



A STUDY TO INTEGRATE INVENTORY MANAGEMENT AND SUPPLY CHAIN MANAGEMENT TO OPTIMIZE VALUE

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Dedication

I dedicate this work to all beloved family, friends and colleagues for their continually support and encouragement.

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The author would like to express his sincere gratitude to Dr. Mohamed Aboushiwa and Dr. Mohamed Ali sherif for their supervision and guidance during the preparation of this dissertation. Special appreciation is also extended to Eng Mostafa A Benhkoma for his valuable advices.

Deepest thanks to my family especially my parents and my brothers for their constant support and prayers throughout the process of this dissertation.

ملخص

هذه الأطروحة معنية بالمقام الأول بتحقيق التكامل بين إدارة المخزون وإدارة سلسلة التوريد لتحسين القيمة.

وقد أجريت تحليلاً لإدارة المخزن في حقل أبو لطفل مع الإشارة بوجه خاص إلى قسم لصيانة بشركة مليته للنفط والغاز. تم شرح فيها بإيجاز جن المشكل العامة التي تواجه وظف التحكم بالمخزون في حقل أبو لطفل، حيث تم تسليط الضوء على جن من أنشطة أقسام لصيانة والتخطيط.

جن المشكل التي تواجه التحكم بالمخزون هي كالمستخدمين الغير المؤهلين بالمخازن، وتكدس المخزون واحيانا نفاذه، ولف جن المواد بب سوء كفاءة التخزين. وهذا العمل موضعاً مع الجلب النظري ذو العلاقة بهذه الدراسة.

البيانات الخاصة بهذه الدراسة تم أخذها من نظام AMOS system والمقابلات الشخصية والمشاهدات من خلال تجميع المعلومات لعمل واقعي لأحد أوامر العمل للتربينة كما تم ذكرها سلفاً . وتم تحليل هذه البيانات في جدول وترتيبها حسب نظام ABC للتحكم بالمخزون. وقد تم من خلاله التوصل إلى رفع كفاءة المخزون حسب ما تم توضيحه بالجلب العملي وبأقل التكلفة وبأقل وقت انتظار، إذا ما تم إتباع هذا الأسلوب.

Abstract

This dissertation is primarily concerned with the Integration of the Inventory Management and Supply Chain Management to Optimize the Value.

An analysis of the management of stock in Abu-Attifel Oil Field with particular reference to the Maintenance department of the Millitah Gas and Oil Company was conducted. In doing this, briefly explain some of the general problems facing the store control functions at Abu-Attifel and went on to touch on the background of the subject matter where some of the activities of the Maintenance & Planning divisions were highlighted.

Some of the problem facing store control systems were highlighted to include the dearth of qualified stores personnel, overstock and sometimes under stocking, pilferages, deterioration, obsolesce and insufficient store materials. The dissertation work further reviewed related literature on the subject matter to sample the opinions of various authors on the subject.

The study employed data collected from AMOS Monitoring System personal interviews and physical observation and the use of secondary data as the major instrument for gathering information. The data gathered was analyzed and shown in contingency tables and ranked based on ABC percentages. Which reached to raise the efficiency of inventory as explained practicality and less cost and less waiting time if this technique is applied.

List of Abbreviations

SCM	Supply Chain Management
SKUs	Stock Keeping Units
WIP	Work-In-Process
JIT	Just-In-Time
MRP	Materials Requirements Planning
VMI	Vendor-Managed-Inventory
AUV	Annual Usage Value
ROP	Reorder Point
SS	Safety Stock
EOQ	Economic Of Quantity
DDLT	Demand During Lead Time
WMS	Warehouse Management System
PO	Purchase Orders
IT	Information Technology
RFID	Radio Frequency Identification
GPS	Global Positioning System
ERP	Enterprise Resource Planning
AMOS	Asset Management Operating System
A100	Abu-Attifel Field

A103	Zuetina Field
NDT	Nondestructive Testing
OQ	Order Quantity
OO	OO Field
UU	UU Field

Table of Contents

Title	Page
Dedication	I
Acknowledgement	II
Abstract (In Arabic)	III
Abstract (In English)	IV
List of Abbreviations	V
List of Contents	VII
List of Tables	XII
List of Figures	XIII
Chapter 1: Introduction	1
1.1 Background	2
1.2 Problem Statement	4
1.3 The Dissertation Aim and Objectives	4
1.4 The Dissertation Hypotheses	5
1.5 The Dissertation Methodology	5
1.6 The Dissertation Limitations	5
1.7 The Dissertation Structure	6
Chapter 2: Concept of the Inventory Management Systems	7
2.1 Introduction	8
2.2 Inventory Management	8
2.2.1 Challenge of Inventory Management	9

2.2.2 Demand Management	10
2.2.3 Inventory Turns	12
2.2.4 Tradeoffs of Inventory	13
2.2.5 Inventory Carrying Costs	14
2.2.6 Classification of Inventory	16
2.2.7 Inventory Control Systems	17
2.2.8 Time of Order	20
2.2.9 Quantity of Order	23
2.3 Summary	27
Chapter 3: Supply Chain Management	28
3.1 Introduction	29
3.2 Definition of Supply Chain Management (SCM)	30
3.3 Supply Chain Management Evolution (SCM)	30
3.4 Advantages Of Supply Chain Management For Manufacturers	32
3.5 The Four Fundamentals of Supply Chain Management	33
3.6 Warehousing	35
3.6.1 The Basic Functions of Warehouse	36
3.6.2 Types of Warehouse	36
3.6.3 Warehouse Layout	37
3.6.4 Warehouse Management System (WMS)	38
3.7 Purchasing Management	39
3.7.1 The Major Purchasing Decision Processes	40

3.7.2 Supplier Relationship Management	40
3.8 IT Application in SCM	41
3.8.1 The Role of IT in SCM	42
3.8.2. IT goals in SCM	42
3.8.3. Integrating Supply Chain IT	43
3.9 ERP Information System in Organizations	44
3.9 ERP Information System in Organizations	45
Chapter 4: The Integration between supply chain and Inventory management	46
4.1 Introduction	47
4.2 Supply Chain Integration	47
4.3 Internal Supply Chain Integration	49
4.4 Significance of Supply Chain Integration	49
4.5 Information & its Significance in the Supply Chain	50
4.6 Information & its Significance in the Supply Chain	50
4.7 ERP Functions in Line With The Integration of Different Sections of The Company	51
4.8 Key Processes in the Supply Chain Management	52
4.9 Opportunities & Obstacles of the Integration of the Supply Chain	52
4.10 The Necessity of Integration in ERP and SCM	54
4.11 Inventory Management in Supply Chain Environment	54
4.12 Significance of Information flow in Supply (SCIM)	55
4.13 How to Implement Supply Chain Management	55

4.14Examining the Basics of Supply Chain Management	56
4.15 Summary	58
Chapter 5: The Practical Part/The Case Study	59
5.1 Introduction	60
5.2 Production & Export Processes	61
5.3 Production Areas	62
5.4 Maintenance Organization	64
5.5 AMOS – Environment	65
5.6 AMOS - Maintenance Management Impact	65
5.7 AMOS - Material Management Impact	66
5.8 Organization Structure	68
5.9 Inventory Control System	68
5.10 ABC Analysis	69
5.11 Warehouse	74
5.11.1 Warehouse Layout	74
5.11.2 Warehouse Management System (WMS)	78
5.12 Information System	78
5.13 Component/Equipment Technical Data	79
5.14 Work Order	81
5.15 Discussion of Finding	82
Chapter 6 Conclusion, Recommendations & Future studies	83
6.1 Introduction	84

6.2 Theoretical Conclusions	84
6.3 Practical Conclusions	85
6.4 Recommendations	86
6.5 Future Studies	87
Appendix	88
References	108

List of Tables

Table No.	Title	Page
3.1	Supply Chain Management	33
4.1	Opportunities, Limitations, & Techniques	53
5.1	GTN-IN-07 3 Year Replacing KIT of Blowoff Valve Technical Data based on AMOS Monitoring System data in	70
5.2	Ranking of items, using a 20-40-40% ABC classification	72

List of Figures

Figure No.	Title	Page
2.1	Saving Inventory Dollars By Inventory Turns	13
2.2	What costs go into inventory carrying costs?	15
2.3	Typical Representation of ABC Analysis	18
2.4	Inventory Level In A Continuous Review Model	21
2.5	ROP With Safety Stock	22
2.6	Inventory Level In A Periodic Review Model	23
2.7	EOQ Model	25
3.1	The "micro" or Internal Supply Chain	34
3.2	The Example Of Material's Barcode Scans	39
3.3	The Cost Of Unsuccessful Supplier Relationships	41
4.1	Integration of Supply Chain with Inventory Management	58
5.1	The Map of Abu-Attifel Field Location	61
5.2	Separation Trains - (1972)	63
5.3	Storage Capacity Enlargement - (1984)	63
5.4	The Organization Structure for Abu-Attifel Field	68
5.5	The Example Of Column Grid Label	74
5.6	Abu- Attifel Warehouse	75
5.7	The Example of Shingle of Zone	76

5.8	The Example Of Item Location Guide	76
5.9	Incorrect Rack Label	77
5.10	Example 1, No Label	77
5.11	Example 2, No Label	78
5.12	Printout of GTIN-0007Technical Data using AMOS Monitoring System	80
5.13	Printout Of Work Order Page Using Amos Monitoring System	88
5.14	Detailed Data On Work Order Page Using Amos Monitoring System	89
5.15	Type Of Items And Spare Parts Need To Ordered	90
5.16	Component/Equipment Technical Data	91
5.17	Financial Data On Work Order Page	92
5.18	Stock Items (Page 1)	93
5.19	Stock Items (Page 2)	94
5.20	Stock Items (Page 3)	95
5.21	Stock Items (Page 4)	96
5.22	Stock Items (Page 5)	97
5.23	Stock Items (Page 6)	98
5.24	Stock Items (Page 7)	99
5.25	Stock Items (Page 8)	100
5.26	Stock Items (Page 9)	101
5.27	Stock Items (Page 10)	102
5.28	Stock Items (Page 11)	103
5.29	Stock Items (Page 12)	104

5.30	Stock Items (Page 13)	105
5.31	Stock Items (Page 14)	106
5.32	Stock Items (Page 15)	107

Chapter One

Introduction

Chapter one

Introduction

1.1Background

Inventory management is managing the parts or stocks of materials in any form inside the plant and stabilizing the flow of materials considering the variability in demand. It is very important that the inventory plans are structured in such a way that they accommodate variability in demand especially when the company deals with multiple products. Inventory management starts from procurement of materials for manufacturing or processing until it reaches the customer as a finished product. Even stocked up finished goods are to be managed inside the facility along with the unprocessed materials. So it becomes important to frame an overall plan that considers all materials to be stocked up inside the facility. Inventory management plans will lead to categorizing parts that comprise to a complete product and helps in deciding the amount of inventory for each part that is stocked at any given time. Inventory management also facilitates a plant to decide the release and order intake dates of raw materials and finished parts considering the demand of the product and allotment of space for stocking materials inside the available facility ⁽¹⁾.

During the 1990s, many manufacturers and service providers sought to collaborate with their suppliers and upgrade their purchasing and supply management functions from a clerical role to an integral part of a new phenomenon known as supply chain management. Since this aspect of supply chain management primarily focuses on the purchasing and supply management functions of industrial buyers, we have classified it elsewhere as the purchasing and supply perspective of supply chain management ⁽²⁾. Correspondingly, many wholesalers and retailers have also integrated their physical distribution and logistics functions into the transportation and logistics perspective of supply chain management to enhance competitive advantage. Over the last 10 years, these two traditional supporting functions of corporate strategy evolved along separate

paths and eventually merged into a holistic and strategic approach to operations, materials and logistics management commonly referred to as supply chain management (SCM) ⁽³⁾.

SCM has in recent years become an important way to enhance the company's competitive strength and therefore an important issue for most companies, a summary definition of the supply chain can be stated as: "All the activities involved in delivering a product from raw material through to the customer including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer and the information systems necessary to monitor all of these activities" ⁽⁴⁾.

Supply Chain Management is a network of facilities that produce raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system. It spans procurement, manufacturing and distribution ⁽⁵⁾ the basic objective of supply chain management is to "optimize performance of the chain to add as much value as possible for the least cost possible". In other words, it aims to link all the supply chain agents to jointly cooperate within the firm as a way to maximize productivity in the supply chain and deliver the most benefits to all related parties ⁽⁶⁾.

Supply chain management coordinates and integrates all of these activities into a seamless process. During the process, inventory holding and warehousing play an important role in modern supply chains. A survey of logistics costs in Europe identified the cost of inventory as being 13% of total logistics costs, whilst warehousing accounted for a further 24% ⁽⁷⁾. As well as being significant in cost terms, they are important in terms of customer service, with product availability being a key service metric and warehousing being critical to the success or failure of many supply chains.

1.2 Problem Statement

The researcher is one of the employees working for Millitah Company at Abu-Attifel field as a Maintenance Planner. AMOS System is effective software program that can help support the maintenance and planning crews to plan and preparing for turnaround scheduled maintenance. Some items and spare parts were shown available based on the given data on AMOS Monitoring System. Indeed the researcher has usually making double check to ensure the availability of the spare parts to be used in the scheduled/planning maintenance for any turbine or other equipments.

Damage to many stocks, nil stock, and missing labeling, bad arrangements and un classification of the spare parts in the warehouse were appeared during the site visit of the planning and maintenance crew.

The AMOS System was well programed to issue a purchase order whenever the parts reached to a minimum certain level. Labeling of varieties of spare parts on the wrong way, which makes it difficult to find the desired product, and sometimes making the issue an order to buy this new product which increases the accumulation of inventory in stock and increase investment in the wrong. Inventory stock-out often occurs despite the heavy investment in inventory. The lead-time of some suppliers in Europe has been further extended from previous three months to six months due to the production delay.

