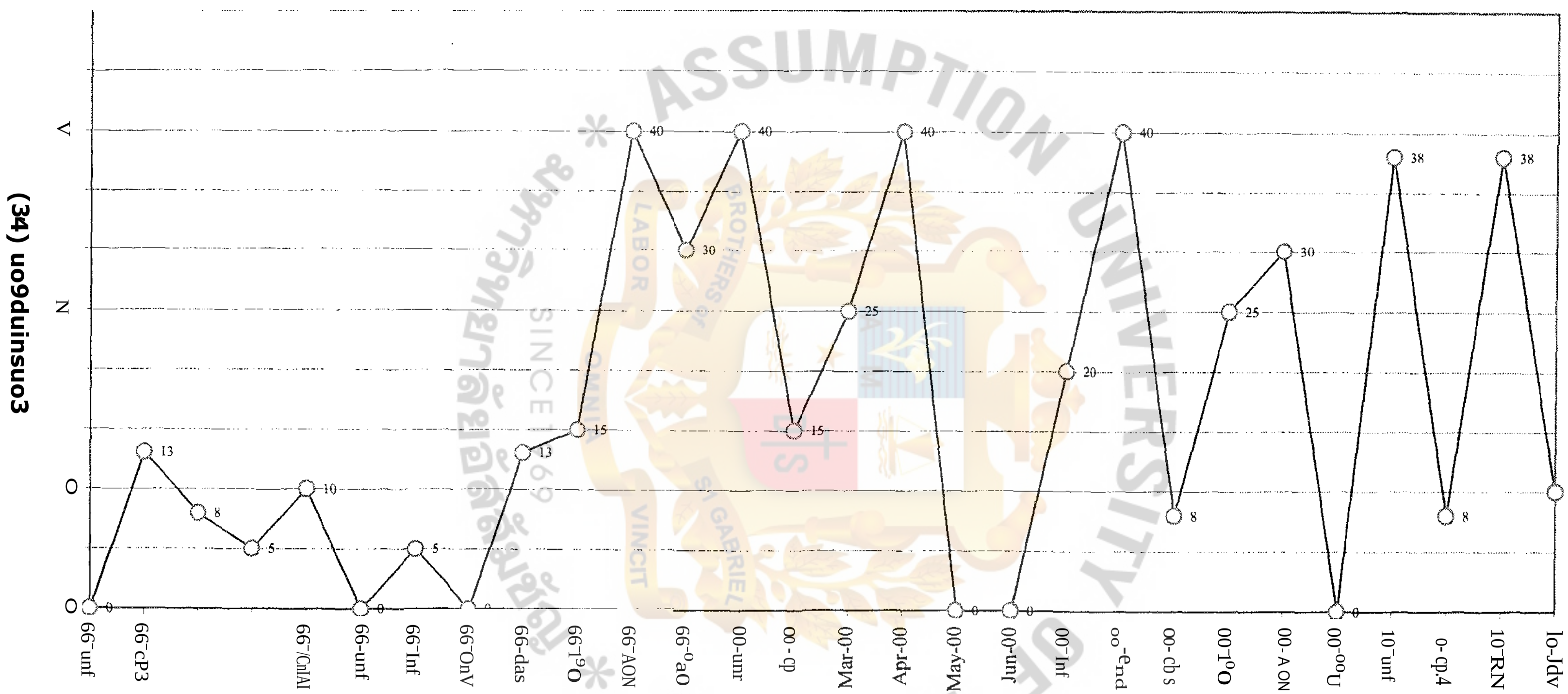
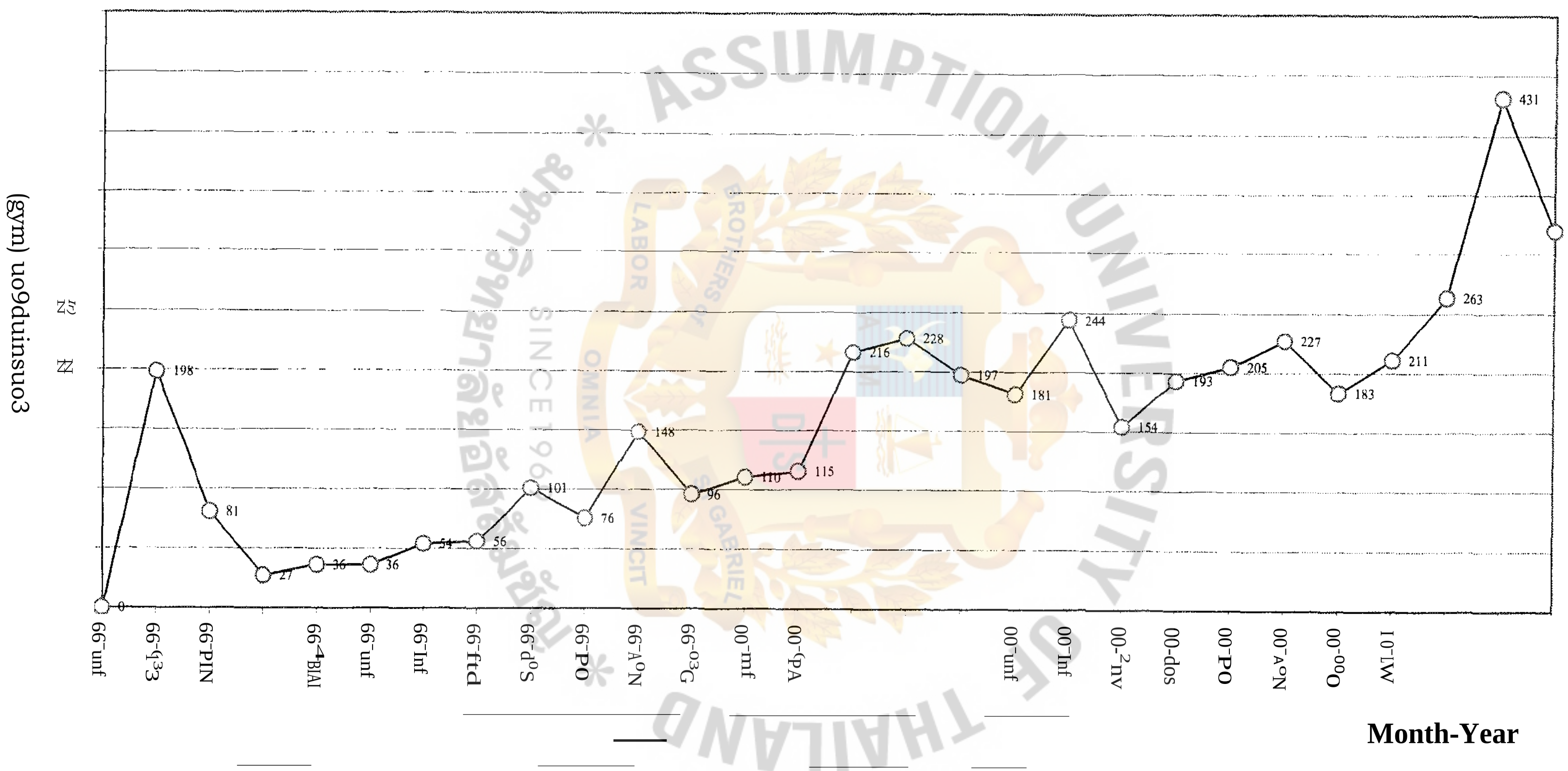


Figure D.9. Trend of Usage "I".



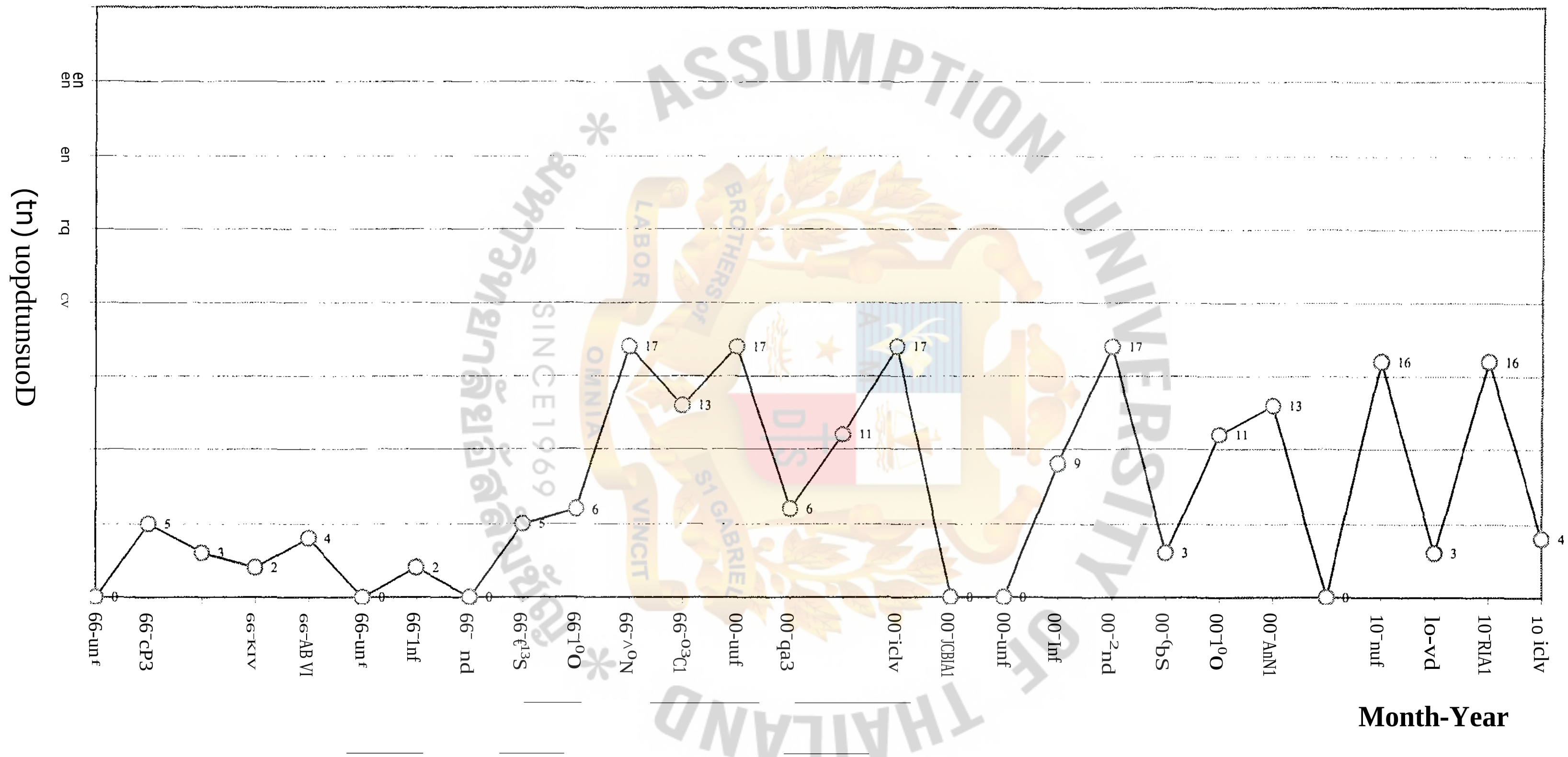
Trend of Usage "J".

Trend of Usage "K" from January 1999 to April 2001



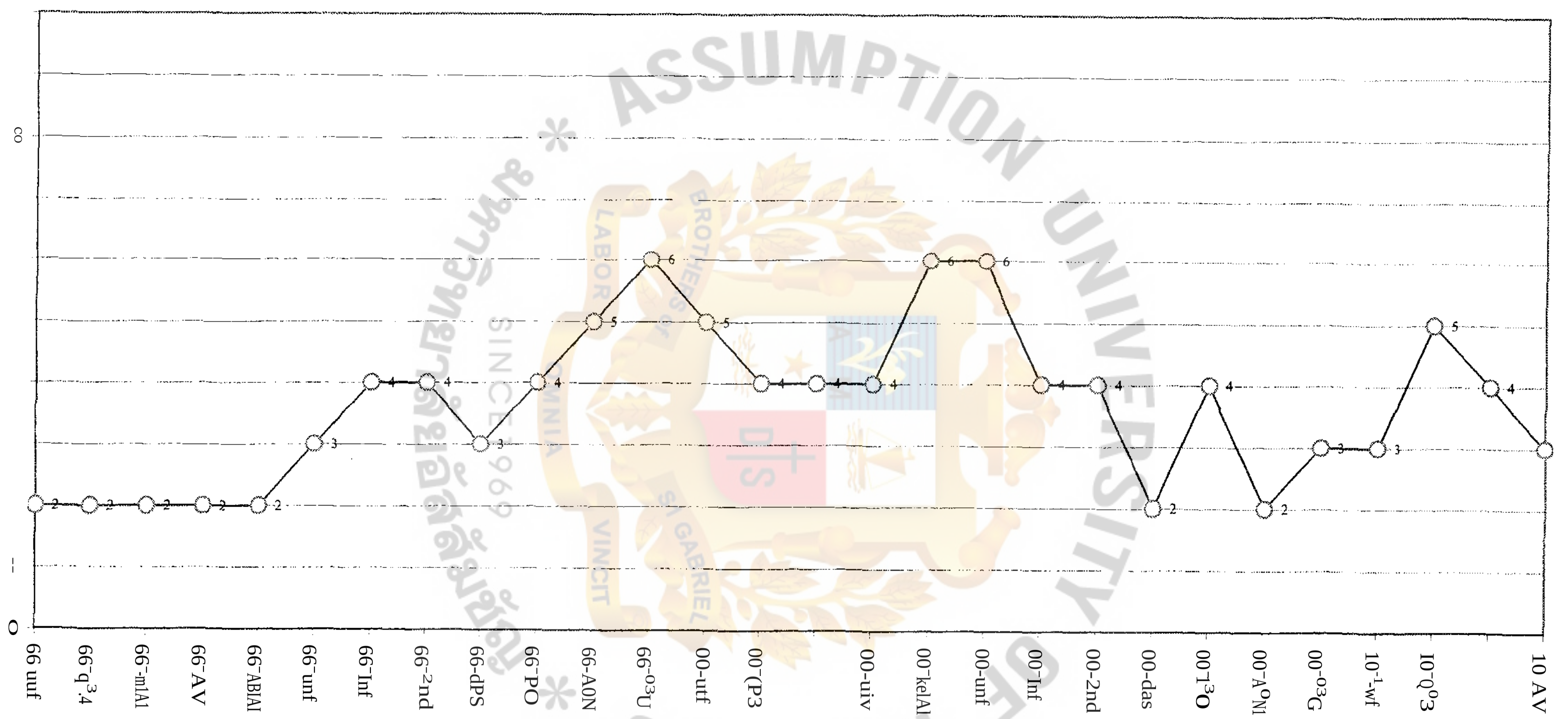
Trend of Usage "K".