1.3 Dissertation Aim and Objectives

The research is aimed to study the intergradation between the inventory management and supply chain management in order to optimize the value. To achieve this aim, the following below objectives must be met:

1. Identify the factors that lead to inefficient inventory management system.
2. Analysis the relevant theories and understand the business operational practice.
3. Investigate the supply chain management to optimize value.

4. Develop feasible managerial suggestions to improve the company's inventory man.

1.4 Dissertation Hypotheses

Poor estimation of required type and quantities of spare parts needed of plant due to not implementing correct stock procedures and Lack proper coordinate management between other supply chain which all leads to poor estimate and low of value.

1.5 Dissertation Methodology

The Methodology of this dissertation was divided into two parts as follows:

1st .Theoretical part:

1. An extensive literature review on related topics of Inventory Management and Supply Chain Management were conducted thoroughly from sources such as: Books, Journals, Magazines, Leaflets and Guides.
2. Many websites related to the topics of Inventory Management and Supply Chain Management were visited which constituted an important sources of information to the dissertation.

2nd. The Practical Part:

In order to achieve the research goals Abu-Attifel Field was used as a quantifies and qualitative a case study. Data collection is mainly through the interviews with the top managers and other staff involved in inventory control operations. Some data were obtained from the actual readings given by the AMOS Monitoring System and compared by the actual availability of the spare parts in the warehouse.

1.6 Dissertation Limitations

The research is restricted only to the following:

1. The case study scope is limited to the internal inventory management of Mellitah Oil Company, not reaching out into the other actors in the supply chain network.

2. Time Limitation: it is impossible to make a longitudinal study, in which the implementation result of the proposed inventory control system can be observed and verified. And this harms the credibility of the study to some extent.

1.7 Dissertation Structure

The dissertation is divided into seven chapters as following including this chapter:

Chapter One: Shows the introduction, the problem statement and the aim of this dissertation.

Chapter Two: Reviews the literature on Inventory Management and methods of repetitive projects. It covers related previous studied.

Chapter Three: Reviews the literature on the Supply Chain Management and its concept of repetitive projects. It covers related previous studied.

Chapter Four: Reviews the concept of the Integration between Inventory Management and Supply Chain Management.

Chapter Five: It shows the practical part and the case study for Abu-Attifel field.

Chapter Six: Conclusions, Recommendations and future studies.

Chapter Two

Concept of the Inventory Management Systems

Chapter Two

Concept of the Inventory Management Systems

2.1 Introduction

Inventory is generally defined as “stock at a particular location”. Traditionally inventory for a manufacturing business is classified as raw materials, work-in-progress, finished goods and MRO (Maintenance, Repairs and Operating supplies). For retail and distribution businesses, majority of the inventory can be labelled as finished goods. For service industries, majority of the inventory can be labelled as consumables. Effective inventory management plays a critical role in the smooth and efficient running of any business. Reducing excess inventory and investing in the right inventories lead to improved customer service, increased inventory turnover, reduced costs and increased profitability.

This chapter explores the different theories and models that are related to the subject of this dissertation and can be used for the analysis

2.2 Inventory Management

Hakansson and Persson ⁽⁸⁾ identifies three different trends in the development of logistics solutions within industry, one trend is concerned with the increased integration of logistics activities beyond organization boundaries with an aim to reduce cost items such as capital costs for inventory and handling costs of flows.

Inventory as an asset on the balance sheet of companies has taken on increased importance because many companies are applying the strategy of reducing their investment in fixed assets, like plants, warehouses, equipment and machinery, and so on, which even highlights the significance of reducing inventory.

Changes in inventory levels affect return on assets (ROA), which is an important financial parameter from an internal and external perspective. Reducing inventory usually improves ROA, and vice versa if inventory goes up without offsetting increases in revenue.

2.2.1 Challenge of Inventory Management

The wholesalers and retailers that are major actors involved in downstream distribution channels face a special challenge in keeping inventory at reasonable levels due to the difficulty of forecasting demand and expectations of customers about product availability.

The challenge grows even bigger when the diversity of products in terms of their color/design, package type, size and so on. To further explain the problem, an accurate demand forecast is assumed; however, the aggregate demand needs to be broken down by various specifications of the product into sub-total demand forecast to guide the stock keeping units (SKUs) in the company in order to fulfill the final customer's order. But the sub-total demand forecasts could be diverse, reaching dozens, hundreds, or even thousands of categories; in that case, they become truly difficult, complex and time-consuming.

The difficulty of forecasting demands accurately naturally results in two problems, which are in opposite extreme, overstock and stock-out of inventory. As companies strive to avoid lost sales from stock-out of inventory, there is a tendency to overstock. Nevertheless, because keeping inventory is costly which definitely reduces the profit margin, companies try to reduce the inventory level, so appears the tendency to stock-out of inventory. Dilemma of inventory management can get an overview, where two opposing powers keep pulling the inventory towards their own direction. It is hard to balance the two powers all the time and station the inventory at the right level constantly.

2.2.2 Demand Management

Demand management may be thought of as “focused efforts to estimate and manage customers’ demand, with the intention of using this information to shape operating decision”⁽⁹⁾. The different types of the demand management approach are as follows:

A. Independent and Dependent Demand

Independent demand is what whose usage is based on external market requirements rather than related to other items’ demand. The market demand for consumer goods is a typical example of independent demand. Dependent demand is determined by the requirements of other items in the manufacturing process. The requirement of components or parts is based on the demand for the finished products.

The inventory corresponds to independent demand is called distribution inventory/ finished product inventory, while dependent demand inventory is known as manufacturing inventory/raw material inventory and work-in-process (WIP) inventory.

Inventory is kept to meet demand, in light of dependent demand and independent demand, different approaches to managing inventory should be applied to align inventory supply with demand. Just-in-Time (JIT) approach and Materials Requirements Planning (MRP) system are typically associated with managing manufacturing inventory to serve dependent demand. Cross-docking is a typical approach for managing distribution inventory efficiently. Nevertheless, Vendor-managed-inventory (VMI) approach is applicable both for manufacturing inventory and distribution inventory.

B. Demand Forecast

Sufficient data result in more effective forecasts. The traditional way to forecast demand is to refer to the historical record of demand. All forecasting techniques are characterized by the fact that the more data are observed, estimates of the average

demand and demand variability should modify more and more. Of course, forecasts are never completely accurate. Indeed, the rules of forecasting hold are as follows⁽¹⁰⁾:

1. The forecast is always wrong. It is very unlikely that actual demand will exactly equal forecast demand.
2. The longer the forecast horizon, the worse is the forecast. A forecast of demand far in the future is likely to be less accurate than a forecast of near-future demand.
3. Aggregate forecasts are more accurate.

C. Stock-out

If stock-out occurs, different scenarios will happen. Subject to distribution inventory stock out or manufacturing inventory stock-out, the impact on the supplier and the customer is different in terms of extent and scale, i.e. the impact is greater and more serious for one party than the other one. So the attitude toward stock-out varies accordingly. For instance, if there is a manufacturing inventory stock-out in the manufacturing companies like Ford and Toyota, the result is critical. The production line will be shut down and startup costs are very high. Hence such stock-out is prohibited. In case of distribution inventory stock out, the impact on the customer is usually not big and serious, e.g. it is not a big deal when consumers encounter such a stock-out, therefore their counterparts-the suppliers, such as wholesalers and retailers, tolerate stock-outs.

When a supplier is unable to satisfy demand with available inventory, one of four events may occur: (1) the customer waits until the new replenishment arrives; (2) the customer back orders the product; (3) the sale is lost; (4) the customer is lost. For most companies, the four results are listed from best to worst in terms of the impact.

D. Safety Stock

Safety stock is one kind of inventory which can protect against fluctuations in demand or supply. And he also indicated that ‘the quantity of safety stock is built into the

reordering system's calculation in a manner that the inventory is not planned for consumption under normal (perfect) circumstances. Because of the situation of uncertainty in demand or delays in lead time or inadequate delivery, the company needs a small amount of safety stock on hand. In other words, the basic function of safety stock is to avoid stock-outs.

Another reason for setting safety stock is it could affect customer service level. When the actual order quantity from the customer is more than prediction, the safety stock needs to be held to avoid customer service problems. The setting of safety stock will base on the tradeoff between service level and inventory investment. The quantity of safety stock should cover more than normal demand during the replenishment lead time. There are some parameters that should be considered when calculating the suitable quantity of safety stock, such as recent demand needs, lead time and the target service level.

2.2.3 Inventory Turns

Inventory turns indicates the number of times per year the companies such as retailers and manufacturers are able to sell off or use up their complete inventory of raw materials or finished goods.

To maximize sales with the least amount of inventory, the company should try to meet demands by ordering smaller quantities more frequently from the suppliers, thus achieving more inventory turns, which refer to the annual number of times that average inventory sells. The inventory turns can be expressed mathematically as⁽⁹⁾:

$$\text{Inventory turns} = \frac{\text{Sales volume at cost}}{\text{Value of average inventory}} \quad (2.1)$$

Increasing inventory turns means the company is holding fewer inventories on average, at the same time being able to fulfill the customer demand. The company's finance desires to reduce inventory, increase inventory turnover, and yield high capital return on assets. But the company should note that there is no such a conclusion that the more inventory turns, the better the inventory policy. Again, individual company should recognize an appropriate number in their best interest.

Figure (2.1) gives an example to demonstrate the relationship between inventory carrying cost and inventory turns. As inventory turns increase, inventory carrying cost will reduce.

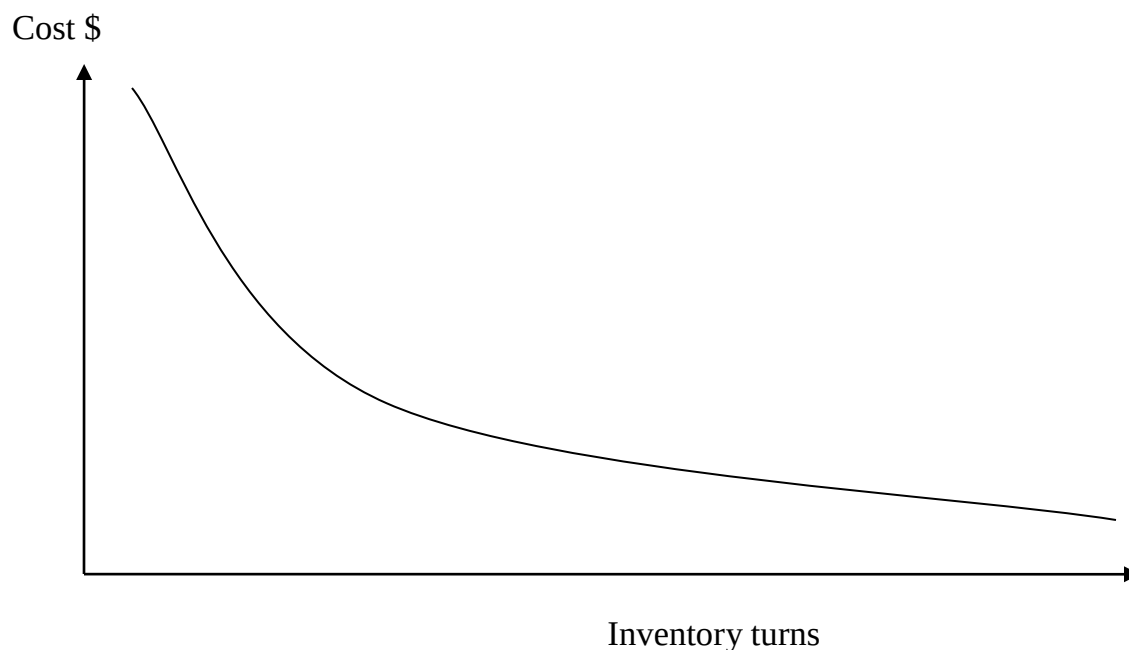


Figure (2.1): Saving inventory dollars by inventory turns. ⁽⁹⁾

2.2.4 Tradeoffs of Inventory

As to the performance measurement of a supply chain there are various parameters that should be taken into consideration from different perspectives. However, some of them are tradeoffs, which mean there are conflicting goals in SCM and identified three tradeoffs concerning inventory as follow ⁽¹⁰⁾:

(a) The Product Variety-Inventory Tradeoff

Obviously, product variety dramatically increases the complexity of SCM. Since it is usually difficult to accurately forecast the demand for each type of product, higher aggregate inventory levels must be maintained to ensure the same customer service level. For a firm that is supplying a variety of products the major challenge needs to be addressed is how to match supply and demand effectively for each product. The suppliers always pursue lower inventory levels because of financial concerns. And they are under temptation to increase the product variety in order to increase total sales volume. But when the product variety increases, inventory levels increase as well, so the effect on sales is offset to some extent by the increase in inventory levels.

(b) The lot Size-Inventory Tradeoff

Manufacturers would like to have large lot sizes to reduce setup costs per unit, however, typical demand does not come in large lot sizes, so large lot sizes lead to high inventory, i.e. the larger is the lot size, and the higher is the inventory level.

(c) The Transportation Cost-Inventory Tradeoff

Full loads minimize transportation costs because they can be spread among the largest possible volume of products. In many cases, however, demand is in small quantity of far less than a single full-load. Thus, when products are delivered in full loads, they have to wait for longer periods of time before they are used, leading to higher inventory costs.

2.2.5 Inventory Carrying Costs

There are costs associated with holding all inventories, and the costs go beyond the expenditure of the inventory investment, inventory carrying costs form an interesting concept, representing both accounting costs and economic costs⁽¹¹⁾. Accounting costs are explicit and call for a cash payment. Economic costs are implicit, not necessarily

involving an outlay but rather an opportunity cost. The components of inventory carrying costs are illustrated in Figure (2.2).