Trend of Usage "L" from January 1999 to April 2001

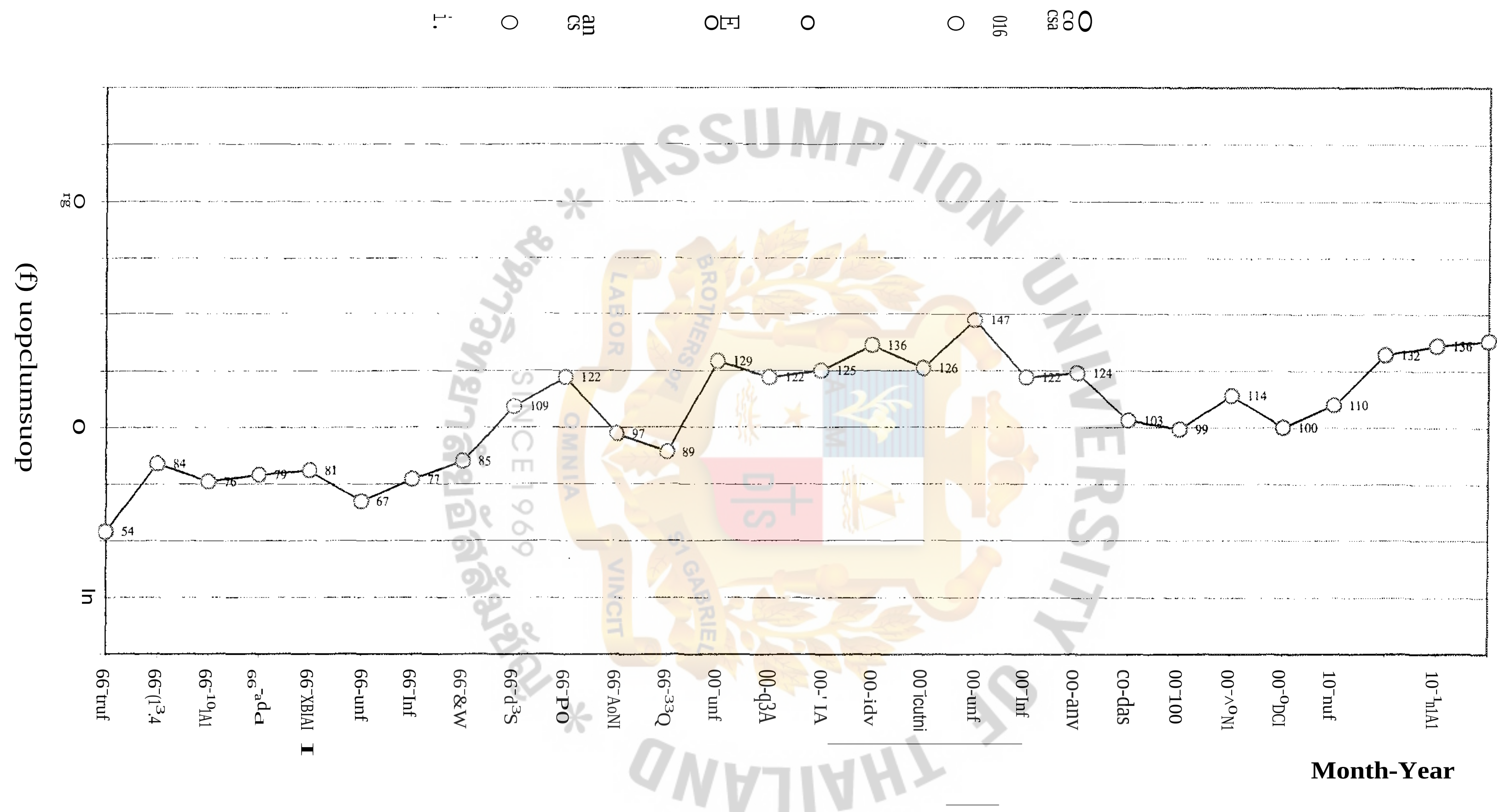


Trend of Usage "L".

Trend of Usage "M" from January 1999 to April 2001



Trend of Usage "M".



Trend of Usage "N".

Trend of Usage "0" from January 1999 to April 2001

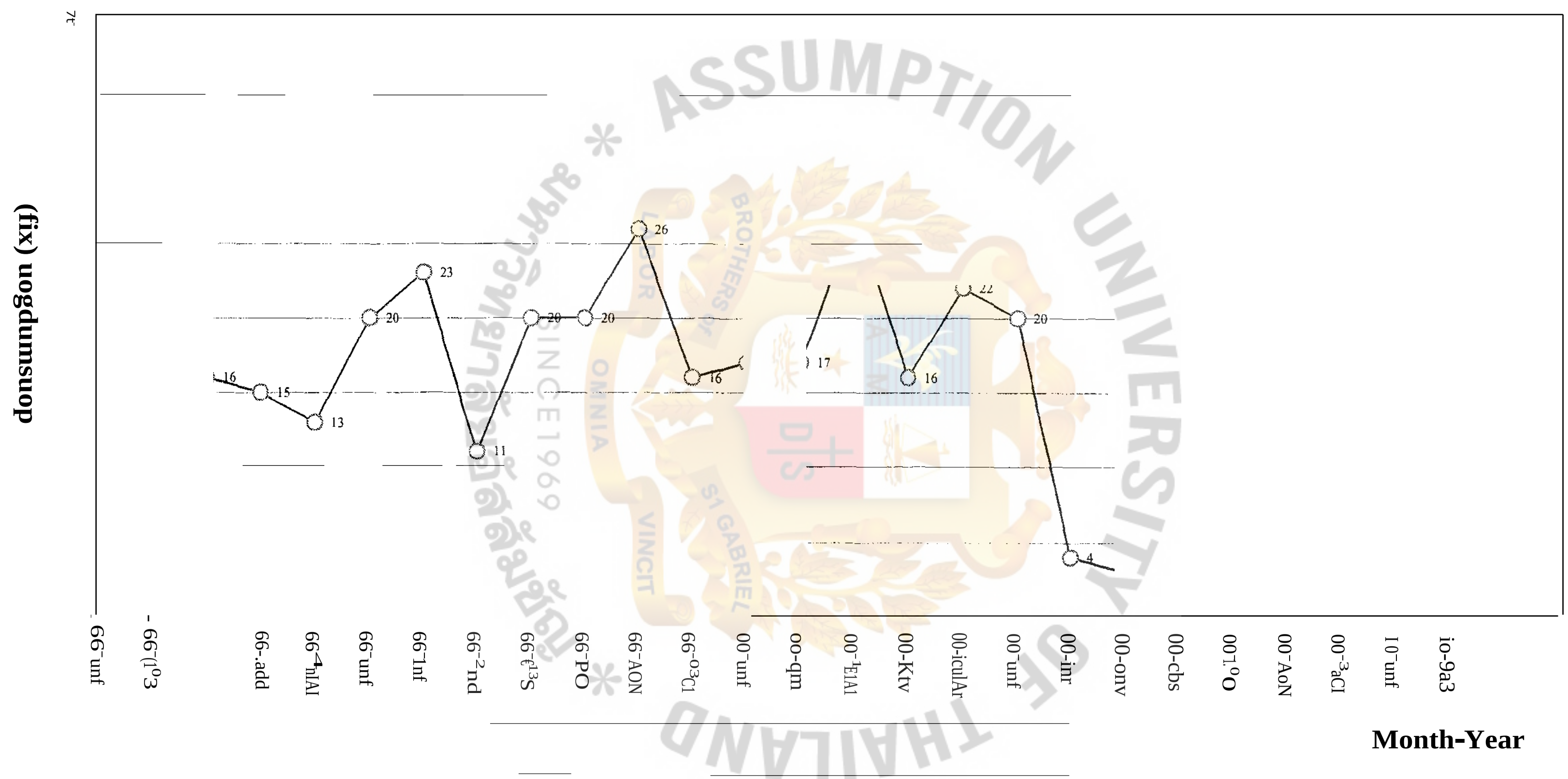


Figure D.15. Trend of Usage "0".

APPENDIX E

THE FORECASTING REPORTS

Report for D/L Model AA - Student Version

Created: 15/10/2544 at 10:54:58

Summary:

- Number of series: 1
- Periods to forecast: 6
- Seasonality: none
- Error Measure: RMSE

Series: ColumnC Range: C6:C33

Method: Single Moving Average

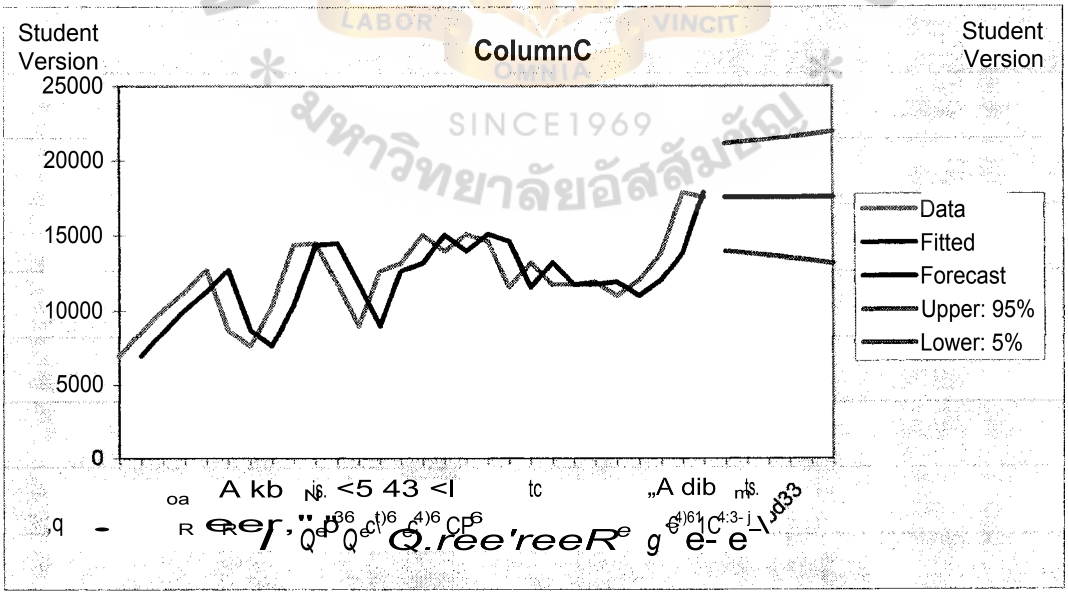
Parameters:

Periods: 1

Error: 2111.3

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period29	13950.31599	17552	21153.68401
Period30	13811.78969	17552	21292.21031
Period3l	13662.18127	17552	21441.81873
Period32	13500.10549	17552	21603.89451
Period33	13323.93617	17552	21780.06383
Period34	13131.75145	17552	21972.24855



Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Moving Average	2111.3	1721.3	14.69%
2nd: Single Exponential Smoothing	2111.4	1721.5	14.69%
3rd: Double Exponential Smoothing	2266.7	1755.3	15.17%
4th: Double Moving Average	2497.8	1999.2	15.18%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Moving Average	1.817	1
2nd: Single Exponential Smoothing	1.838	1
3rd: Double Exponential Smoothing	1.792	1.01
4th: Double Moving Average	0.861	1.12

Method Parameters:

Method	Parameter	Value
Best: Single Moving Average	Periods	1
2nd: Single Exponential Smoothing	Alpha	0.999
3rd: Double Exponential Smoothing	Alpha	0.999
	Beta	0.092
4th: Double Moving Average	Periods	5

Report for D/L Model BB - Student Version

Created: 15/10/2544 at 10 57 39

Summary:

- Number of series: 1
- Periods to forecast: 6
- Seasonality: none
- Error Measure: RMSE

Series: ColumnD Range: D12:D33

Method: Double Exponential Smoothing

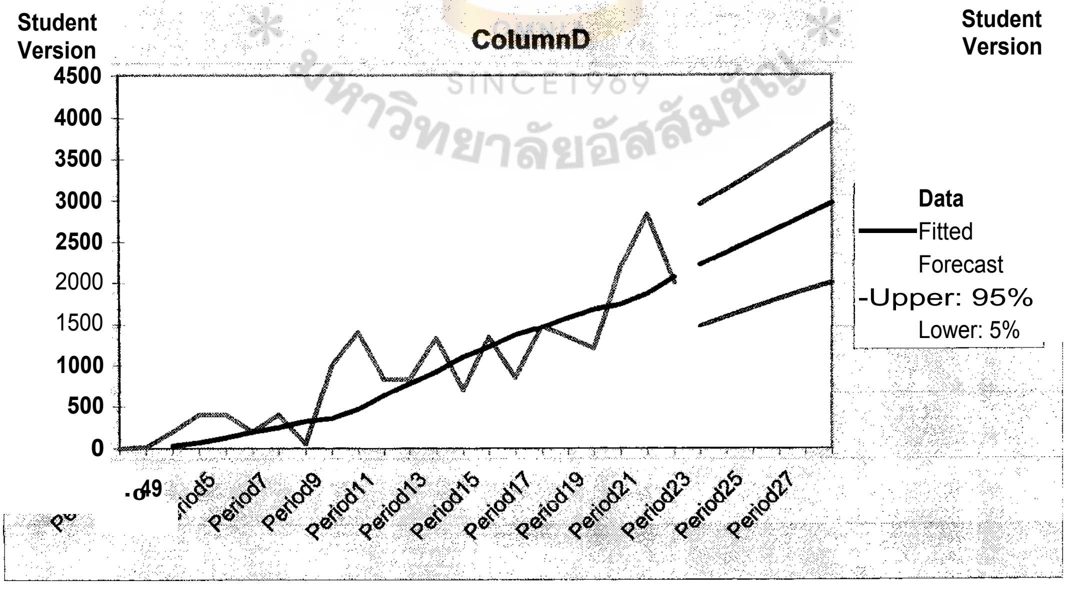
Parameters:

- Alpha: 0.048
- Beta: 0.999

Error: 426.77

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period23	1478.637402	2214.096047	2949.554693
Period24	1591.395396	2363.626974	3135.858552
Period25	1700.282556	2513.157901	3326.033246
Period26	1804.653741	2662.688827	3520.723914
Period27	1903.712016	2812.219754	3720.727493
Period28	1996.461209	2961.750681	3927.040153



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Method Errors:

Method	RMSE	MAD	MAPE
Best: Double Exponential Smoothing	426.77	332.77	59.86%
2nd: Single Exponential Smoothing	469.76	371.48	68.00%
3rd: Single Moving Average	497.21	405.55	64.45%
4th: Double Moving Average	526.66	409.55	30.43%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Double Exponential Smoothing	1.588	0.688
2nd: Single Exponential Smoothing	1.966	0.918
3rd: Single Moving Average	1.931	0.82
4th: Double Moving Average	1.727	0.729

Method Parameters:

Method	Parameter	Value
Best: Double Exponential Smoothing	Alpha	0.048
	Beta	0.999
2nd: Single Exponential Smoothing	Alpha	0.58
3rd: Single Moving Average	Periods	2
4th: Double Moving Average	Periods	6

Report for D/L Model CC - Student Version
Created: 1511012544 at 10:58:32

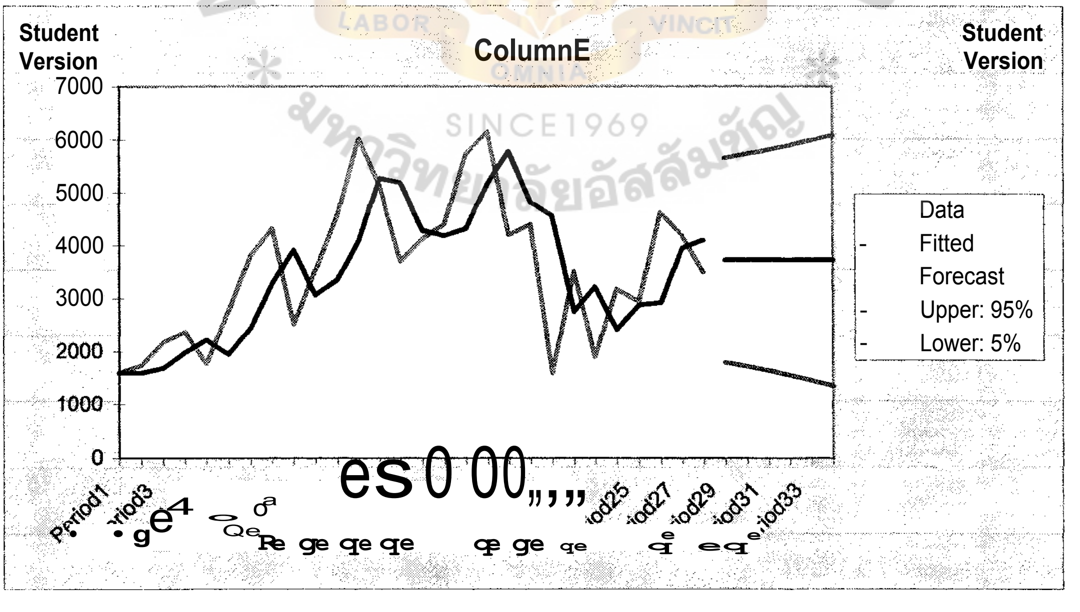
Summary:
Number of series: 1
Periods to forecast: 6
Seasonality: none
Error Measure: RMSE

Series: ColumnE Range: E6:E33

Method: Single Exponential Smoothing
Parameters:
Alpha: 0.608
Error: 1129.9

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period29	1796.493132	3724.006381	5651.519631
Period30	1722.358007	3724.006381	5725.654756
Period3l	1642.292072	3724.006381	5805.720691
Period32	1555.553975	3724.006381	5892.458787
Period33	1461.273436	3724.006381	5986.739326
Period34	1358.421939	3724.006381	6089.590824



Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Exponential Smoothing	1129.9	906.86	29.27%
2nd: Double Exponential Smoothing	1149.6	898.22	29.92%
3rd: Single Moving Average	1175.7	976.58	30.01%
4th: Double Moving Average	1461.5	1185.8	34.63%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Exponential Smoothing	1.902	0.798
2nd: Double Exponential Smoothing	1.885	0.732
3rd: Single Moving Average	1.574	0.763
4th: Double Moving Average	1.883	1.122

Method Parameters:

Method	Parameter	Value
Best: Single Exponential Smoothing	Alpha	0.608
2nd: Double Exponential Smoothing	Alpha	0.597
	Beta	0.001
3rd: Single Moving Average	Periods	2
4th: Double Moving Average	Periods	2

Report for D/L Model DD - Student Version
Created: 15/10/2544 at 10:59:06

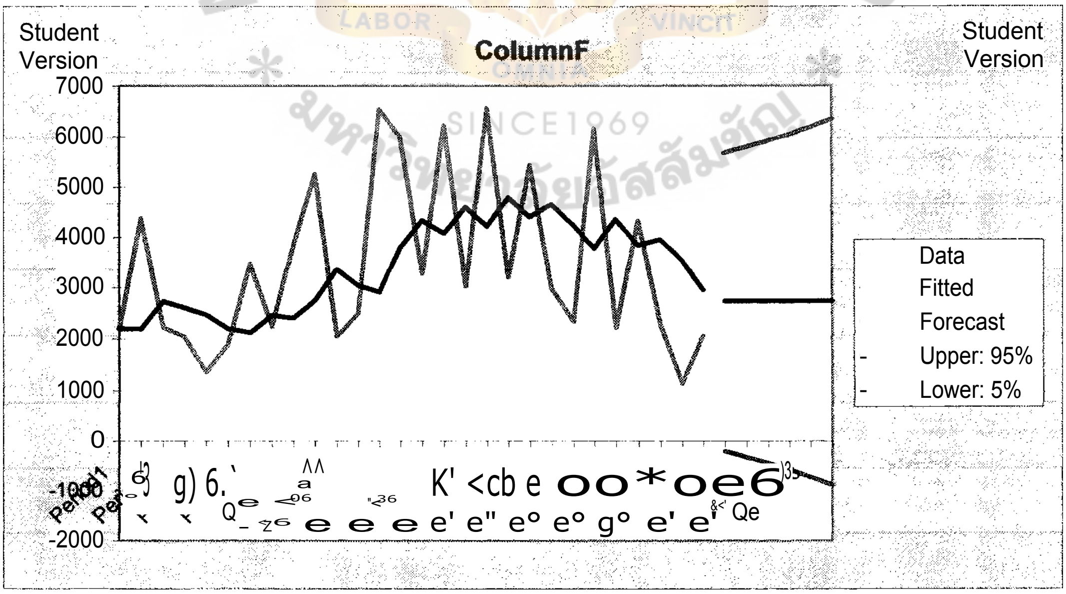
Summary:
- Number of series: 1
- Periods to forecast: 6
- Seasonality: none
- Error Measure: RMSE

Series: ColumnF   Range: F6:F33

Method: Single Exponential Smoothing
Parameters:
Alpha: 0.245
Error: 1724.6

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period29	-206.6420435	2735.420294	5677.482632
Period30	-319.7982873	2735.420294	5790.638876
Period3l	-442.0070305	2735.420294	5912.847619
Period32	-574.3998357	2735.420294	6045.240425
Period33	-718.3050588	2735.420294	6189.145648
Period34	-875.2925748	2735.420294	6346.133164



Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Exponential Smoothing	1724.6	1522.5	49.70%
2nd: Single Moving Average	1726.6	1565.8	50.34%
3rd: Double Moving Average	1740	1543.7	52.51%
4th: Double Exponential Smoothing	2289.5	2026.6	73.93%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Exponential Smoothing	2.348	0.826
2nd: Single Moving Average	2.342	0.786
3rd: Double Moving Average	2.799	0.62
4th: Double Exponential Smoothing	2.017	1.082

Method Parameters:

Method	Parameter	Value
Best: Single Exponential Smoothing	Alpha	0.245
2nd: Single Moving Average	Periods	5
3rd: Double Moving Average	Periods	7
4th: Double Exponential Smoothing	Alpha	0.475
	Beta	0.408

Report for D/L Model EE - Student Version
Created: 15/10/2544 at 10:59:37

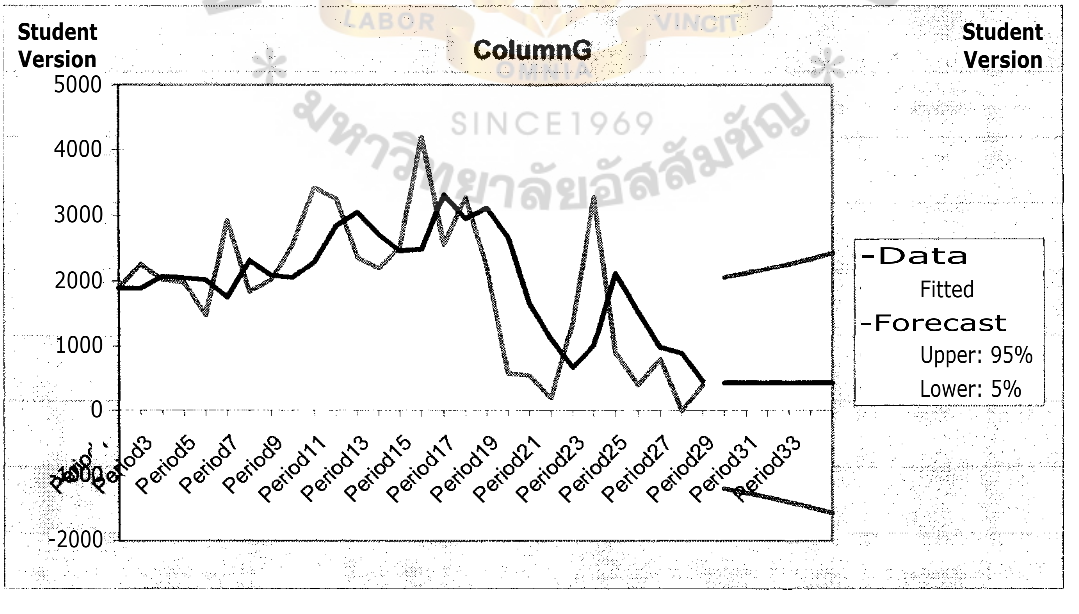
Summary:
- Number of series: 1
- Periods to forecast: 6
- Seasonality: none
- Error Measure: RMSE

Series: ColumnG Range: G6:G33

Method: Single Exponential Smoothing
Parameters:
Alpha: 0.486
Error: 953.60

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period29	-1196.997708	429.7657566	2056.529221
Period30	-1259.565534	429.7657566	2119.097047
Period3l	-1327.138785	429.7657566	2186.670298
Period32	-1400.343141	429.7657566	2259.874654
Period33	-1479.913093	429.7657566	2339.444606
Period34	-1566.716677	429.7657566	2426.248191



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Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Exponential Smoothing	953.6	752.46	75.58%
2nd: Single Moving Average	1010.4	796.67	61.78%
3rd: Double Exponential Smoothing	1051.1	815.08	96.02%
4th: Double Moving Average	1201.9	874.9	157.17%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Exponential Smoothing	1.725	0.804
2nd: Single Moving Average	2.465	1
3rd: Double Exponential Smoothing	1.105	0.797
4th: Double Moving Average	0.947	0.766

Method Parameters:

Method	Parameter	Value
Best: Single Exponential Smoothing	Alpha	0.486
2nd: Single Moving Average	Periods	1
3rd: Double Exponential Smoothing	Alpha	0.065
	Beta	0.999
4th: Double Moving Average	Periods	8