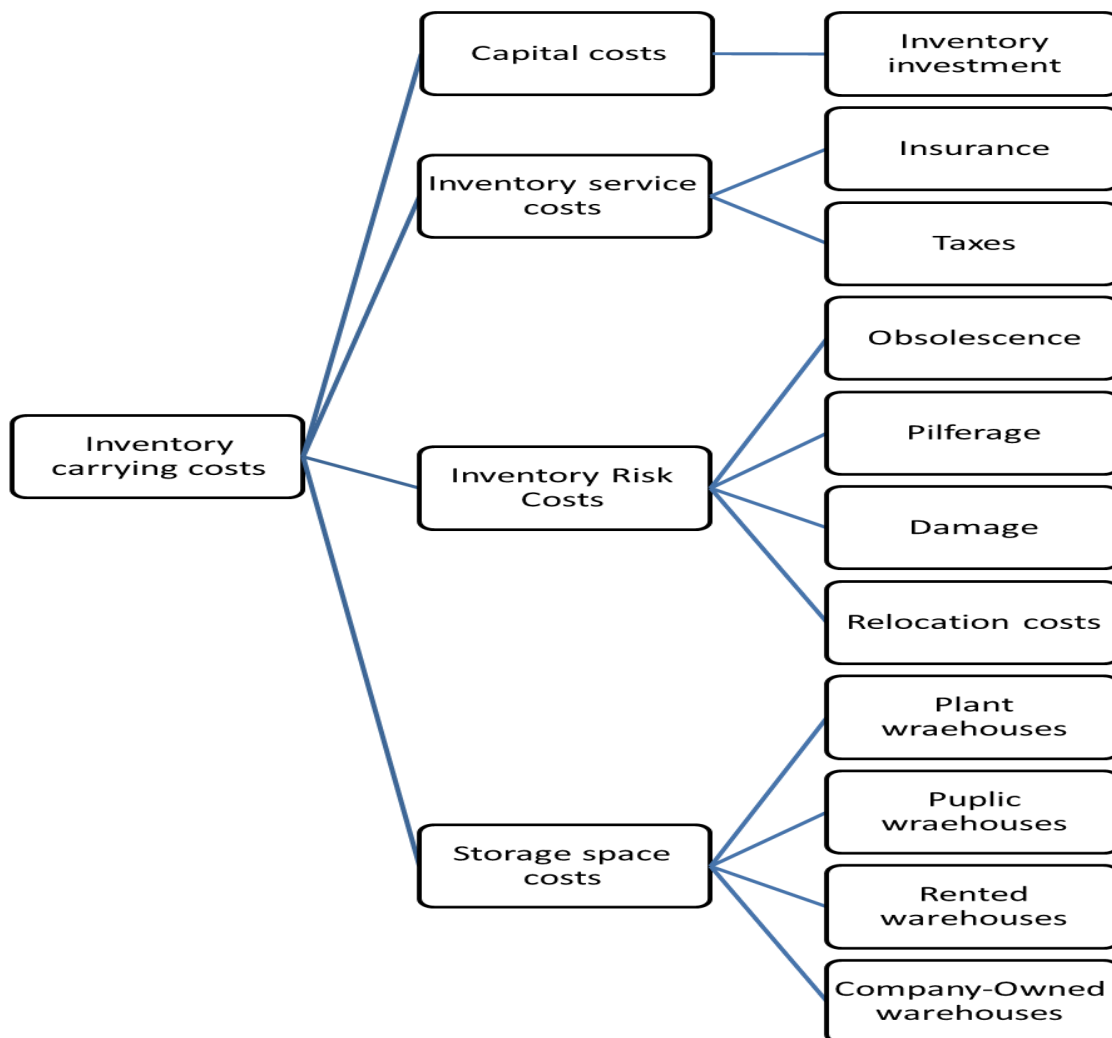


Figure (2.2): Inventory carrying cost. ⁽¹¹⁾

Figure (2.2) explains the cost components, comprehensively as following; the capital cost is the single biggest factor of inventory carrying cost. It is opportunity cost; to clarify its sense, just think about what else could be done with the amount of capital if it were not tied up in inventory? Inventory is viewed as an asset on the balance sheet; hence, many state governments impose property tax rates on inventory. Insurance premiums are paid to provide coverage against loss or damage to inventory. Obsolescence reflects the

real possibility that inventory value may decline in the course of being kept. Storage costs in this figure just refer to variable costs of storage. Fixed warehousing costs, which do not change with the volume of inventory maintained, are not included in inventory carrying costs but are calculated as warehousing costs in a total logistics cost.

2.2.6 Classification of Inventory

There are three types of motives of inventory control, and based on which classifies inventories into five categories. The three motives are transaction, safety, and speculation motives. The transaction motive is a result from the fact that ordering and manufacturing decisions are made at certain points of time instead of being performed continuously. The safety motive emerges in uncertainty where lead-time, demand and production yield are unknown at the time when decisions are made. The speculation motive generally refers to the special uncertainty in prices, if there is an anticipation of price increase for purchased goods, order are made in advance. In light of three motives, inventories are divided into five groups as follows⁽¹²⁾:

1. Cycle stocks. The cycle stock induced by batching alternates between an upper level when a batch has just arrived and a lower level just before the arrival of the next batch. Cycle stocks mostly attribute to economies of scale of purchasing and transportation, and technological restrictions in production.
2. Pipeline stocks. Order processing times, production, and transportation rates contribute to pipeline stocks, also called process inventories. Materials that are in process, in transport, and in transit to another processing unit belong to pipeline stocks.
3. Safety stocks. The safety stock is interpreted as the expected inventory just before the next replenishment arrives. It is caused by the uncertainty of demand, processing time, yield and other factors. And its major function is to protect business performance from forecasting errors.

4. Speculative stocks. Expected price increase may result in earlier supply than would have been experienced under constant price, meaning there are more inventories on hand than actual demand at certain period of time, the redundant inventory is speculative inventory. And additionally, stimulated by the possible higher selling price, speculative stock may also appears.
5. Anticipation stocks. Some products are characterized with seasonal demand, this fact, rather than expectations, generate anticipation stocks. A time varying demand pattern asks for balancing of overtime and inventory carrying cost in order to deal with the demand peak. Companies with significant seasonality find it more efficient to use smaller plants and produce prior to demand, which obviously means accumulation of inventory ⁽⁹⁾.

Despite the above seemingly clear classification, it is difficult to determine to which of the categories a certain item belong. This problem arises from the fact that stocks may originate from more than a single inventory control motive and that there exists a certain degree of substitution ⁽¹²⁾.

2.2.7 Inventory Control Systems

There are many inventory control systems and control techniques discussed in books and journal articles. In the following content, some inventory control systems will be introduced as following.

A. ABC Analysis

Inventory classification systems help allocate time and money in inventory management and allow firms to deal with multiple product lines and multitude of stock-keeping units (SKU). The most widely used classification model is ABC analysis. ABC analysis is an inventory classification technique in which the items in inventory are classified according to the dollar volume (value) generated in annual sales ⁽¹³⁾.

When ABC analysis is applied to an inventory situation, it determines the importance of items and the level of control placed on the items. The result of importance ranking is determined by two factors, the usage rate for an item and its unit value. These two factors can be multiplied to give the annual usage value (AUV), which is the total value of the annual usage. The bigger each factor, the more top ranking is the item. Therefore, close control is more important for fast moving items with a high unit value. To the contrary, for slow moving, low unit value items the cost of the stock control system may exceed the benefits to be gained and simple methods of control should be substituted.

By dividing a company's inventory into different classifications-A, B, or C indicates that managers can focus on the items that account for the majority of the inventory. Generally, the A items include approximately 10 percent of the items in inventory, while accounting for roughly 50 percent of the dollar volume generated. The next classification, B items, includes roughly 40 percent of the items with 40 percent of the dollar volume. The remaining items, the C items, account for only 10 percent of the dollar volume, yet include approximately 50 percent of the items. Figure (2.3) illustrates the concept of ABC analysis ⁽¹⁴⁾.

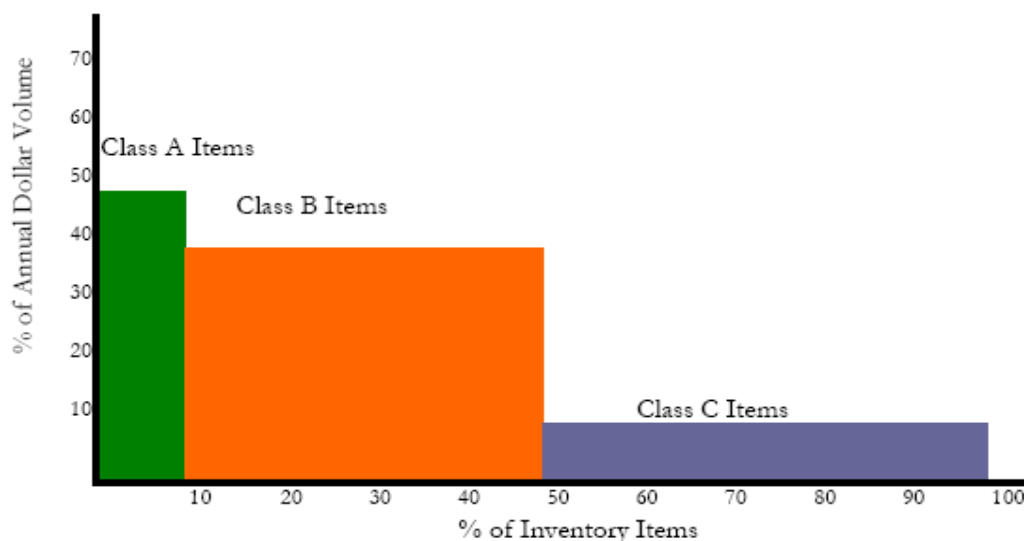


Figure (2.3): Typical representation of ABC analysis. ⁽¹⁷⁾

When ABC classification is done, different types of inventory should be analyzed separately, such as, finished goods analysis is done separately from raw materials.

B. Benefits and Pitfalls of ABC Analysis

The advantage of dividing inventory items into classes allows policies and controls to be established for each class. Policies that may be based on ABC analysis include the following:

1. The purchasing resources expended on supplier development should be much higher for individual A items than C items.
2. A items should have tighter physical inventory control; perhaps they belong in a more secure area, and perhaps the accuracy of inventory records for A items should be verified more frequently.
3. Forecasting A items may warrant more care than forecasting other items.

Better forecasting, physical control, supplier reliability, and an ultimate reduction in safety stock can all result from inventory management techniques such as ABC analysis. There are also some pitfalls of ABC analysis as shown below⁽¹⁴⁾:

1. Although an item is classified as a C item, this does not necessarily mean that this item can (or should) be eliminated from the product mix. For example, a retail establishment may not be able to eliminate a particular item even though it is a C item because customers expect to be able to purchase that item in that store.
2. In manufacturing endeavors, a stock-out of a C item may cause serious delays in the completion for a finished product.
3. Some inventory situations do not lend themselves to classification. If the inventory situation does not reasonably reflect the underlying basis of the ABC technique-

the “important few” and the “trivial many”-then such a technique should not be employed.

2.2.8 Time of Order

Continuous review and periodic review are two main types of models for companies to decide when to order. Continuous review model inventory should be reviewed every day. Then management makes the decision whether the company needs to order more. And different from the continuous review policy, the periodic review is the policy in which the inventory is reviewed at regular intervals, and an appropriate quantity is ordered after each review.

The above two models have a common basis, which is the concept of inventory position. The inventory position in real time is the actual inventory at the facility plus items ordered by the company but not yet arrived minus items that are back ordered ⁽¹⁰⁾.

2.2.8.1 Continuous Review Model

This inventory review model is characterized by two parameters, the reorder point (ROP) “s” and the order-up-to level “S”. Whenever the inventory position is at or below the reorder point “s”, an order should be placed to increase the inventory level to the order-up-to level “S” ⁽¹⁰⁾. Figure (2.4) shows the inventory level in a continuous review model.

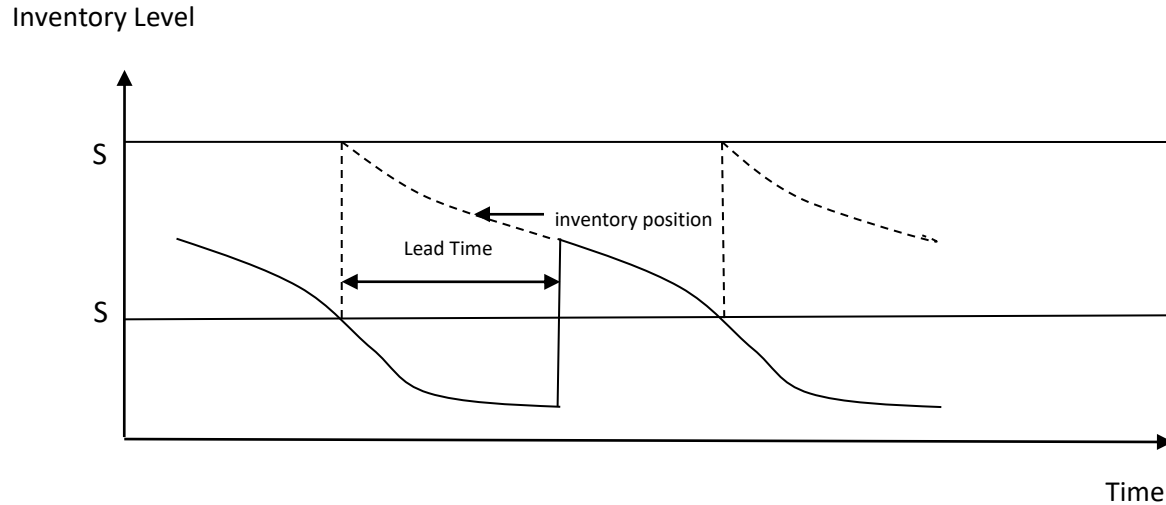


Figure (2.4): Inventory level in a continuous review model. ⁽¹⁰⁾

2.2.8.2 Reorder Point (ROP) System

The reorder point (ROP) system determines when to place orders based on the number of component units on hand. The reorder point consists of two components ⁽¹⁶⁾. The first is the average demand during lead time, and the second is the safety stock. The safety stock is the amount of inventory that the company needs to keep at the warehouse and in the pipeline to protect against deviations from average demand during lead time ⁽¹⁰⁾. ROP is calculated using lead time, average demand, and safety stock. If demand has no seasonal fluctuation, and the supplier's lead time is reliable, the reorder point is just the demand during lead time (DDLT) plus a small amount of safety stock ⁽¹³⁾. Figure (2.5) shows the ROP with the safety stock.. Following above mentioned, the formula can be described as ⁽¹³⁾:

$$\text{ROP} = \text{AD} \times \text{MLLT} + \text{SS} \quad (2.2)$$

Where:

AD = The average demand of the coming season

MLLT = The most likely lead time

SS = The safety stock

Inventory Level

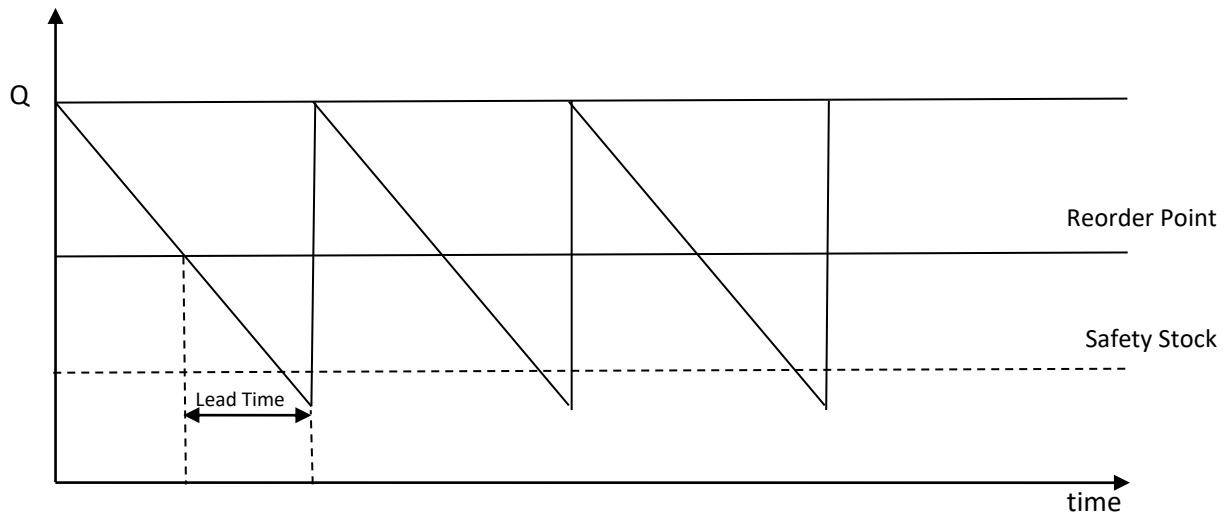


Figure (2.5): ROP with safety stock. ⁽¹³⁾

2.2.8.3 Periodic review model

In many real situations, the continuous review is generally not practical. The more popular way is that the inventory is reviewed periodically, at regular interval. For example, the inventory level may be reviewed at the end of each month and an order may be placed at the same time. The review period can be set according to the company's actual situation. Since the inventory levels are reviewed at a periodic interval, the fixed cost of placing an order is a sunk cost and hence can be ignored ⁽¹⁰⁾.

Since fixed cost does not play a role in this review model, one parameter for inventory is the base-stock level. The company determines a target inventory level, the base-stock level, and each review interval point the inventory position is reviewed, and the replenishment order is placed for an amount large enough to bring the inventory level back to the base stock level ⁽¹⁵⁾. Figure (2.6) illustrates the inventory level in a periodic review model.

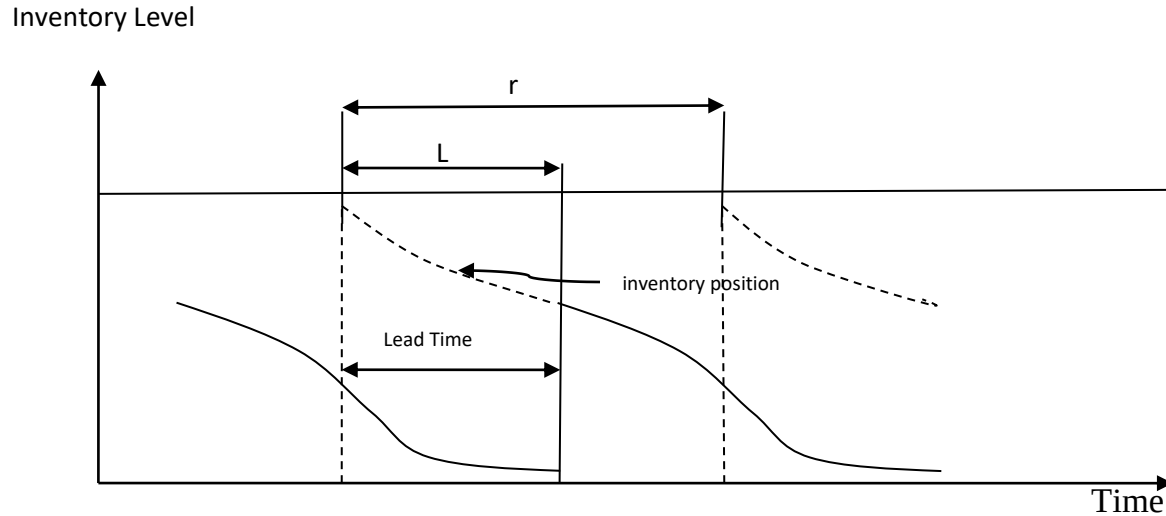


Figure (2.6): Inventory level in a periodic review model. ⁽¹⁰⁾

The base-stock level consists of two components: (1) average demand during an interval of time equal to the review period plus the lead time and (2) safety stock, which is the amount of inventory that the company needs to cover deviations from average demand during the same period.

It is difficult to determine the appropriate safety stock level, as it is affected by a variety of characteristics, like the service level. The service level is a critical factor in relation to safety stock determination. If a higher service level is desired, more safety stock will be required. Also, if demand is highly variable (frequently much higher or lower than average), it is also important to hold more safety stock. Similarly, if lead time is long, more safety stock is needed to guard against possible stock-outs during lead time⁽¹⁰⁾.

2.2.9 Quantity of order

There are some techniques will be introduced for managers to determine how much should be ordered for replenishment orders as following below:

2.2.9.1 Economic Order Quantity (EOQ) Model

EOQ technique is based on several assumptions⁽¹⁷⁾:

- A. Demand is known and constant.
- B. Lead-time is known and constant.
- C. Receipt of inventory is instantaneous.
- D. That is, inventory from an order arrives in one batch, at one time.
- E. Quantity discounts are not possible.
- F. The only variable costs are cost of placing an order and the cost of holding inventory.
- G. Stock-outs can be completely avoided if orders are placed at the right time. With these assumptions, the graph of inventory usage over time has a saw tooth characteristic.

- **Minimizing acquisition cost**

The significant variable costs constituting acquisition cost are:

- (i) Ordering cost.
- (ii) Holding cost.

- **Variation of ordering cost versus holding cost**

The more quantity of materials is ordered at a time, the less the ordering or replenishment cost, and the more holding cost; and vice-versa. The combination of above objective functions should be optimized as follows⁽¹³⁾:

$$\text{Min } \sum \{ \text{ordering costs} + \text{holding costs} \}$$

This optimization leads to the following deductions: (1) minimum acquisition cost is a compromise of cost of ordering versus cost of storage, and (2) minimum total costs (acquisition cost) will be achieved by the economic order quantity.

The classical EOQ model is given as⁽¹³⁾:

$$EOQ = \sqrt{\frac{2DC_o}{C_h}} \quad (2.3)$$

Where:

D=annual demand (units per year), C_o = cost/order, and C_h = variable holding cost (cost/unit/year).

The simplified classical EOQ model assumes that stock is replenished just at the point when inventory is zero. This zero inventory before replenishment is known as stock-out.

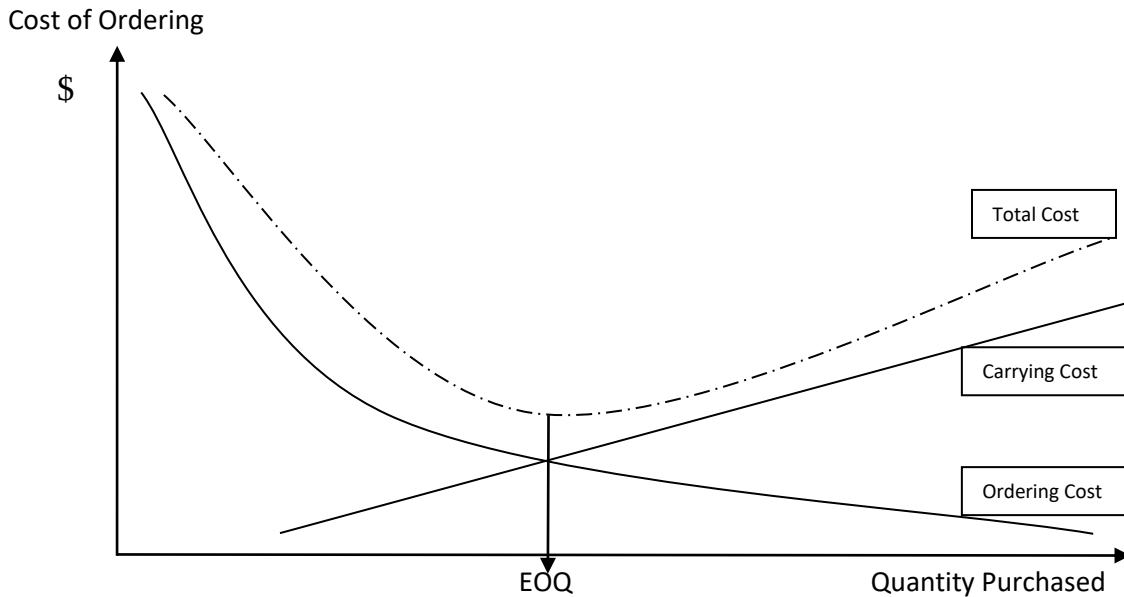


Figure: (2.7) EOQ model.⁽¹³⁾

2.2.9.2 Alternative Order Quantity Approach

The inventory control systems should be inexpensive, easy to understand, easy to use, and not too time-consuming. From the managers' aspects, the ideal systems are those that allow them to set policies, rules, and procedures easily, and have them implemented by the subordinate without any difficulty.

The application of the EOQ formula is difficult. Some estimating parameters, like order cost and inventory carrying cost for EOQ are not easy when records of various costs are inadequate or nonexistent. EOQ might have to be re-calculated each time there is a change in interest rate, price, or demand. This will increase the order cost.

Lin, E. ⁽¹³⁾ suggested the following two methods can be easily. The first method is called maximum inventory. The manager sets the maximum stock level for each item based upon his/her experiences or analysis of company's financial situation and desirable return on inventory investment. The formula is ⁽¹³⁾:

$$\text{OQ} = \text{Maximum Inventory level} - \text{Reorder Point} + \text{DDLT} \quad (2.4)$$

OQ: order quantity

DDLT: demand during lead time

The second method that he proposed is called desired covering period. Based on sales forecast, the manager can set the order quantity that will cover the period he/she likes. The outcome number might have to be modified to meet business requirements. For instance, the supplier probably sells certain products at the multiple of batch quantity or sets a minimum order quantity for a product.

2.3 Summary

1. Inventory serves a useful purpose in the supply chain. That said, firms can help minimize the need for inventory by carefully managing those factors that drive inventory levels up.
2. Inventory items can be divided into two main types: Independent demand and dependent demand items. The systems for managing these two types of inventory differ significantly.
3. The two classic systems for managing independent demand inventory are periodic review and perpetual review systems.
4. The economic order quantity (EOQ) is the order quantity that minimizes total holding and ordering costs for the year. Even if all the assumptions don't hold exactly, the EOQ gives us a good indication of whether or not current order quantities are reasonable.
5. The reorder point formula allows us to determine the safety stock (SS) needed to achieve a certain cycle service level. In general, the longer the lead times are, and the greater the variability of demand and lead times, the more SS will need.

Chapter Three

Supply Chain Management

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3.1 Introduction

Supply chain management (SCM) is one of business strategy increasingly being used in the business world today and has become the focus of academic attention in recent years ⁽¹⁴⁾. Because the concept of SCM is still in development, there are several theoretical frameworks and research methodologies need to be developed in the study of SCM ⁽¹⁵⁾. However, many articles have been published in various disciplines to try to define the SCM and discuss future directions and the corresponding empirical research methodology. According to Lummus and Vokurka⁽¹⁶⁾ SCM as all activities involved in delivering products from raw material to customer, including sources of raw material and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to customers and information systems required to monitor all activity.

In the 1980s companies discovered new manufacturing technologies and strategies that allowed them to reduce costs and better compete in different markets. Strategies such as just in time (JIT) manufacturing, kanban, lean manufacturing, total quality management, and others become more popular, and vast quantities of resources were invested in implementing these strategies. In the last few years, however, it has become clear that many companies have reduced manufacturing costs as much as is practically possible ⁽¹⁷⁾. In order that manufacturing companies could increase their competitiveness and thus their market share and profitability, many of them are discovering that effective supply chain management is the next step they need to take in order to increase profit and market share.

This section outlines definitions and development of supply chain management, evolution of supply chain management, advantages of supply

chain management for manufacturers and supply chain management practices. They are explained in turn.