Report for D/L Model FF - Student Version

Created: 15/10/2544 at 11:00:12

Summary:

- Number of series: 1
- Periods to forecast: 6
- Seasonality: none
- Error Measure: RMSE

Series: ColumnH — Range: H20:H33

Method: Single Moving Average

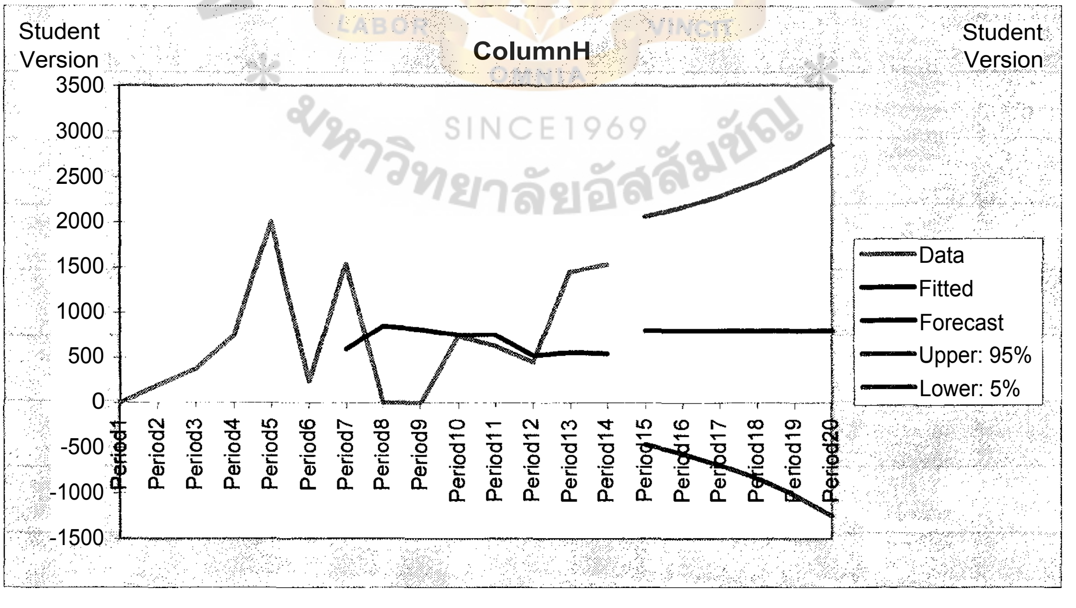
Parameters:

Periods: 6

Error: 710.30

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period15	-460.3310353	798	2056.331035
Period16	-565.1919549	798	2161.191955
Period17	-689.1184962	798	2285.118496
Period18	-837.8303459	798	2433.830346
Period19	-1019.589273	798	2615.589273
Period20	-1246.787932	798	2842.787932



Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Moving Average	710.3	584.67	37.37%
2nd: Single Exponential Smoothing	739.43	612.64	78.30%
3rd: Double Exponential Smoothing	782.9	592.24	89.91%
4th: Double Moving Average	896.06	679.83	152.81%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Moving Average	1.183	0.885
2nd: Single Exponential Smoothing	1.998	0.821
3rd: Double Exponential Smoothing	2.256	0.463
4th: Double Moving Average	1.603	0.342

Method Parameters:

Method	Parameter	Value
Best: Single Moving Average	Periods	6
2nd: Single Exponential Smoothing	Alpha	0.319
3rd: Double Exponential Smoothing	Alpha	0.471
	Beta	0.001
4th: Double Moving Average	Periods	3

Report for D/L Model GG - Student Version
Created: 1 5110)2544 at 11:00:35

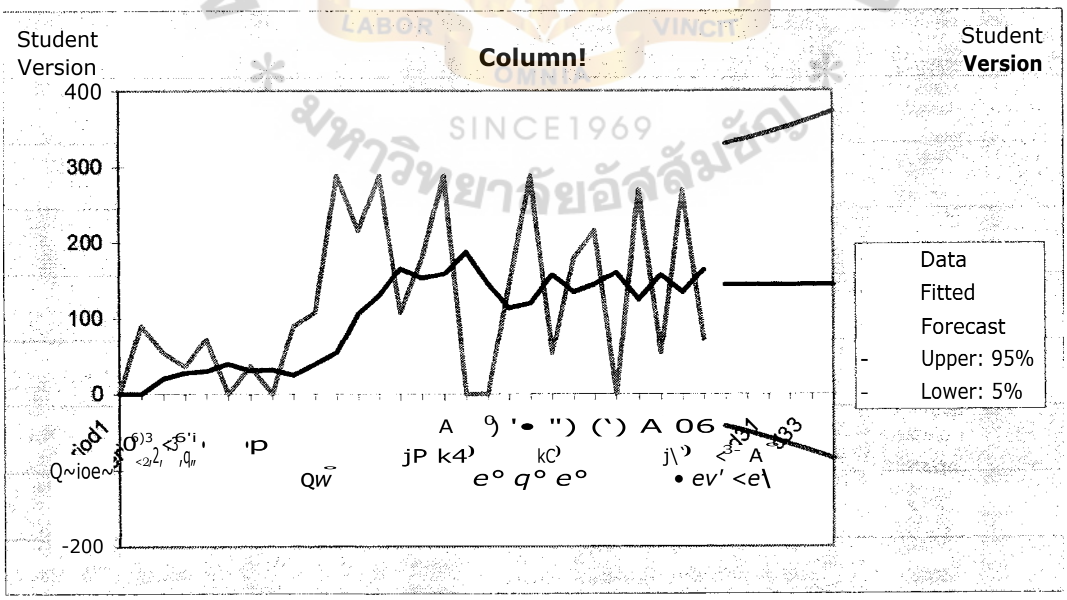
Summary:
- Number of series: 1
- Periods to forecast: 6
- Seasonality: none
- Error Measure: RMSE

Series: Columnl — Range: 16:133

Method: Single Exponential Smoothing
Parameters:
Alpha: 0.223
Error: 109.32

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period29	-42.65628191	143.8323229	330.3209277
Period30	-49.82892056	143.8323229	337.4935663
Period31	-57.57537029	143.8323229	345.240016
Period32	-65.96735751	143.8323229	353.6320033
Period33	-75.08908274	143.8323229	362.7537285
Period34	-85.04005573	143.8323229	372.7047015



Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Exponential Smoothing	109.32	92.191	65.93%
2nd: Single Moving Average	111.04	97.938	65.58%
3rd: Double Exponential Smoothing	135.3	119.2	115.36%
4th: Double Moving Average	141.76	116.27	78.74%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Exponential Smoothing	2.193	0.752
2nd: Single Moving Average	2.763	0.608
3rd: Double Exponential Smoothing	2.091	1.216
4th: Double Moving Average	2.314	0.824

Method Parameters:

Method	Parameter	Value
Best: Single Exponential Smoothing	Alpha	0.223
2nd: Single Moving Average	Periods	13
3rd: Double Exponential Smoothing	Alpha	0.467
	Beta	0.232
4th: Double Moving Average	Periods	4

Report for D/L Model HH - Student Version
Created: 15/10/2544 at 11:02:44

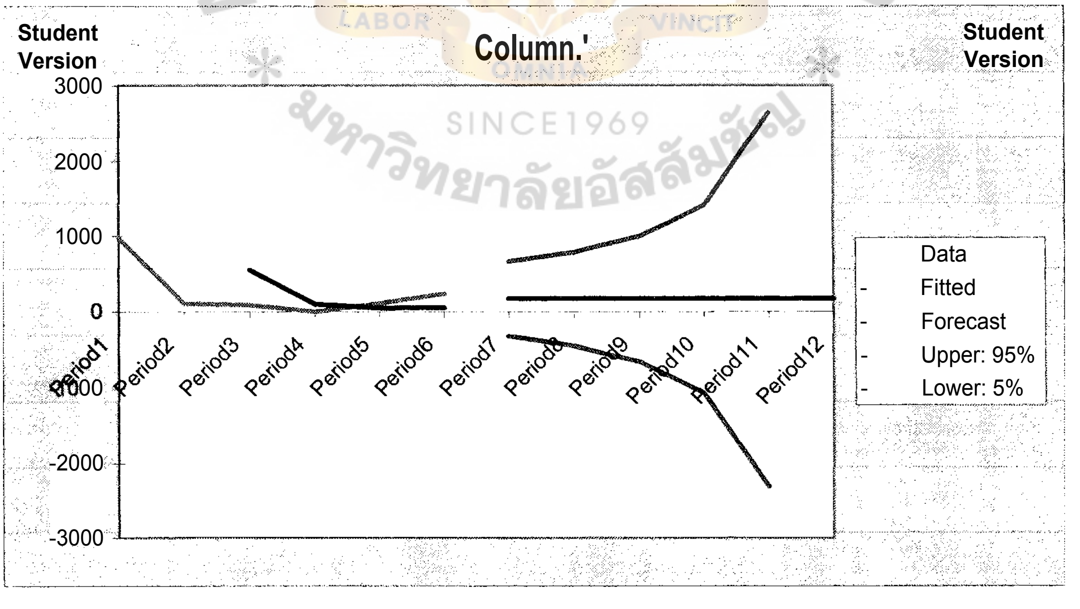
Summary:
Number of series: 1
Periods to forecast: 6
Seasonality: none
Error Measure: RMSE

Series: ColumnJ   Range: J28:J33

Method: Single Moving Average
Parameters:
Periods: 2
Error: 250.69

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period7	-323.8592012	171	665.8592012
Period8	-447.5740015	171	789.5740015
Period9	-653.7653354	171	995.7653354
Period10	-1066.148003	171	1408.148003
Period 11	-2303.296006	171	2645.296006
Period 12		171	



Page 1

Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Moving Average	250.69	198.75	212.86%
2nd: Double Moving Average	351.16	292.5	102.24%
3rd: Single Exponential Smoothing	398.22	242.58	245.08%
4th: Double Exponential Smoothing	433.15	269.4	365.68%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Moving Average	0.657	1.3
2nd: Double Moving Average	0.485	1.321
3rd: Single Exponential Smoothing	1.924	1.001
4th. Double Exponential Smoothing	0.9	0.384

Method Parameters:

Method	Parameter	Value
Best: Single Moving Average	Periods	2
2nd: Double Moving Average	Periods	2
3rd: Single Exponential Smoothing	Alpha	0.999
4th: Double Exponential Smoothing	Alpha	0.932
	Beta	0.999

Report for D/L Model II - Student Version

Created: 15/10/2544 at 11:03:50

Summary:

Number of series: 1
Periods to forecast: 6
Seasonality: none
Error Measure: RMSE

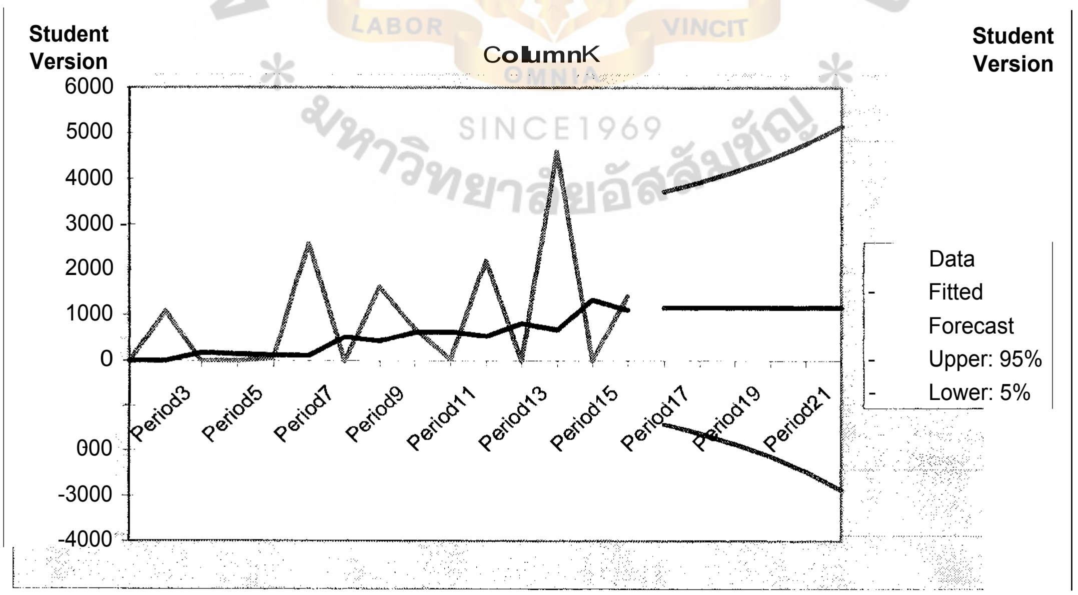
Series: Column K

Range: K19:K33

Method: Single Exponential Smoothing
Parameters:
Alpha: 0.163
Error: 1462.4

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period16	-1428.049244	1149.44302	3726.935285
Period17	-1626.31788	1149.44302	3925.203921
Period18	-1857.631288	1149.44302	4156.517329
Period19	-2131.00168	1149.44302	4429.887721
Period20	-2459.04615	1149.44302	4757.932191
Period2l	-2859.989391	1149.44302	5158.875432



Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Exponential Smoothing	1462.4	1022.6	250.41%
2nd: Single Moving Average	1576.2	1161.7	400.79%
3rd: Double Exponential Smoothing	1864	1593.9	661.04%
4th: Double Moving Average	2147	1842.8	869.92%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Exponential Smoothing	2.879	0.853
2nd: Single Moving Average	3.229	0.633
3rd: Double Exponential Smoothing	2.393	0.814
4th: Double Moving Average	3.061	0.974

Method Parameters:

Method	Parameter	Value
Best: Single Exponential Smoothing	Alpha	0.163
2nd: Single Moving Average	Periods	6
3rd: Double Exponential Smoothing	Alpha	0.234
	Beta	0.999
4th: Double Moving Average	Periods	4

Report for D/L Model JJ - Student Version

Created: 15110/2544 at 11 05 22

Summary:

- Number of series: 1
- Periods to forecast: 6
- Seasonality: none
- Error Measure: RMSE

Series: ColumnL — Range: L6:L33

Method: Single Moving Average

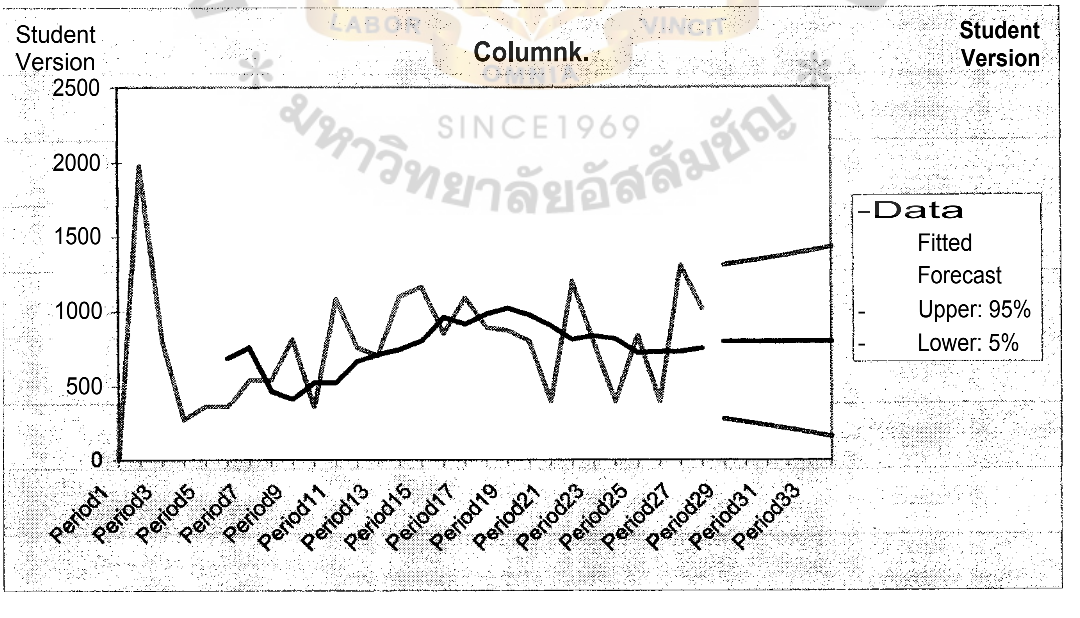
Parameters:

Periods: 5

Error: 303.84

Forecast:

Date	Lower: 5%	Forecast	Upper: 95%
Period29	273.6733938	792	1310.326606
Period30	253.7377551	792	1330.262245
Period31	232.2072653	792	1351.792735
Period32	208.882568	792	1375.117432
Period33	183.5296362	792	1400.470364
Period34	155.8718924	792	1428.128108



Method Errors:

Method	RMSE	MAD	MAPE
Best: Single Moving Average	303.84	254.9	38.01%
2nd: Double Moving Average	324.15	260.56	35.57%
3rd: Single Exponential Smoothing	479.98	303.5	40.41%
4th: Double Exponential Smoothing	807.89	525.79	81.48%

Method Statistics:

Method	Durbin-Watson	Theils's U
Best: Single Moving Average	2.066	0.686
2nd: Double Moving Average	2.235	0.784
3rd: Single Exponential Smoothing	1.928	0.709
4th: Double Exponential Smoothing	1.399	1.234

Method Parameters:

Method	Parameter	Value
Best: Single Moving Average	Periods	5
2nd: Double Moving Average	Periods	6
3rd: Single Exponential Smoothing	Alpha	0.261
4th: Double Exponential Smoothing	Alpha	0.94
	Beta	0.515

APPENDIX F

THE EOQ AND ROP FREQUENCY CHARTS

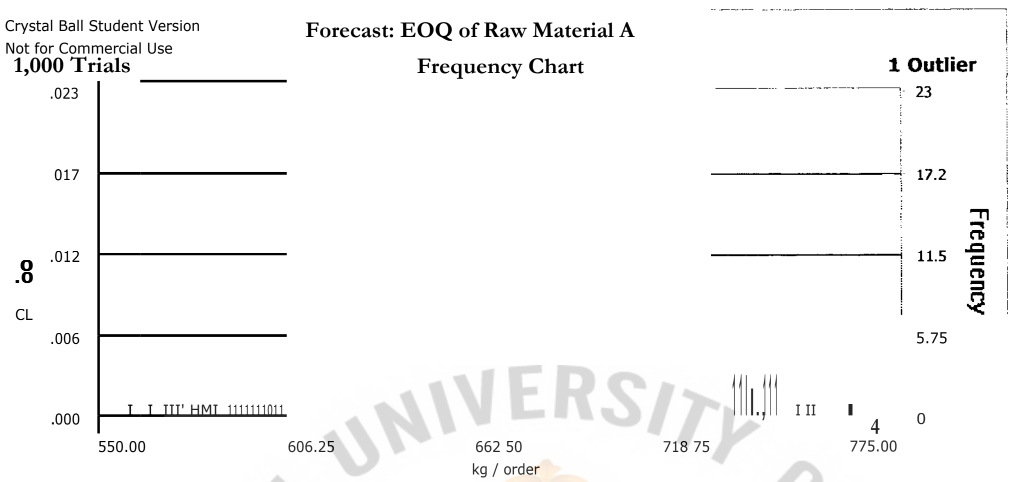


Figure F.1. EOQ Frequency Chart of Raw Material A.

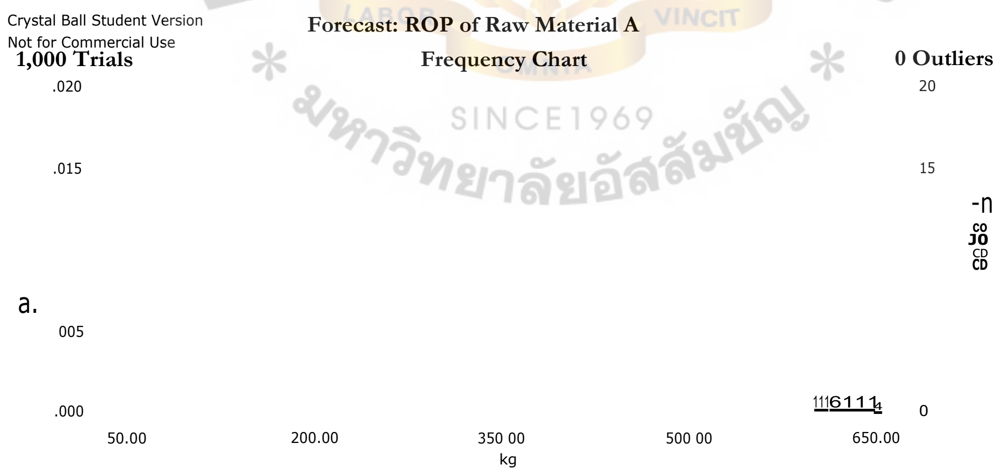


Figure F.2. ROP Frequency Chart of Raw Material A.

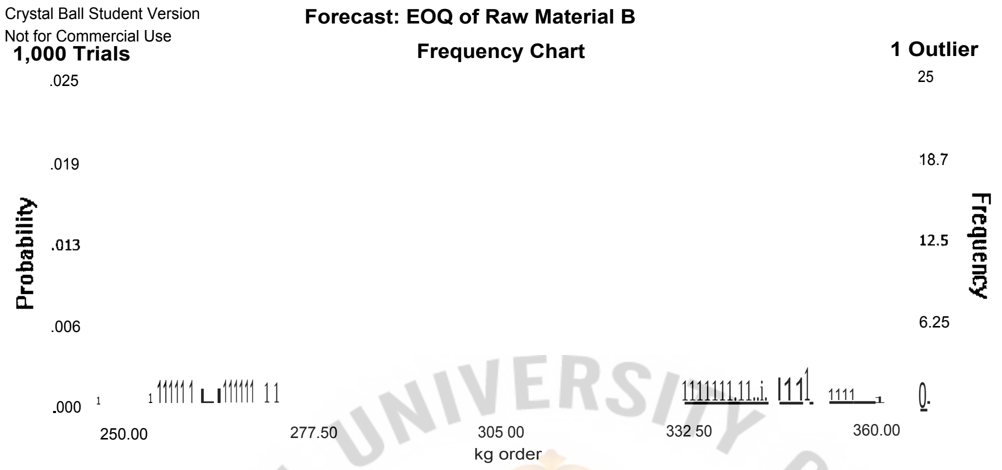


Figure F.3. EOQ Frequency Chart of Raw Material B.

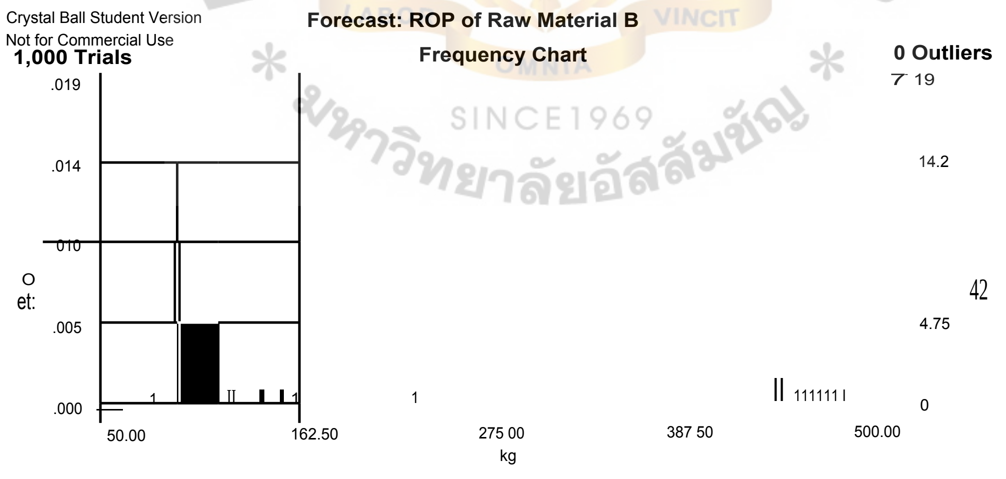


Figure F.4. ROP Frequency Chart of Raw Material B.

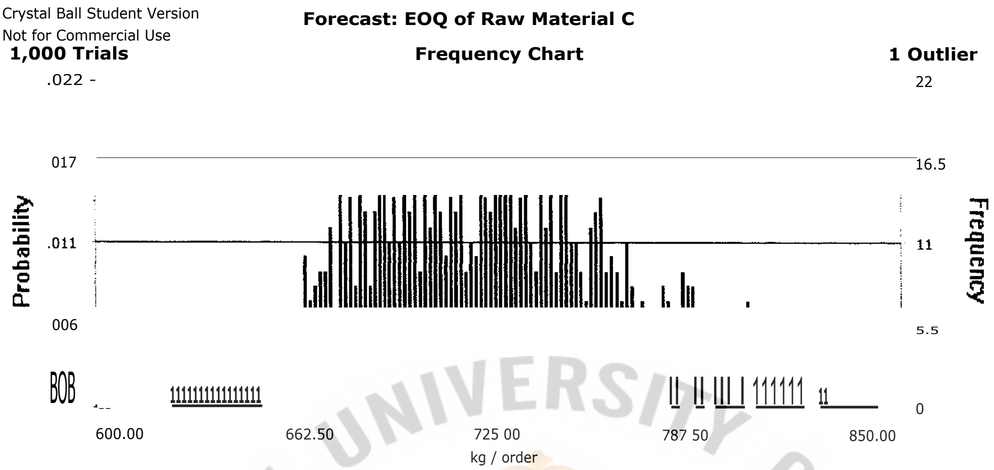


Figure F.5. EOQ Frequency Chart of Raw Material C.

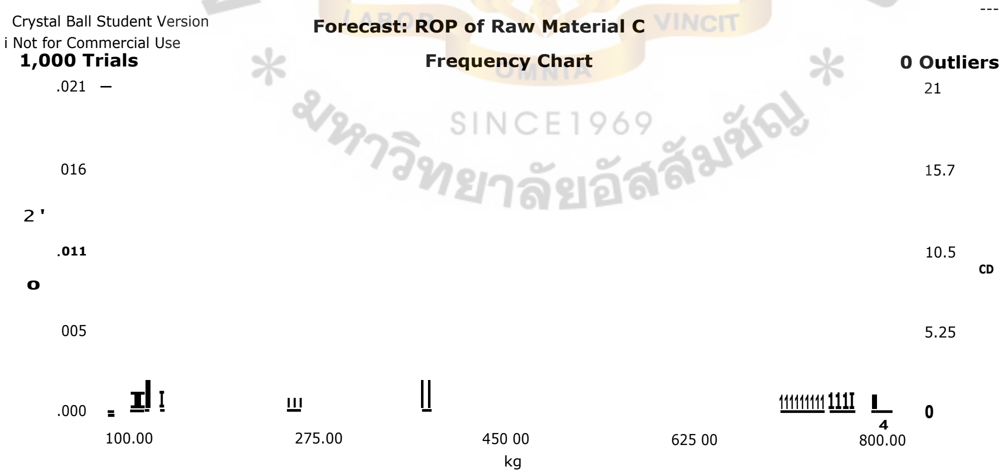


Figure F.6. ROP Frequency Chart of Raw Material C.