3.2 Definition of Supply Chain Management (SCM)

There have been many definitions and variations of the term SCM in the literature, and some definitions include SCI. For example, Cooper and Ellram, ⁽¹⁸⁾ define SCM as “an integrative philosophy to manage the total flow of a distribution channel from the supplier to the ultimate user”. Bowersox, Closs, and Stank ⁽¹⁹⁾ state that the supply chain management mission is “to manage the efficient and effective sourcing, production, and delivery of products, services, and related information, from point of material origin to point of ultimate consumption, to maximize value for the end-customer”.

The term “supply chain management” has become a popular buzzword, probably first used by consultants in the late 1980s and then analyzed by the academic community in the 1990s. Supply chain management is a set of approaches utilized to effectively integrate suppliers, manufacturers, logistics, and customers for improving the long-term performance of the individual companies and the supply chain as a whole ⁽⁷⁾.

The Institute for Supply Management, ISM (U.S.A) defines SCM as “the design and management of seamless, value-added processes across organizational boundaries to meet the real needs of the end customer. The development and integration of people and technological resources are critical to successful supply chain integration” ⁽²⁰⁾.

3.3 Supply Chain Management Evolution (SCM)

Supply Chain Management (SCM) represents a significant change in how most organizations view themselves. Traditionally, firms view themselves as having customers and suppliers. Historically, a firm did not consider the

potential for either its supplier or its customer to become a partner. In many industries each firm was very competitive with its suppliers and customers, fearing that they would be taken advantage of by them.

Beginning in the 1960s and 1970s firms began to view themselves as closely linked functions whose joint purpose was to serve their customers. This internal integration was often referred to as materials logistics management or materials management. In this structure those management functions involved in the material flow were grouped together. Firms that adopted the materials management structure integrated their purchasing, operations, and distribution functions to improve customer service while lowering their operating costs. Those firms that successfully integrated these functions did improve their performance. But, the firms were still constrained by other functions in the firm, which were not integrated, such as product development. Or, the firms were constrained by either their customer's or their supplier's unresponsiveness.

Mentzer et al.⁽²¹⁾ express the evolution of supply chain into three steps as follows:

1. **A direct supply chain:** A supply Chain is a set of 3 or more companies directly linked by one or more of the upstream and downstream flows of products, services, finances and information from a source to a customer.
2. **An extended supply chain:** An extended supply chain includes supplier of the immediate supplier and customer of the immediate customer, all linked by one or more of the upstream and downstream flows of products, services, finances and information.
3. **An ultimate supply chain:** An ultimate supply chain includes all the companies involved in the upstream and downstream flows of products, services, finances and information flow from the initial supplier to the ultimate customer.

3.4 Advantages of supply chain management for manufacturers

Tan *et al.*⁽²²⁾ note that as product life cycles shrank and global competition intensified in the 1990s, many manufacturers collaborate with their suppliers to improve product quality and lead time. Correspondingly, many wholesalers and retailers also integrate their logistics functions to enhance competitive advantage. Eventually, these two functional areas of a corporation evolve and merge into a holistic and strategic approach to materials and logistics management. Supply chain management is viewed as a viable initiative to enhance competitive advantage⁽²³⁾. Scott and Westbrook⁽²⁴⁾ describe supply chain management as the chain linking each element of the manufacturing and supply process from raw materials through to the end user, encompassing several organizational boundaries and treating all organizations within the value chain as a unified virtual business entity. Supply chain management focuses on how firms utilize their suppliers' processes, technology and capability to enhance competitive advantage; and the coordination of the manufacturing, logistics, materials, distribution and transportation functions within an organization⁽²⁵⁾. While ideally supply chain management emphasizes total integration of all the business entities within the supply chain, a practical approach is to consider only strategic suppliers and customers since most supply chains are too complex to achieve full integration of all the supply chain members⁽²⁶⁾.

Many manufacturers and merchants have embraced the concept of supply chain management to improve product development, quality and delivery goals, and to eliminate waste. It has enabled firms to exploit supplier strengths and technologies to support new product development efforts⁽²⁷⁾, and seamlessly integrate logistics functions with transportation partners to deliver directly to the point of use. Supply chain management is a management philosophy that extends traditional internal activities by embracing an inter-enterprise scope, bringing trading partners together with the common goal of optimization and efficiency⁽²⁸⁾.

3.5 The Four Fundamentals of Supply Chain Management

Edward Sweeney ⁽²⁶⁾ has summarized the four absolutes or fundamental of Supply Chain Management according to Table (3.1) as shown below:

Table (3.1): Supply Chain Management ⁽²⁹⁾ .

FUNDAMENTAL		INDICATIVE DESCRIPTOR
1.	Objectives	Customer Service/Supply Chain Investment and Costs
2.	Philosophy	Supply Chain vs. Supply Chain (i.e. not Company vs. Company) - the chain is only as strong as its weakest link
3.	Manage the flows	Integrated management of the material, money and information flows throughout the chain relationships
4.	Relationships	

These fundamentals refer to the objectives, the philosophy, the "three flows" and customer/supplier relationships. These are now explained further ⁽²⁹⁾:

1. **Objectives:** Firstly, the objectives of SCM are to achieve high levels of customer service in targeted markets/segments and to optimize total supply chain investment and cost. This service/cost approach has long been regarded as central to supply chain management. This approach requires companies to have a clear understanding of both issues. Customer service requirements, dictated by the market place, sets the spec for the supply chain. Achieving this level of service at the optimal cost focuses attention on the elimination of NVAs throughout the supply chain.

2. **Philosophy:** Secondly, every product or service is delivered to the final consumer (the only source of "real" money in the chain) through a series of often complex movements between companies which comprise the complete chain. An inefficiency anywhere in the chain will result in the chain as a whole failing to achieve its true competitive potential. In other words, supply chains are increasingly competing with other supply chains rather than, in the more traditional axiom, companies simply competing with other companies. The phrase "supply chain" is used to indicate that the chain is only as strong as its weakest link.

The representation in Table (3.1) (above) is of a "macro" supply chain shows materials flowing from the raw material supplier through the various stages in the chain to the final customer. Money then flows back down the chain. The point is that every link matters and that value is added, and profit generated, at each link along the way.

You can describe most businesses in terms of the five functions buy, make, store, move and sell - known as the "micro" or internal supply chain as in figure (3.1).

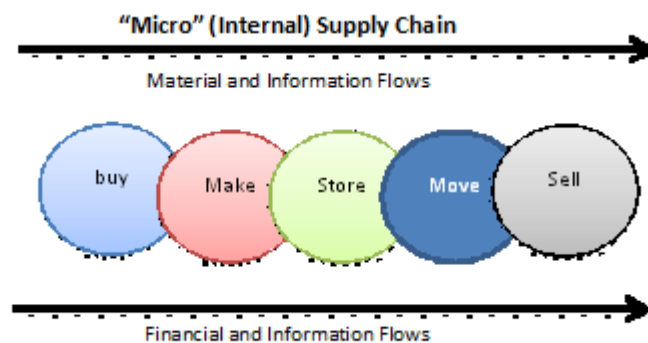


Figure (3.1): The "micro" or internal supply chain. ⁽²⁹⁾

Traditionally, these functions have been managed in isolation, often working at cross purposes. Supply chain management means thinking beyond the established boundaries, strengthening the linkages between the functions, and finding ways for them to pull together. A recognition that the whole is greater than the sum of the parts calls for

more effective integration between purchasing and procurement (buy), production planning and control (make), warehouse management (store), transport management (move) and customer relationship management (sell).

3. **Manage the flows:** For a supply chain to achieve its maximum level of effectiveness and efficiency, material flows, money flows and information flows throughout the entire chain must be managed in an integrated and holistic manner, driven by the overall service and cost objectives. This view of a macro chain indicates the way in which material, money (funds) and information flow between the companies which participate in the chain. Flows in the micro chain can be thought of in a similar way.
4. **Relationships:** Finally, this holistic approach requires a reappraisal of the way in which both internal and external customer/supplier relationships are created and managed. SCM is not a "zero-sum" game based on adversarial relationships, rather, it needs to be a "win-win" game based on partnership approaches. This point is relevant to the interactions between the key "internal supply chain functions of buy, make, store move and sell, as well as to relationships between an organization and its external customers and suppliers. One of the biggest manifestations of the application of supply chain philosophy in recent years has involved the move away from adversarial relationships throughout the supply chain towards relationships which are based on mutual trust and benefits, openness and shared goals and objectives.

3.6 Warehousing

‘The warehouse is a point in the logistics system where a firm stores or holds raw materials, semi-finished goods, or finished goods for varying periods of time.’⁽⁹⁾.

3.6.1 The Basic Functions of Warehouse

There are three basic functions of warehouse as follow⁽³⁰⁾:

- a. Movement is necessary to store a product properly. It can be divided into three activities:
 - Receiving inbound goods from transportation carriers and performing quality and quantity checks.
 - Transferring goods from the receiving docks and moving them to specific storage locations throughout the warehouse.
 - Shipping the goods outbound to customers by some forms of transportation.
- b. Storage is the second function of warehousing. It can be performed in two different ways:
 - Temporary storage means that storing a product, which is necessary for inventory replenishment.
 - Semi-permanent storage is used for inventory in excess of immediate needs. It is the safety or buffer stock.
- c. The last function of warehouse is the information transfer. When the product is moved and stored, this function occurs at the same time. It is important for the management to have timely and accurate information in order to administer the warehouse activity.

The information can cover a lot of things like inventory levels, throughput levels, and data of the customer, facility space utilization and also about the personnel.

3.6.2 Types of Warehouse

One of the warehouse decisions is choosing the type or combination of types to use. There are three basic types of warehousing: private, public and contract.

- a) Private warehouse: The firm producing or owning the goods owns private warehouses. This type of warehouse is main focus on storing the firm's own goods until they are delivered or sold ⁽³¹⁾. Also stated the stability of warehouse demand must be examined over multiple products and another advantage of using a private warehouse is the ability to maintain the physical control over the facility ⁽⁹⁾.
- b) Public Warehouse: If a company without large inventory accumulations or a very seasonal need for warehousing space that they could not utilize a private warehouse consistently and efficiently, they would find a public warehouse. Or if a company shipping in small quantities for long distances would also usually find a public warehouse. The reasons for using public warehousing which are: (1) avoid the capital investment and financial risks; (2) flexibility of public warehousing ⁽⁹⁾.
- c) Contract Warehouse: 'Contract warehousing is one specialized form of public warehousing. Some reasons for the growth of contract warehouses are: (1) product seasonality; (2) geographic coverage requirements; (3) flexibility in testing new marketing; (4) management expertise and dedicated resources; (5) off-balance sheet financing; (6) reductions in transportation costs' ⁽³¹⁾.

3.6.3 Warehouse Layout

The objectives of warehouse layout and design should be as following ⁽³¹⁾:

1. Warehouse capacity utilization must be optimized.
2. Whatever is stored must be protected.
3. The layout should consider space utilization and stock placement.
4. The warehouse should be as mechanized and automated as possible.

5. The warehouse layout should lead to high productivity in receiving, storing, picking, and shipping.
6. The warehouse design should be flexible and allow for improvement.

From above mentioned, the rational utilization of warehouse space is the most important issue in warehouse layout management. The good utilization of space should begin with good warehouse visibility.

The warehouse visibility includes ⁽³⁰⁾: labels on the grid of columns which are supporting the ceiling, dock numbers that remain visible when docks are open, three-sided overhead zone identification signs, aisle /column / level labels on each slot in a pallet rack.

3.6.4 Warehouse Management System (WMS)

The computer-based warehouse management system (WMS) has been implemented widely in many companies. It could assist the warehouse manager to control the various operations, like receiving, put-away, picking, packing, shipping, storage location, work planning, warehousing layout, and analysis activities ⁽⁹⁾. The system could help managers with workload reductions in terms of data collection, achieving higher accuracy, faster retrieval, and could support for cycle counting and data mining ⁽³⁰⁾.

Barcode scanning is used in many warehouses. Its function is to match serial numbers to customer purchase orders (PO), and the hardware and communication infrastructure to support a WMS is in place. Figure (3.2) shows one example of the materials handler scans barcodes for both location and item number when loading a pallet.

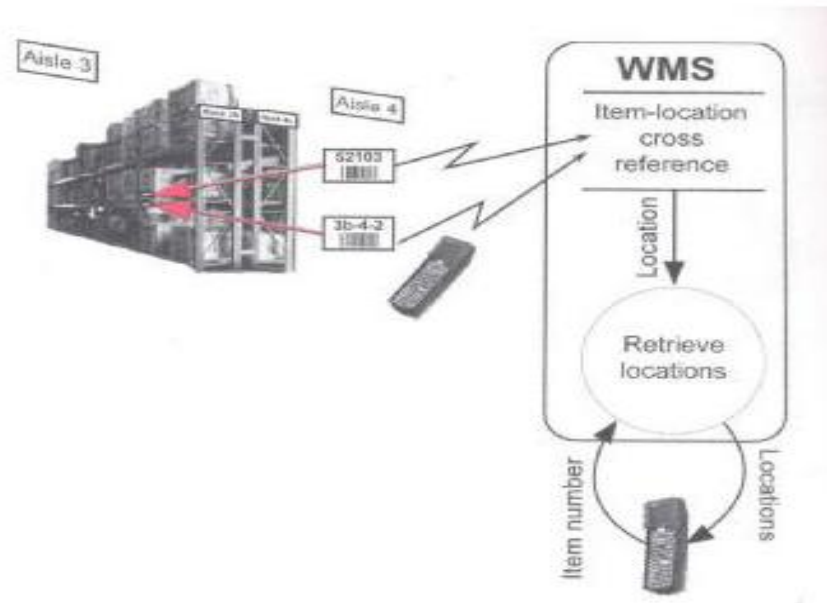


Figure (3.2): The example of material's barcode scans. ⁽³⁰⁾

3.7 Purchasing Management

Purchasing has two main objectives, one is to purchase for resale, and the other one is to purchase for consumption or for transformation.