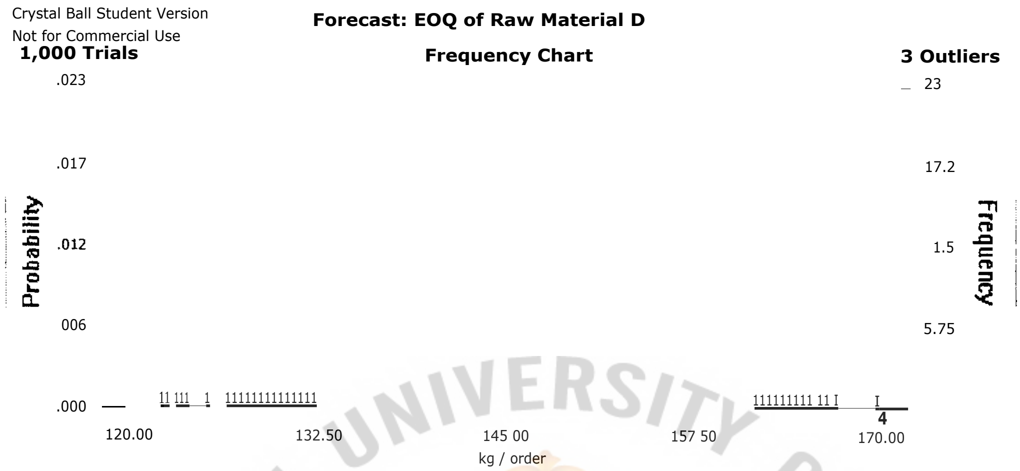


Figure F.7. EOQ Frequency Chart of Raw Material D.

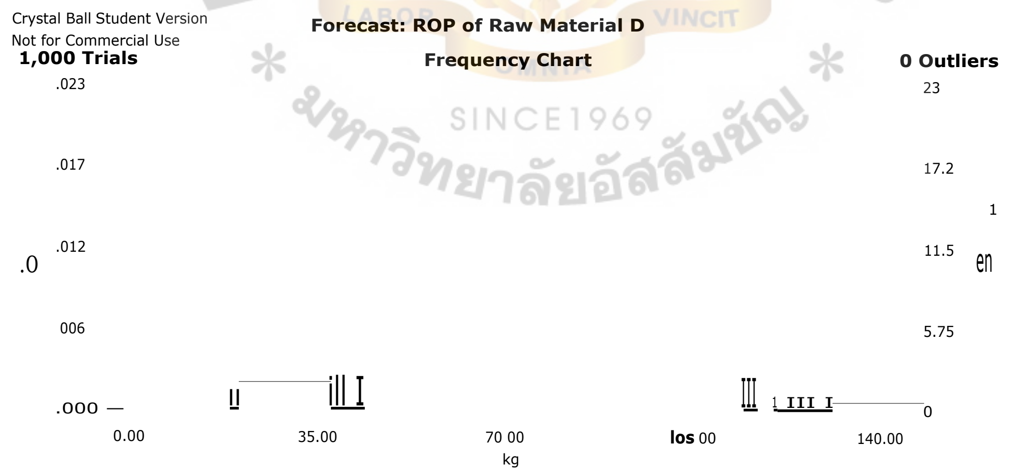


Figure F.8. ROP Frequency Chart of Raw Material D.

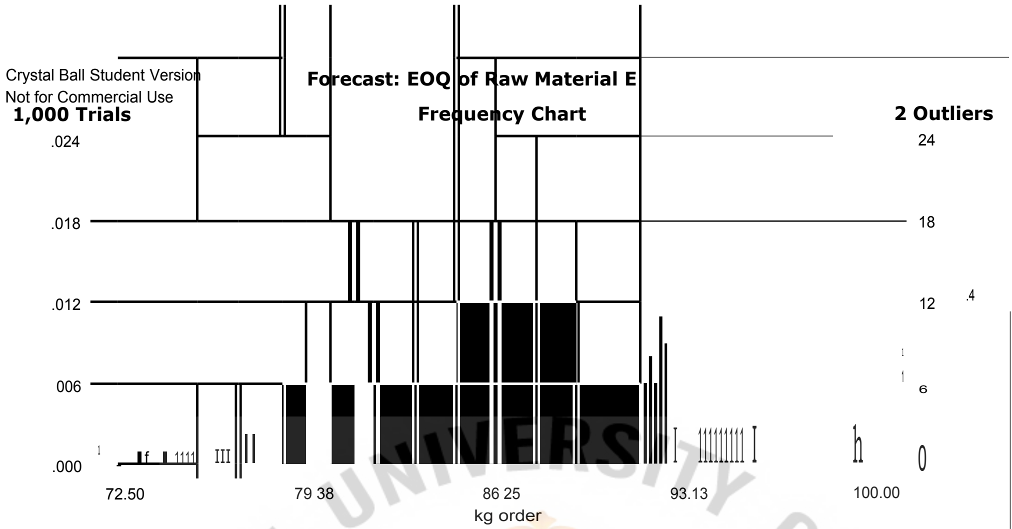


Figure F.9. EOQ Frequency Chart of Raw Material E.

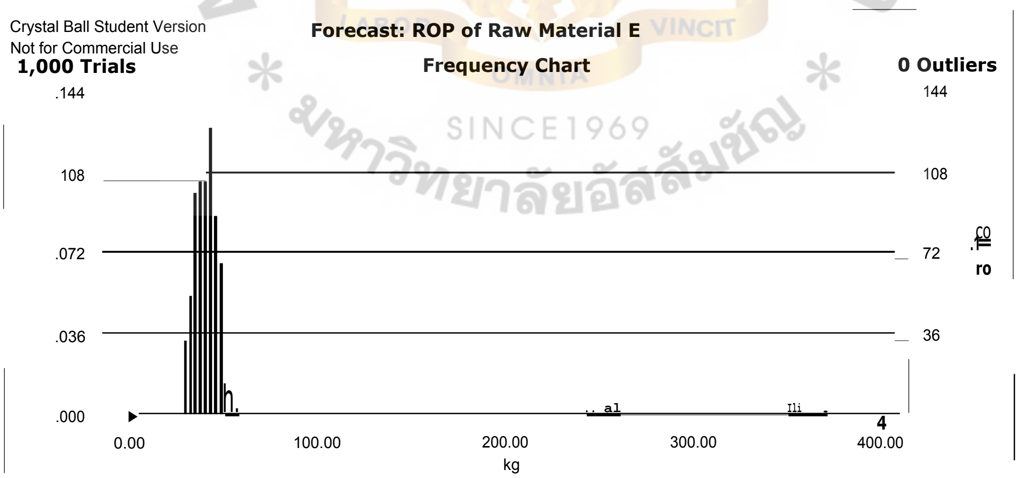


Figure F.10. ROP Frequency Chart of Raw Material E.

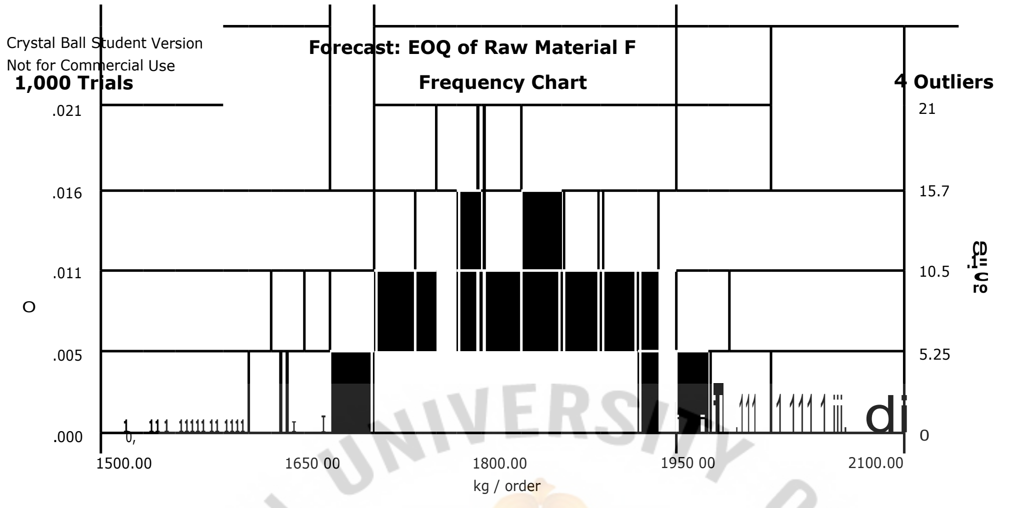


Figure F.11. EOQ Frequency Chart of Raw Material F.

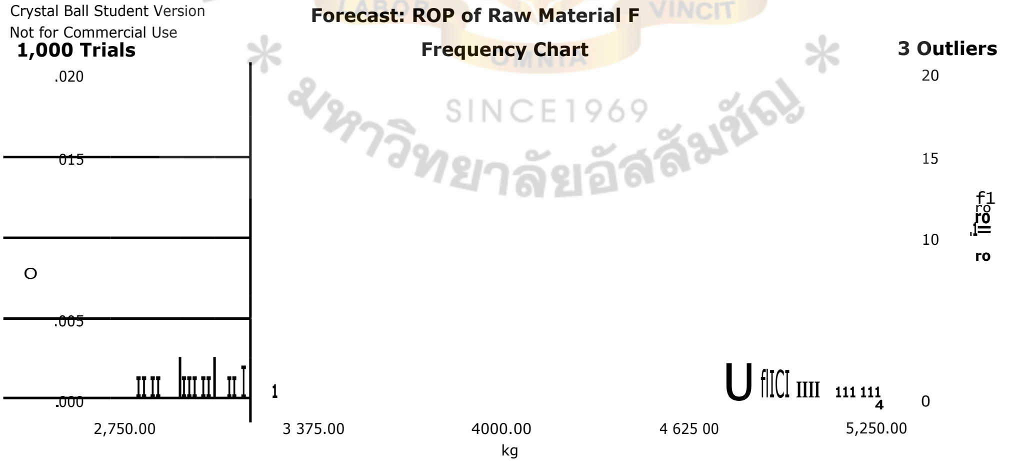


Figure F.12. ROP Frequency Chart of Raw Material F.

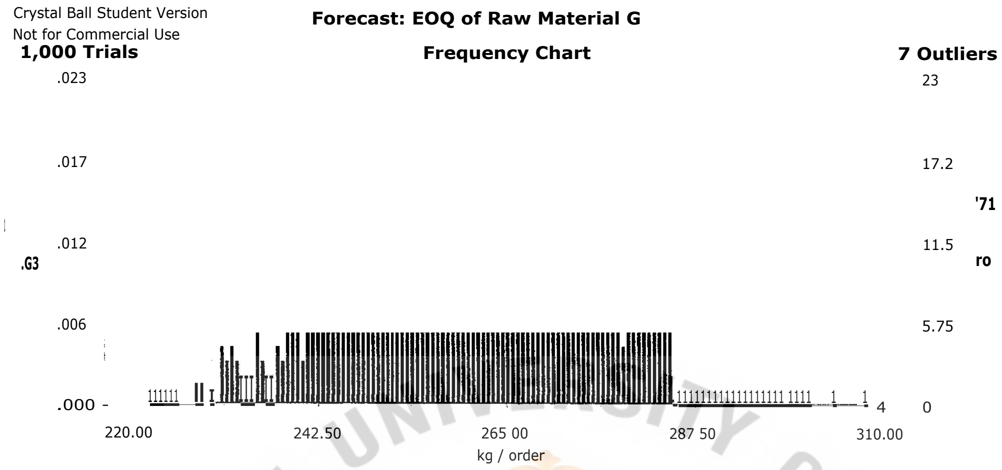


Figure F.13. EOQ Frequency Chart of Raw Material G.

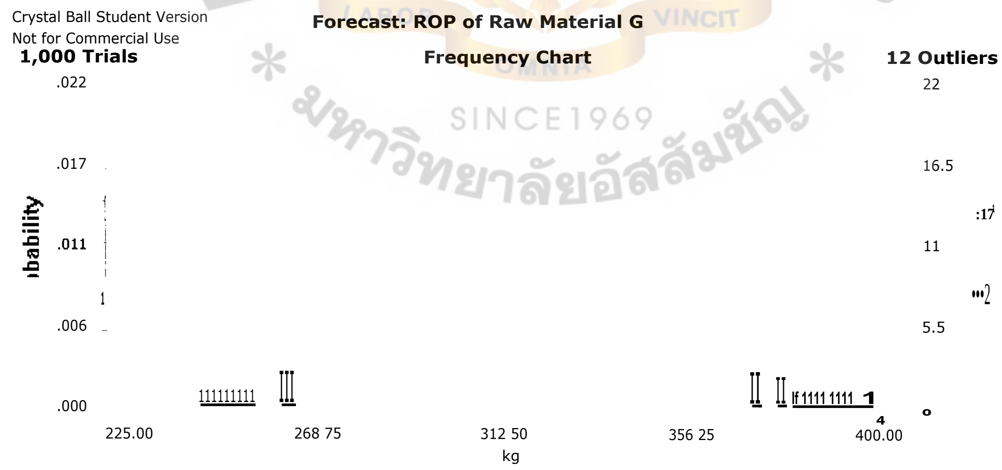


Figure F.14. ROP Frequency Chart of Raw Material G.

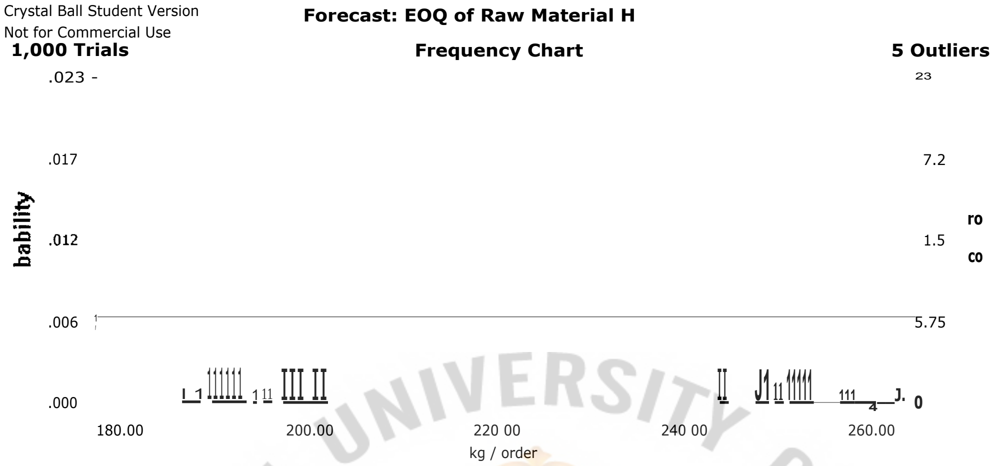


Figure F.15. EOQ Frequency Chart of Raw Material H.

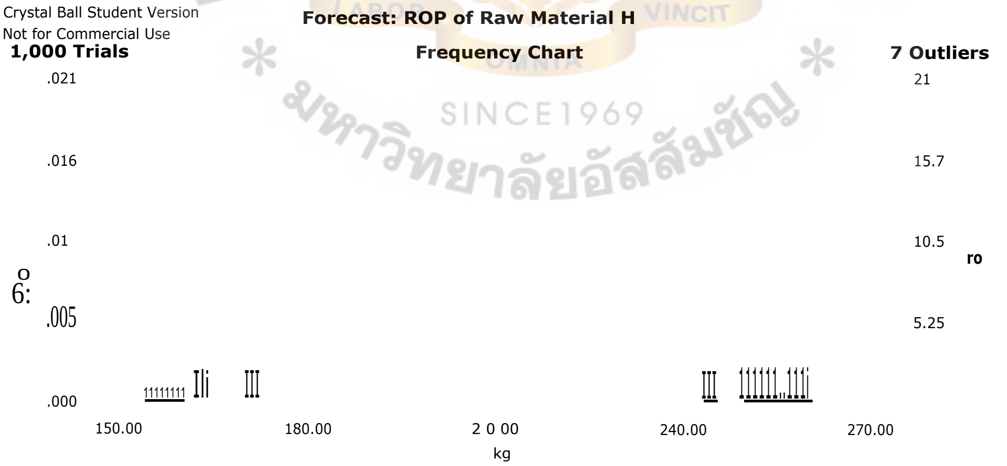


Figure F.16. ROP Frequency Chart of Raw Material H.

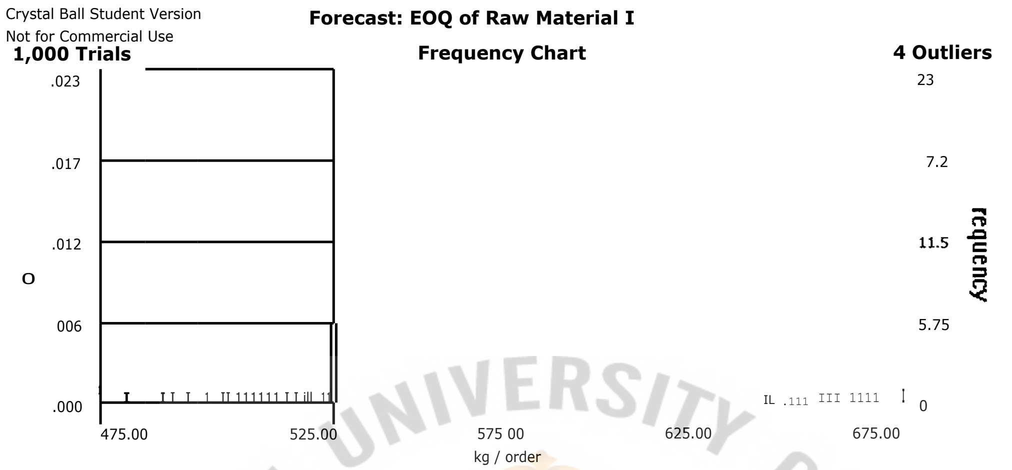


Figure F.17. EOQ Frequency Chart of Raw Material I.

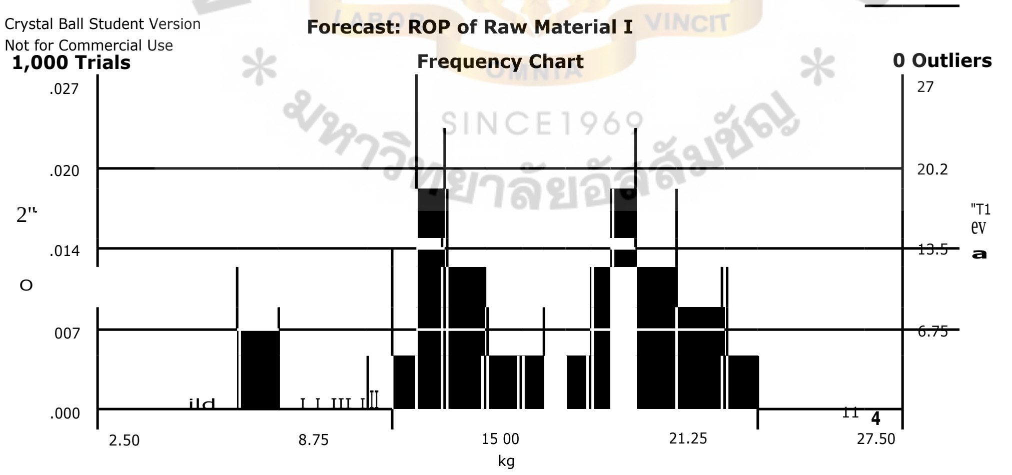


Figure F.18. ROP Frequency Chart of Raw Material I.

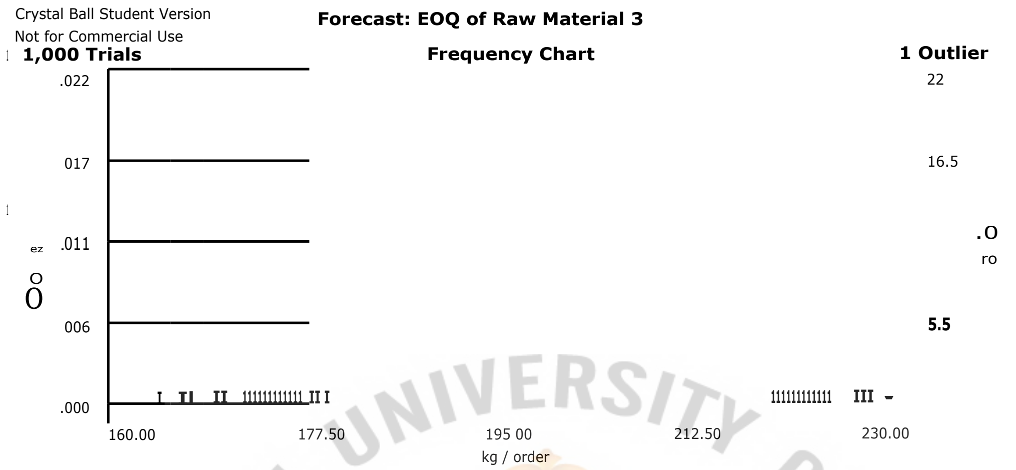


Figure F.19. EOQ Frequency Chart of Raw Material J.

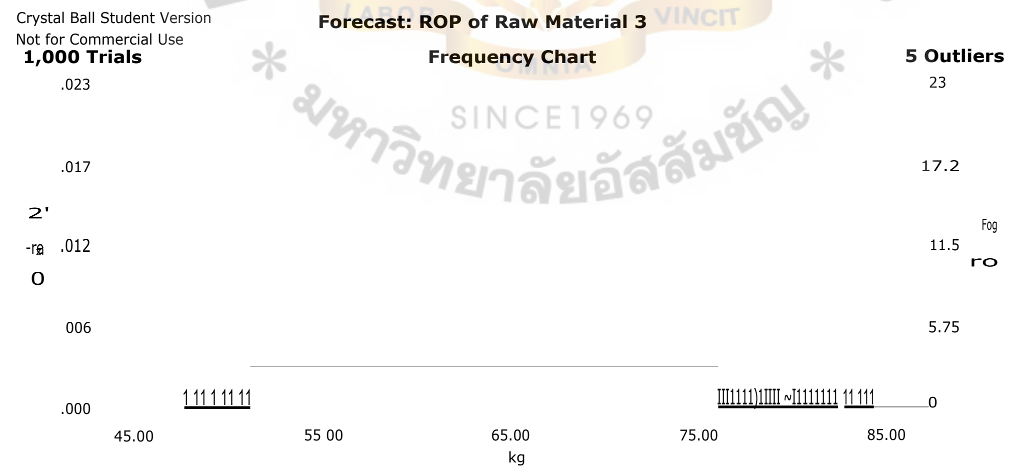


Figure F.20. ROP Frequency Chart of Raw Material J.

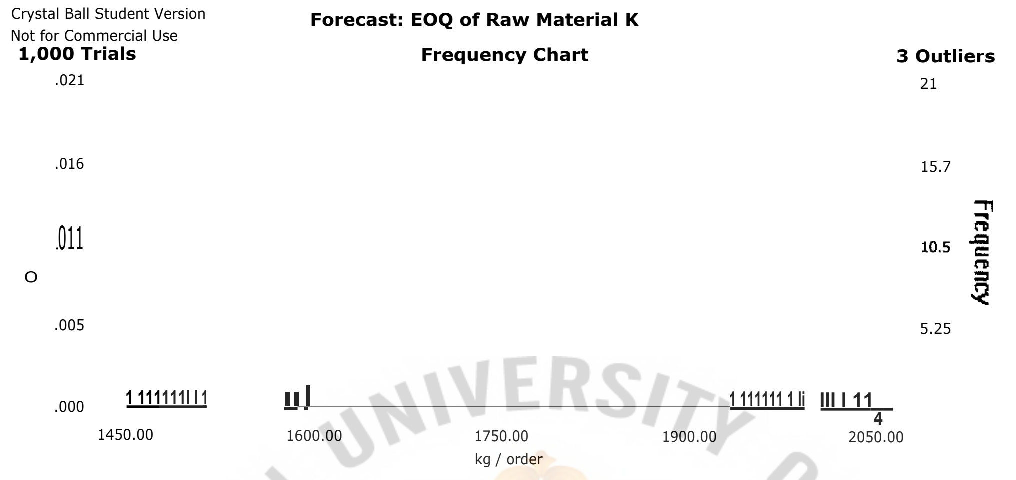


Figure F.21. EOQ Frequency Chart of Raw Material K.

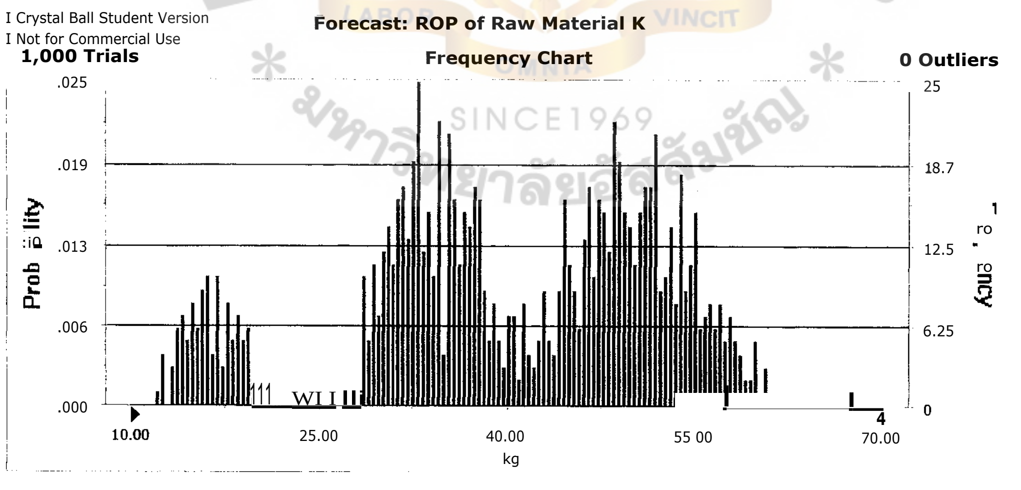


Figure F.22. ROP Frequency Chart of Raw Material K.