Purchasing function starts as subordinate to the more important functions of marketing, finance and operations. Firms give more attention to purchasing when the costs of purchased items increase. Reengineering the supply chain strategy concerns not only coordination of the various activities in the supply chain but also deciding what to produce in-house and what to outsource ⁽¹⁰⁾. With the strong trend towards more outsourcing over the last decade, presently purchasing has evolved as an important strategic area of management.

purchasing strategy which is to choose a competitive supplier, establish a commitment to the supplier, and analyze the complete production process

with a cost-analysis mind-set, and co-ordinate with the supplier early and frequently to maximize cost efficiency⁽³¹⁾.

3.7.1 The major purchasing decision processes

There are six major purchasing decision processes: (1) ‘make or buy’, (2) supplier selection, (3) contract negotiation, (4) design collaboration, (5) procurement, and (6) sourcing analysis.

In the ‘make or buy’ decision process, based on the part/service is a finished/semi-finished goods or not, a company will decide the part/service should be produced internally or outsourced; In the supplier selection process, a number of supplier are chosen for purchasing according to a predefined set of criteria; the purchasing contract could be either short-term or long-term; as to design collaboration, the buyer and the supplier cooperate closely to design part/service that meet the customer’s specific requirements; the procurement decision process is related to ensuring delivery of the part/service in time from the supplier and with minimum costs; finally, in the sourcing analysis phase, a company should examine the effectiveness and efficiency of its procurement process⁽³²⁾.

3.7.2 Supplier relationship management

The most important purchasing activity is to select and keep close relationships with several reliable and high-quality suppliers, in order to reduce product costs, maintain good product quality and customer services⁽³²⁾. Relations between suppliers and buyers in industrial markets have been found to be long term and characterized by stability⁽³³⁾. Partnership should be established because if the buyer is to be best served, then the parties to a deal must work together for the win-win situation and both parties have an interest in each other’s success⁽³⁴⁾.

Figure (3.3) shows that a company is better off remaining in transactional relationships if it is not ready to develop relationships properly. Poor partnership is, instead, more costly than staying in a transactional relationship with suppliers ⁽¹¹⁾. But it also shows in case of trust existence, good partnership is less costly than a transactional relationship.

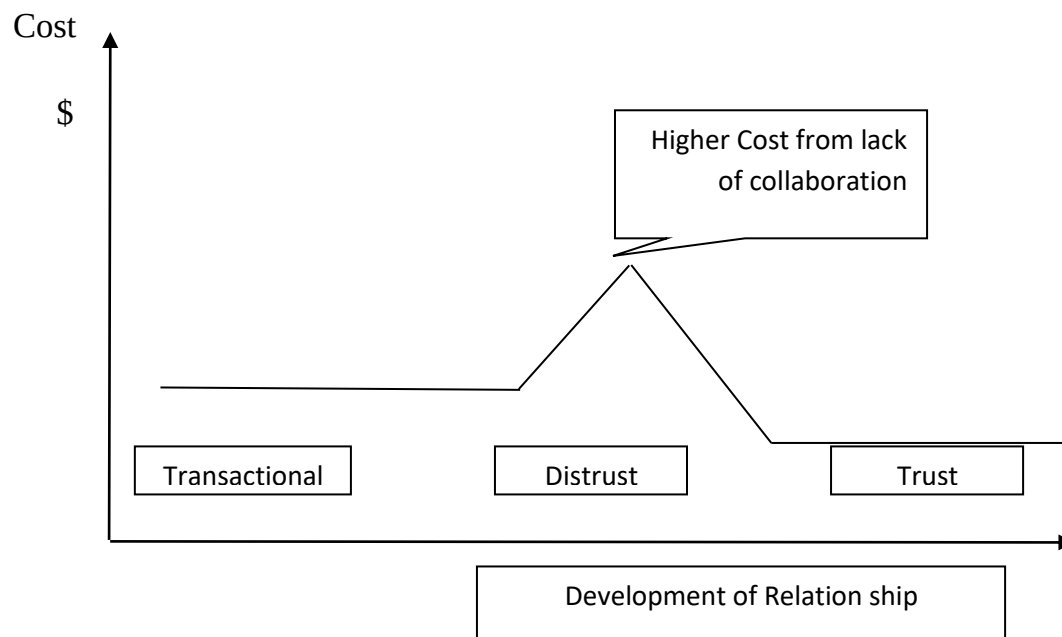


Figure (3.3): The cost of unsuccessful supplier relationships. ⁽¹¹⁾

3.8 IT Application in SCM

Information Technology (IT) systems play a significant role in the success of a supply chain because they enable management to make decisions over a broad scope. The IT systems monitor materials, orders, schedules, finished goods inventory, and other information throughout the entire organization. SCM systems are a combination of many of the preceding applications and are used to span the stages in the supply chain and to allow for a more global scope because they can span many supply chain stages with their different modules. SCM systems have the analytical capabilities to produce planning solutions and strategic level decisions. As supply chains become more

global and complex and as customers and competition become more demanding, companies will need the supply chain capabilities that only sophisticated IT systems can provide.

3.8.1 The Role of IT in SCM

Many practitioners perceive the SCM concept primarily as a phenomenon driven by the developments in the information and communication technology area ⁽⁸⁾. Information technology is a crucial enabler of effective and efficient SCM ⁽¹⁰⁾. These statements indicate that IT evolution has been and will keep on acting as the major driving force for SCM development.

The revolution change that has occurred in technology, both hardware and software, has forced many companies worldwide to change the way they “do business.” Technology can be viewed legitimately as a facilitator of change process since it enables companies to implement many of the strategies ⁽⁹⁾.

IT application is extremely broad and deep in SCM through various approaches, for instance, in-house information systems and their integration, inter-organizational information transmission and sharing (in real-time or not), collaborative inter-organizational information systems, tracking technologies in which barcode, RFID and GPS are paradigms, internet, intranet, extranet. All in all, IT can be found everywhere when there is a need or a possibility.

3.8.2. IT goals in SCM

Classify IT goals for SCM into four groups as follows ⁽¹⁰⁾:

1. Collect information. The information availability in regard to the status of material is the foundation on which intelligent supply chain decisions can be made. In addition, it is not sufficient just to track the status of material across the supply chain; there is also a need to alert diverse

systems to the implications of this movement. This goal calls for standardization of product identification, e.g. bar coding, across companies.

2. Access data. The single-point-of-contact concept is important for effective IT. The aim is that all the available information can be accessed in one stop regardless of the mode used or who is making the inquiry. In many companies, information systems are isolated, standing alone in light of their functions within the company. It will be ideal that everyone who needs certain data actually has access to the same real-time data through any interface device.
3. Analyze based on supply chain data. The information system should be used to find the best way of operating the whole supply chain. This entails various levels of decision making, from operational decisions to tactical decisions, lastly to strategic decisions. To facilitate this, information systems should be flexible enough to adapt to supply chain strategic changes. And the flexibility requires the information systems to be highly configurable and have new standards.
4. Collaborate with supply chain partners. Depending on its position in the supply chain, a company may be asked to either integrate with its customer's procurement system or require its own suppliers to link into its own procurement systems or collaborative platforms or both. In recent years, collaboration has become a new focus of supply chain system development. Two types of systems have been developed-supplier relationship management (SRM) applications and customer relationship management (CRM) applications.

3.8.3. Integrating Supply Chain IT

Supply chain management is extremely complicated, different companies have their own concerns about introducing the IT innovation, they may worry about the magnitude of return on investment, or too detailed

information making no sense for the customer, or certain IT investment is too big.

How can all the components of IT join together? The key is to analyze each component contribution to the company and make investment plan according to the particular needs of the company. Because of the lack of standards, it is much likely that in the near future middleware will be developed to mediate between different systems and different standards, eventually, the concept of supply chain standards can be established into the basic systems that constitute the infrastructure ⁽¹⁰⁾.

3.9 ERP Information System in Organizations

Enterprise Resource Planning (ERP) is a system that attempts to do planning according to supply and demand information taken across the entire network. ERP traditionally covers manufacturing, human resources, and financials but now has become the backbone of most IT infrastructures. Originally, ERP information system is for integrating internal operations like billing, payroll, cost analysis, sales analysis, and etc. ERP can produce great benefits, mostly in the form of more efficient business processes ⁽³⁵⁾. With the new development of ERP II, such information system is expanding to include new functionality, is providing Web-based access and services and becoming more open to external integration ⁽¹⁰⁾. Due to the integration, inventory control system becomes better and inventory management also gets improved.

3.10 Summary

In this chapter is showing the supply chain and supply chain management. The central aim of supply chain management, to have the right products in the right quantities (at the right place) at the right moment at minimal cost, is translated into the interrelated issues of customer satisfaction, inventory management, and flexibility. Customer satisfaction is to a high degree dependent on the flexibility of the supply chain, i.e. its ability to respond to changes in demand. Flexibility is often imperfect because of long lead times, uncertainties, and unforeseen event. To counterbalance this lack of flexibility companies will keep inventories at various levels of the supply chain. Balancing the costs of imperfect customer satisfaction and holding inventory is a classic issue of logistics and supply chain management.

Increasing globalization of supply chains causes longer lead times, which worsen flexibility, and creates the need for more inventories. When lead times can no longer be shortened, an important tool for improving the supply chain performance is that of increased coordination.

Modeling is an important tool for understanding and managing the supply chain. The dynamic behavior of a real life system is usually so complex that analytic models are not powerful enough to analysis the system, simulation must therefore be used.

Chapter Four

The Integration between supply chain and Inventory management

4.1 Introduction

Supply chain management has become an important issue in a business organization. Organizations are facing increasing competitive pressure with respect to prices, delivery, quality, variety and innovation of products and services. In order to respond to these challenges, organizations require an integrated supply chain.

Lambert ⁽³⁶⁾ emphasis's that successful supply chain management needs cross-functional integration of key business processes within the firm and across the network of companies that consist of the supply chain. Furthermore, Lambert ⁽³⁶⁾ states that executives in many companies struggle to accomplish the required integration because they don't fully understand the supply chain business processes and the linkages required to integrate eight key SCM processes.

4.2 Supply chain integration

"Integration" means that the system of the elements of organization, coordination and restructuring, so that resources will be the optimal configuration, the highest system efficiency. Supply chain is a node contains all enterprise and internal department systems, in this system have the information flow, capital flow and logistics flow of transmission, will be in the supply chain to integrate the various elements to improve the efficiency of supply chain management are core mission.

Supply chain integration is defined as suppliers of raw materials to finished goods to end-users the full process, including outsourcing, manufacturing, distribution, inventory management, transportation, warehousing, customer service, unified coordination and restructuring in order to make this Net chain enterprises can achieve maximum benefits.

Supply chain integration has two basic points: First, flow integration, the main aspect is the convergence of various functions to optimize the efficiency of integration; second, integrated sections, the main sections are the functions of the efficiency of the integration itself, usually happed as a whole system ⁽³⁷⁾.

Generally supply chain integration including the integration of the following elements:

1. Integrated flow from raw material supply, product manufacturing, product distribution, to the end-users.
2. Integration of suppliers, manufacturers, distributors, retailers, customers
Process integration of information flow, logistics, capital flow and management.
3. Comprehensive integration of supply chain management, organization management technology, and management approach Supply Chain Management emphasis includes suppliers, manufacturers, channel intermediaries and customers integration. J Stevenson proposed four stages of integration: the benchmark organizations, the functions integration, internal integration, and external integration ⁽³⁸⁾.

Stage of internal integration is to implement the direct control of enterprise integration and supply chain implementation within enterprises and external supply chain suppliers and their respective user management part of the integration, the formation of the internal integration of the supply chain. At the same time, internal integration is not only the Department integration, is also the department's standardized flow integration, the formation of the standard flow and management mechanism. In the study, the main consideration in the optimization of resources, capacity, based on the lowest cost and fastest speed in the production of the best products, quick response to user needs in order to improve the responsiveness and efficiency of enterprises.

External integration is the key to integration, the internal and external supply chain suppliers and users together to form an integrated supply chain network. External integration is the most advanced stage, the actual meaning of that supply chain integration. Supply chain integration through information technology tools and management tools to achieve the supply chain of manufacturing processes and logistics seamlessly ⁽³⁸⁾.

4.3 Internal supply chain integration

Internal supply chain integration is to have the internal relations between supply and demand adjust to optimize the flow, so that products or services at a faster transmission, more flexible, more economical and effective, so that the operation of enterprises improve operational efficiency, improve business competitiveness. Through information technology and management tools for internal supply chain integration, enterprise internal supply, manufacture, sales in pursuit of common objectives and implementation strategies in line. Internal supply chain integration has four main areas: information integration, decision-making integration, financial integration and the operation of integration. Information integration refers to the supply chain to participate in Department information sharing, which is the basis of supply chain integration. Decision-making supply chain integration refers to a number of aspects on the synergy between the plans. Financial integration will change the supply chain nodes to pay the relationship between the departments, is to coordinate the overall interests of the supply chain means.

Integration refers to the operation of upstream and downstream supply chain between the human resources (such as procurement, marketing, design, etc.) as well as the sharing of material resources ⁽³⁷⁾. Internal supply chain integration will involve the operation of enterprises of various flow and business department, coordination and restructuring, so that various departments within enterprises connected, open and effective information sharing, so that the optimal overall operation more efficient operation.

4.4 Significance of Supply Chain Integration

There are two currents present in the supply chain: one is the physical current which includes raw materials, distribution, transporting of the products, and second, the intangible and non-physical current which is inclusive of the information and financial processes. In effective and efficient management of these two currents requires a unified attitude that identifies analyses and unifies the interaction between the entire elements inside the Supply Chain

successfully. However, what is more important in the effective and efficient management in the supply chain is the coordination between the supply chain members which can not be achieved without having and sharing information in a suitable manner. The share of the information is, in fact, a tendency on the part of the supply chain companies to provide the exact information in time and share them among themselves in order to establish coordination on all levels of the supply chain which covers a vast area of the information. The other cases that highlight the significance of the integration of the supply chain are summarized as follows ⁽³⁹⁾:

1. Establish relationships between the internal partners' systems and the external ones
2. Utilize the common processes in the new method of interaction
3. Integration of the business processes
4. Reduce the product balance and improve the store management
5. Reduce the delivery time and costs
6. Increase services and customer satisfactions.