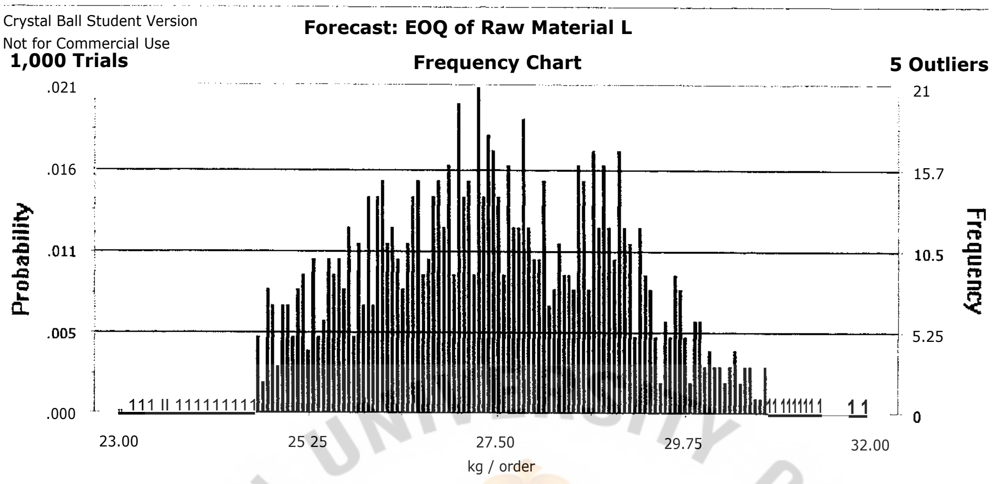


Figure F.23. EOQ Frequency Chart of Raw Material L.

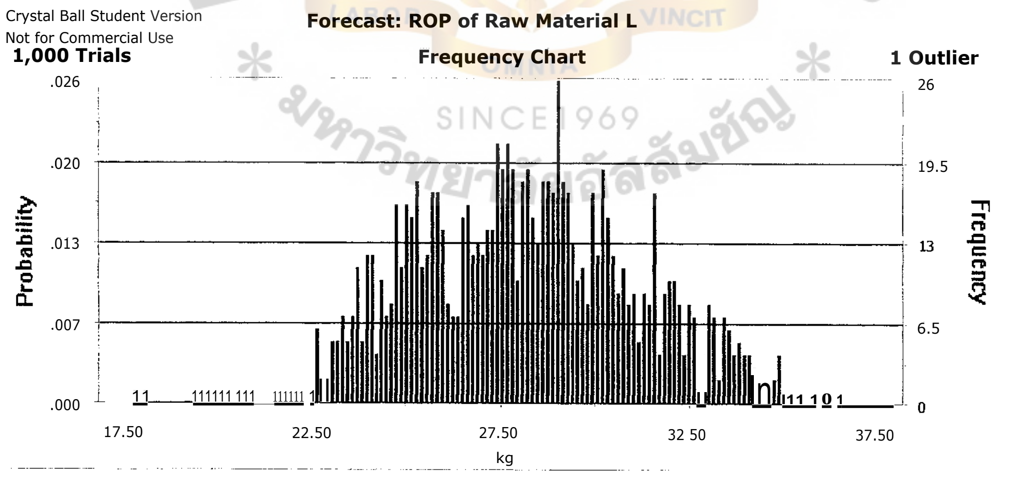


Figure F.24. ROP Frequency Chart of Raw Material L.

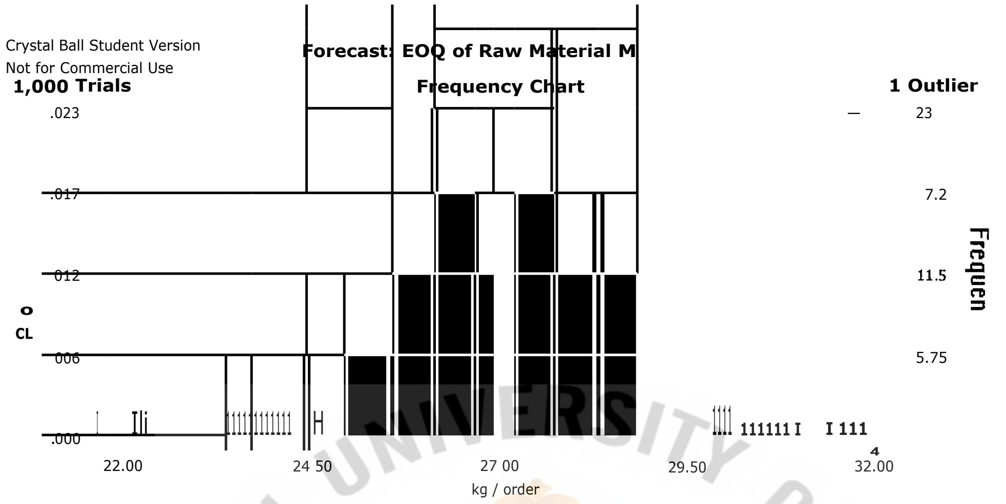


Figure F.25. EOQ Frequency Chart of Raw Material M.

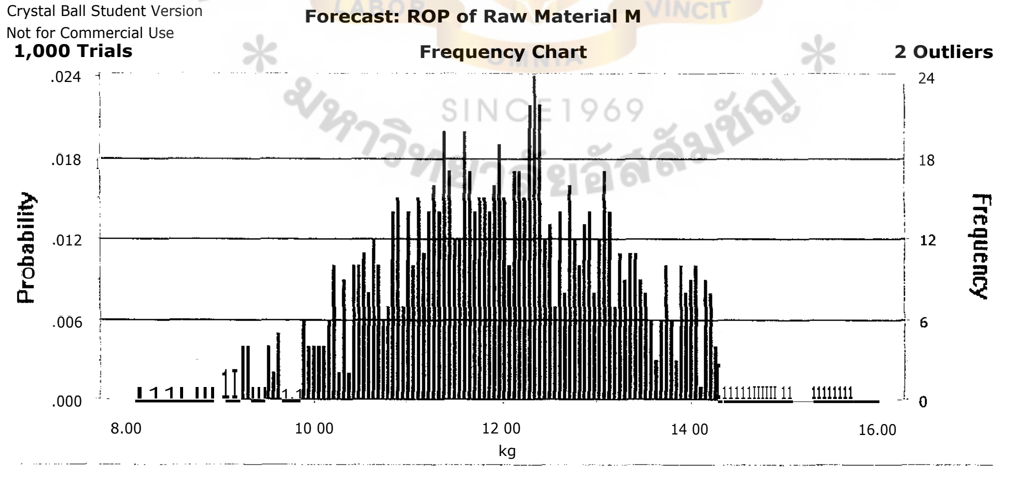


Figure F.26. ROP Frequency Chart of Raw Material M.

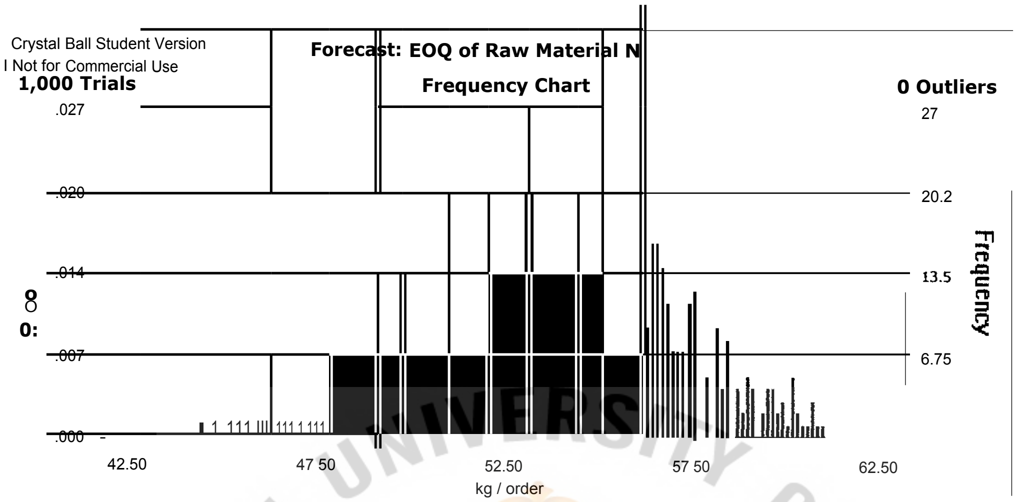


Figure F.27. EOQ Frequency Chart of Raw Material N.

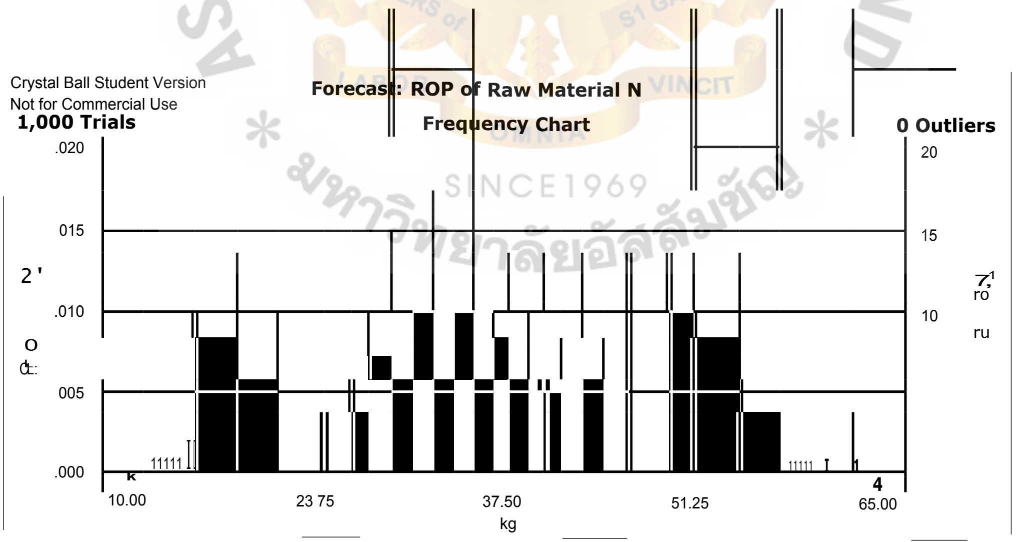


Figure F.28. ROP Frequency Chart of Raw Material N.

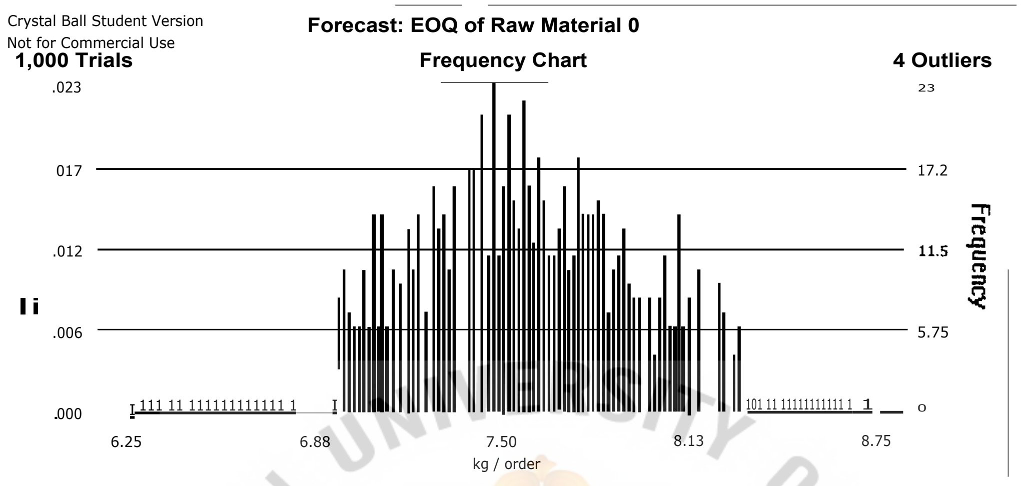


Figure F.29. EOQ Frequency Chart of Raw Material 0.

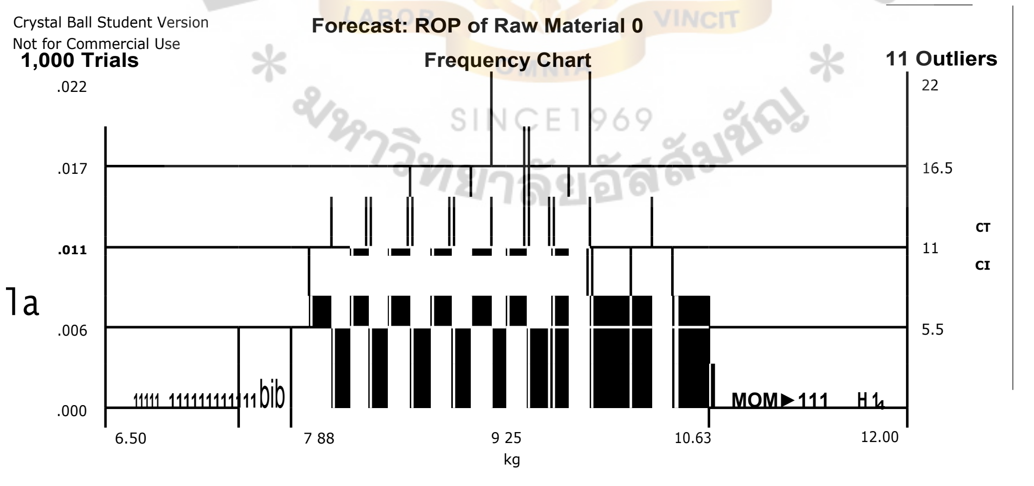


Figure F.30. ROP Frequency Chart of Raw Material 0.

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