4.6 Information & its Significance in the Supply Chain

Information has a key role in the structure of the supply chain and its success. Since it makes the management capable of making decisions on a vast area of the duties and operations, in such a situation, the companies will be able to implement the intelligent strategies which take into considerations all factors of the supply chain. The managers have to have access to the correct and up to-date information on all company's duties and the supply chain of the partners in order to have the overall supply chain ⁽⁴⁰⁾. The necessary information for achieving an overall sphere can be divided into the following sections which are compatible with various levels of the supply chain:

1. Provide information on what products may be purchased, at what price, and how and when they can be delivered? The supplied information can

also include the orders, reduction, change and method of payments and so on.

2. Production Information deals with the followings: which products are made where, and how and at what quantity, when and at what price and in what size and packaging?
3. Retails and distribution information: what is transported, where, in what quantity, what method is used, at what price, the amount of supply on each site, and its logistic?
4. Demand Information: who is buying what, at what price, where and what quantity? The demand information including forecast information in demand and distribution of information.

The information gained must have three important characteristics so that it can be useful in making strategic decision in the supply chain, The information must be precise, The information must be accessible on demand, The information must be correct.

In short, if the managers are in possession of the precise and up-to-date information, their ability and vision with regards to the supply change will increase considerably and empowers them to cover vast sphere which will enable then to make better decisions with regards to the supply chain. Therefore, this information plays a key role in the success of the supply chain.

4.7 ERP Functions in line with the Integration of different Sections of the Company

The main aim of the ERP is to unify all different departments of the company via the application of a software package. The information is managed through the ERP system and can be used by different methods. The main function of the ERP as follows ⁽⁴¹⁾:

1. Information integration
2. Information management
3. Information sharing
4. Coordinate different sections

5. Automatically updated information
6. Rapid information feed back

4.8 Key Processes in the Supply Chain Management

In the Delphi meeting which was held by the executive managers of the Dutch company, 12 cases out of 22 were identified as key processes in the supply chain process which are as follows⁽⁴²⁾:

1. Integration of the activities among customers & producers in the whole organization's supply chain of the future (87%)
2. Introduce flexibility in the Organizational Resource Planning Systems as a response to the changing needs and requirements of the Supply Chain (57%)
3. Mass Customize (39%) (Louis, 1384)
4. Coordinating drivers in the supply chain (35%).
4. Supply Chain including different agencies (35%).
5. Exchange of all information in the whole sections of the chain (35%).
6. Outsourcing of most activities like physical distribution for the integration of various sections of the chain (30%).
7. Globalization, how to globalize the ERP systems (20%)
8. Making more clarification in the global market (26%)
9. Internet technology as a backbone for the partners' communication systems in the supply chain (26%).
10. Standardization of the processes, & information based on the IT infrastructure (22%).

4.9 Opportunities & Obstacles of the Integration of the Supply Chain

The materialization of the ERP enables the organizations to develop their moves towards the future, and their business models and also improve the general value of the Supply Chain. In order to achieve an efficient supply

chain, companies need to exchange information with regards to planning, and operation, organizing information for the annual contracts, and developmental reports for the prompt delivery ⁽⁴³⁾. ERP provides various tools: the two most important ones are; for the integration of the supply chain, and to follow up on the simultaneous interactive and the integration of the internal processes. Using these two tools just mentioned, will provide 4 opportunities, and 4 limitations for the company which are reflected in Table 4.1, together with the techniques⁽⁴⁴⁾:

Table (4.1): Opportunities, Limitations, & Techniques.

No.	Opportunities	Tools for sharing information
1	Limitations	Companies' lack of desire to share information
	Solutions	Showing the potential advantage with regards to income, and money savings through sharing information.
	Opportunities	Accessible information regarding planning & operations, detailed information on large quantity
2	Limitations	- How to choose data to share with partners? - Failing to support the decisions regarding operations with partners in the supply chain
	Solutions	- Data analysis - Provide cooperating models among suppliers-purchasers.
	Opportunities	- Improve decisions regarding operation - Tools for integration
3	Limitations	Fail to support the integration of operation's policy with partners in the supply chain.
	Solutions	Provide improved cooperation policy.

4.10 The Necessity of Integration in ERP & SCM

In recent years, the issue of integration of the ERP & SCM systems was debated among many senior managers of many companies. There are lots of reasons offered in support of the integration which is reflected below from all different points of view ⁽⁴⁵⁾:

Create an integrated information system in order to transfer from one geographical sphere to the other. Rapid change in the external environment and the decision makings imposed on the companies as a result of these changes:

1. Global competition.
2. Effective communication inside the company by using application programs, Establish improved business process in order to improve cooperation among departments.
3. Integration of operation
4. Coordinate the distribution operation with the supply mangers, production managers and IT department, Transform hereditary systems into flexible one.

4.11 Inventory Management in Supply Chain Environment

Most of the researches in supply chain areas are concerned about optimizing the supply chain in terms of its efficiency and competence in the product market, but only limited studies are done considering the inventory management in supply chains. Effective inventory management in a supply chain can play a vital role in cutting inventory holding costs across the different stages of the supply chain, thus emphasizing the need of a general model for managing inventories within a supply chain. Baganha & Cohen ⁽⁴⁵⁾ developed a stabilizing model for effective inventory management for supply chains. Supply chain materials management methods could be made complex considering a multi product scenario and discontinuous supply chains. So the models developed should have room for all kinds of supply chain variability.

Lee & Billington ⁽²⁵⁾ developed a model for inventory management considering decentralized supply chains.

4.12 Significance of Information flow in Supply (SCIM)

Inventory management for supply chains could be effective only when the information flow from top to bottom of a supply chain is streamlined. Cachon & Fisher⁽⁴⁶⁾ developed a value shared information model and performed a comparative study with the conventional data sharing strategies and ended up with the proposed model performing better, reducing inventory holding expenses. Strategic plans for the effective distribution of information are essential for supplying goods at the customer expected rate. Mutual sharing and analyzing of the information and standards between the supplier and customer at every stage of the supply chain is crucial and it also nurtures customer supplier relationships. Thus incorporating information flow standards in inventory management in a supply chain will definitely result in increased returns.

4.13 How to Implement Supply Chain Management

Inventory control is a key element in supply chain management. The inventory relationship between supply chain components contributes to the cultural and attitudinal relationship. Very often, the cost of inventory determines if an individual component is very profitable, barely profitable or is not profitable.

A firm in the supply chain must initiate the attempt to form partnerships and actively manage the supply chain. Often a firm that has a large amount of market power in the chain will become the leader of the supply chain. This firm needs to justify the effort to manage the supply chain by explaining the benefits that will accrue to each member in the supply chain and to itself. To do this, the

supply chain leader must show the partners where the improvements in the supply chain will arise and how these will lead to a gain for everyone.

To establish trust among the members of the supply chain, the lead firm must also suggest how communication can be opened up and how every member will be ensured that it is receiving its fair share of profits. One recent example of this has been Abu-Attifel Field. For years it has gathered extensive data on customer buying patterns. Abu-Attifel Field has used this data internally to manage its own layouts and inventory. Now it is beginning to share all of this data with its most trusted suppliers. This will allow the supplier who knows how to take advantage of this data an opportunity to improve service to Abu-Attifel Field while decreasing its own costs.

Managing a supply chain is more complex and difficult than managing an individual firm. But, the principles of management used to integrate Inventory to own internal functions also apply to managing the entire supply chain.

This principle applies to the entire supply chain. While the supply chain is driven by customer demand, it is constrained by its own internal resources. One difference is that these resources may not be owned by the same firm. It is possible for the output of an entire supply chain to be limited because one firm does not have capacity to meet surging demand. It is also possible for every firm in the supply chain to be operating at a low utilization because there is not enough demand in the market for the products from the supply chain. There are bottlenecks inside the supply chain just as there are bottlenecks inside firms. To properly manage the supply chain, its members must be aware of the location of their bottlenecks internally and also of the bottlenecks in the supply chain.

4.14 Examining the Basics of Supply Chain Management

Since the principles of managing the supply chain are the same as those required to integrate the internal functions of the firm, the basic principles of supply chain management at an individual firm and then examine how these principles apply to the entire supply chain. There is no cookbook for managing

the supply chain. However, there are some basic principles that can be used for it. And, a set of best management practices is evolving as managers gain experience managing their supply chains as shown below ⁽⁴⁸⁾.

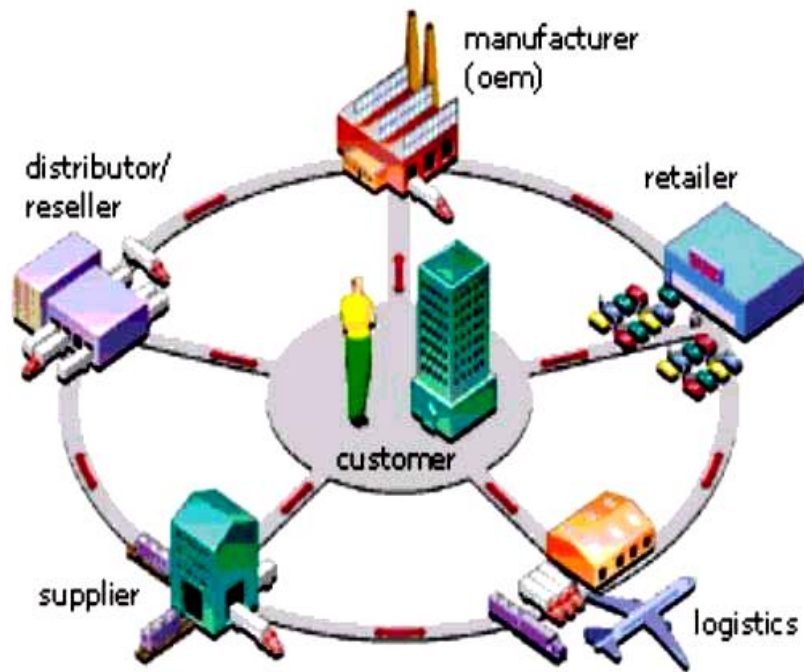


Figure (4.1): Integration of Supply Chain with Inventory Management. ⁽⁴⁸⁾

4.15 Summary

Integrating a supply chain is an incremental process, with priority typically given to the highest potential returns on investment. Based on strategies, needs, and potential returns, different priorities and approaches may be assigned to the supply chains of different segments of a business. The integration process can be expensive and is, in many respects, an exercise in resource allocation.

Many companies adopt an approach that begins at home and gradually works outward through the supply chain. The first step is to make in-house improvements, such as inventory reductions that can reduce working capital, warehousing, and transportation costs. An analysis of in-bound logistics can often reveal opportunities for savings. From there, the integration effort expands outward.

Chapter Five

**The Practical Part/
The Case Study**

Chapter Five

The case study

5.1 Introduction

In this chapter, the researcher has conducted the analysis guided by theoretical framework. The analysis part is based on our empirical findings. Furthermore, the author presents his suggestions upon the problems identified.

Abu-Attifel Field (A100) is situated 400 Km south of Benghazi and about 60 Km away from Jalo Oasis in Libya; it is placed on a "Sand Sea" to the bound of a wide range of dunes in Libyan Desert at 61 meters height on the sea level. The Field was discovered on January 1968 and on March 1972 started the production. It was subjected to numerous developments with the time and many projects were implemented (Gas Compression Plant, Water Injection Plant, NGL Plant in addition to other three remote Stations and facilities)⁽⁴⁷⁾. In a rather closed area are placed all the Production Plants that including a relevant Power Station, Utilities and Facilities becomes the Field totally autonomous.

Warehouse and Workshop are closed together in front the offices; the Power Station built on two floors is the first installation noted coming from the road. The camp (living quarter) is just placed at 1 Km far from the production areas. The Remote Stations (R82, OO, UU, YY, and KK) are accessible after crossing an average of 60 / 80 Km of desert route toward dunes, to reach those places with the car it has always been an attractive challenge.

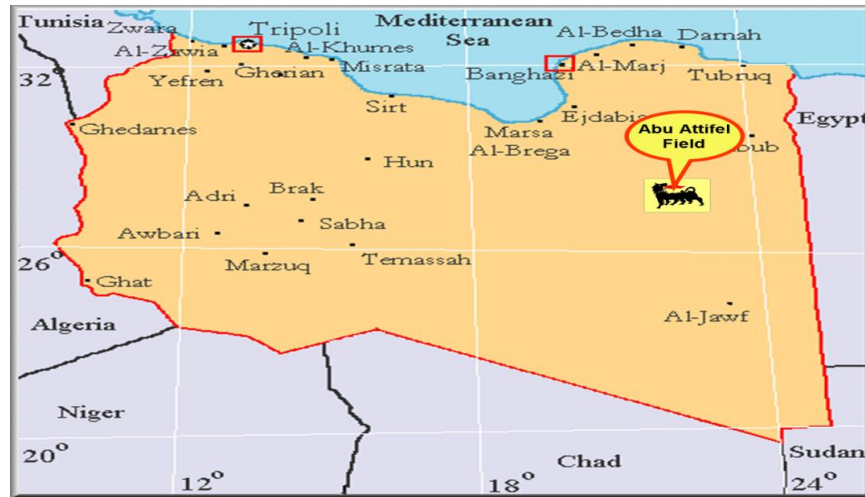


Figure (5.1): The map of Abu-Attifel field location. ⁽⁴⁷⁾

5.2 Production & Export Processes ⁽⁴⁷⁾

- A100 with 85% of total production is the crude oil gathering center of Abu-Attifel; all the crude oil produced flows to this center for the first processes and dispatchment.
- R82; production 1,300 bbl/d power installed 2,3 MW; it is the second oil field implemented in the time; since it is provided of all utilities and facilities (water supply and treatment, accommodation and power generation), it is totally autonomous. The field is connected to A100 by 72 Km of pipeline (12") and about 80 Km of desert route; the oil production is reduced with the time but the field still has its importance as crude oil displacement base and accommodation.
- OO; production 8,500 bbl/d, power installed 5.9 MW; the oil center is the more productive in this area; the crude oil flows through 19 Km pipeline 10" size to R82, the field is implemented with Water Injection Plant.
- UU; production 3,600 bbl/d, power installed 1.7 MW; it is provided of all utilities and accommodation to be autonomous; a branch of pipeline permits the displacement of crude oil together with 12" coming from R82.

- The other Stations YY and KK produce together 1,200 bbl/d, total power installed about 2.7 MW.

The crude oil from Remote Stations through a single pipeline 72 Km long (12") is dispatched to A100. While three pipe lines (30", 10" & 34") provide the transportation of heavy & light hydrocarbons from A100 to Zuetina Field (A103) situated 133Km west of Abu-Attifel on the way to the sea.

5.3 Production Areas

A100 – Oil Plant: Separation, Heating, Storage and Shipment are the main process always treated from over 30 years. The separation is the first process the Crude Oil faces coming from production wells, it is composed of three production lines and one testing line, each one is provided of four separators, two as 1st stage and one for each 2nd and 3rd stages. The separation lines were implemented of a low pressure pipeline manifold which permits the Crude Oil to flow directly to the 2nd and 3rd stage.

As the Abu-Attifel crude oil solidifies at ambient temperature, four heaters provide to warm it during displacement phase, in order to maintain the temperature in the storage higher than the pour point.

In the Storage the crude oil pass the final stage of processing; then by five shipping pumps the crude oil is shipped through Metering lines and 133 Km of pipeline to A103 Field and onward to ZUETINA port after other 211 Km.

By "Storage Capacity Enlargement" the Oil Plant was afterward implemented of two crude oil tanks with 250,000 bbl of total capacity, and other associated equipment as heaters, pumps meters etc.

Moreover, Oil Gathering Center Enlargement (200,000 bbl/d), Oil separator and Manifold, Let Down System are other important implementations which made the field's history.

The major difficulties which maintenance section faces to maintain the Plant's efficiency is due to the aging associated to the numerous equipments (type/number) installed. Often,

relevant corrective interventions are required to restore the efficiency of equipments, especially flow/pipe lines.



Figure (5.2): Separation Trains - (1972).



Figure (5.3): Storage Capacity Enlargement - (1984).

5.4 Maintenance Organization

The maintenance organization structure in Abu-Attifel Feild is mentioned below in brief discussion:

1. Maintenance Superintendent; Operative Maintenance, engineering Maintenance, Plant Inspection are all under the control of the Maintenance Superintendent. The maintenance structure as it is configured confers full effectiveness and homogeneity to the responsibilities.
2. The Operative Maintenance; provides to carry out the planned maintenance activities and unexpected works with skilled internal resources and specialized contractor's manpower in cooperation with Maintenance Engineering Section, defines day by days the best Practices and the best Actions Plan for the major jobs; (shutdown, general overhaul etc.) improving the technical quality of maintenance. The operative maintenance provides also the best distribution of the resources of various sections (Mechanical, Electrical, Instrument, Turbine and Remote Stations), minimizing as much as possible interferences and/or lack of manpower.
3. The Operative Maintenance Supervisors are the most skilled personnel; they apply the instruction taken from operative maintenance coordinator and report at the end of the job the results of the activities through an appropriate feed back procedure.
4. The Maintenance Engineering; checks quality and effectiveness of the scheduling maintenance activities improving the maintenance planning.
5. The Maintenance Analysts provide the optimization of planned maintenance by analyzing history and amending the program as required.
6. The Maintenance Planner schedules the maintenance activities on the main structures/equipments, he plans all extraordinary works, and he assists in the preparation of the maintenance budget on the basis of activities to be carried out. He prepares a weekly, monthly and yearly package of work taking information from AMOS.

7. The Plant Inspection; provides to inspect static equipments using NDT system test or by internal inspection, certifying lifting equipments and safety valves calibration.

5.5 AMOS Environment

During the simultaneous operation of the old system ISIS and the new AMOS starting in August and September 2004 prior to conclusive approval in 2005 one of the most remarkable differences was subject to experience. Since the old ISIS also known as Reflection was built on a DOS basis it had a typical text interface appearance and package of features. The root construction of menus, simple, low resolution screens and keyboard-based communication were typical for the business management aids of the past epoch.

On the other hand there was a modern Windows-based tool offering plenty of new possibilities such as multi-level operation, versatile and intuitive menus enabling to move across the structure in horizontal and vertical directions, powerful search engines and many others which very quickly became landmarks of the new work style.

The user-friendly graphic interface has helped to improve the communication between the user and database optimizing the information access by simultaneous operation of numerous data exchange routes. The typing error and other human related interferences have been reduced due to easier traceability and visual serial comparison possibilities.

The appearance of the user interface can be easily adjusted to better fit individual preferences what is a very important factor when comfortable work circumstances are concerned.

5.6 AMOS Maintenance Management Impact

The flow of major activities in the maintenance management works starting from maintenance request or work request, work order planning, work order check/approval,

work execution, work check and file, history and analysis. In a complex maintenance situation such as Abu-Attifel, where, for the field aging and numerous installations (for type & number), the planning of the activities represented one of the most difficult aspects for Maintenance Section.

The more flexible and reliable MM System (AMOS) introduced a remarkable support in the controlling and execution of the numerous tasks which the implementation of maintenance program is concerned.

Work Request; AMOS offers a good and clear access to the right Equipment and different fields to report the essential data and information of the Requested Job. Good and precise information at this stage have direct influence in the work request Workflow Efficiency.

Work Planning; practically this means not only identifying works to be undertaken but also the work that can not be achieved; the availability and controlling of spare parts is a factor which could affect the completion of the work, being AMOS system integrated at all stages, Maintenance, Warehouse and Procurement, this simplify the overall planning Job.

Maintaining of Files and Analysis; by the numerous History information and Filtering Facilities which AMOS offers it is possible a reliable Analysis which is a key role in the optimization of all activities as: planning maintenance, developing technical solution, technical evaluation for material requisition, costs assessment estimating man-hours etc.

5.7 AMOS - Material Management Impact

The main aims from the AMOS system is mentioned in brief points as flows:

a. The Function

The stream of main activities of the material business starting from item codification, through requisition processing, purchase, receiving of goods and finally

stock control and movement (material withdrawal) is now more flexible and efficient thanks to better inter-stage feedback and functionality. A number of supplemental features such as variety of adjustable reports and printouts help better control the document flow and optimize the overall procurement activity.

b. Particularly the following areas are worth to mention

1. New material codification; unlike in the old system the registration of new items has improved by means of constant monitoring ability of the active family or subfamily; this simplifies inserting the repeating information especially when series of items are concerned, simultaneously better protecting from typing errors etc.; in the old system every single codification had to start from scratch even within series of allied items.
2. Material requisition processing; out of similar reasons this cyclic operation is much more reliable and precise, because of saving many unnecessary steps such as printing and analyzing of under-stock list; it allows to concentrate on flexible analysis and validation of selected items by means of checking the actual movement against stock parameters using the stock control facilities run as parallel application; the system obviously cannot take all aspects in account that have role to play in the ultimate shape of requisition; therefore appropriate manual adjustment is now more important than ever to keep stocks sufficient and the value low; the more flexibility in hand of user at this stage, the more optimum target is achieved at the end.
3. Stock control; this activity has a key role in maintaining the highest level of confidence in material business; the stock parameters such as reorder level or quantity are the most powerful tools in user's hand to perform the reliable procurement not forgetting about keeping the stock value optimally low; it is very important to restrict the access to modify these parameters and on the other hand facilitate tracing the random unauthorized approach.

5.8 Organization Structure

Organization Structure is a diagram that shows the structure of an organization and the relationships and relative ranks of its parts and positions/jobs. Figure (5.4) shows the Organization Structure chart for Abu-Attifel Field.

ABU ATTIFEL FIELD ORGANIZATION CHART

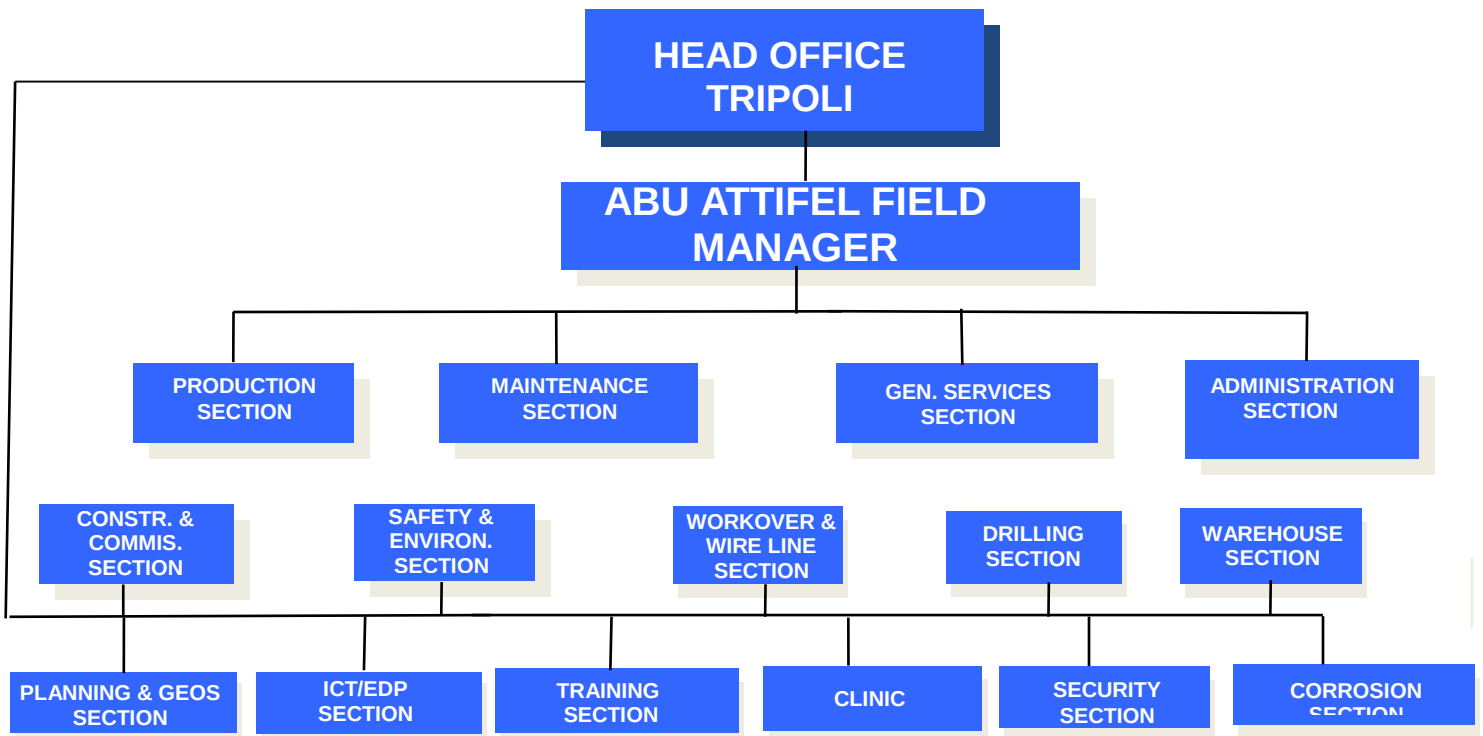


Figure (5.4): The organization structure for Abu Attifel field.

5.9 Inventory Control System

After several interviews with the manager and planning/maintenance crews in Abut-fell Field, the researcher realized that there was not a formalized inventory control system. Normally, the manager and the staff working in the warehouse placed new orders from his intuition and experience, or when inventory happened to be found few left in the information system or as the result of visual check by the staff working in the warehouse.

Such practice has two opposite results. The first one is stock-out, where the maintenance players have to wait for a period of time, shorter or longer, if they do not cancel the order.

The second one is overstock, where unnecessary inventory accumulates and sits in the warehouse, costly but useless. Therefore, a formalized and standardized inventory control system should be established to solve the problems.

5.10 ABC Analysis

At present, there have been a lot of different spare parts in Abu-Attifell Warehouse.

If the manager and staffs allocate same time and effort on inventory control for each item, it would take them extra time and effort that would have been used otherwise, hence increasing labor costs, so this classification for all the inventory items into several different level groups, then the different inventory groups can be treated differently and believe this classification can save much time, effort and cost on the daily inventory operation. And it is a cost-efficient solution for the company, with improved management under limited resources.

According to Onwubolu et al. ⁽³²⁾, classifying inventory items into A, B, C categories should follow several steps:

1. Determine annual quantity usage of each item.
2. Multiply the annual quantity usage of each item by the cost of the item to obtain the total annual dollar usage of each item.
3. Add the total dollar usage of all items to get the aggregate annual dollar inventory expenditure.
4. Divide the total annual dollar usage of each item by the aggregate annual inventory expenditure to obtain the percentage of total usage for each item.
5. List the items in rank order by percentage of aggregate usage.

6. Review annual usage distribution and classify items as A, B, or C.

Table 5.1 presents data collected based on AMOS Monitoring System for only 20 items as a case study: Work order No. WO-02-07-OO3293

Location: GTN-IN-07 3 YEAR REPLACING KIT OF BLOWOFF VALVE

Table (5.1): GTN-IN-07 3 YEAR REPLACING KIT OF BLOWOFF VALVE
Technical Data based on AMOS Monitoring System data in Source: own prepared.

No	Item No.	Description	In Use	In Stock	The Actual In store	stock maximum	stock minimum	Reorder level	Reorder Qty.	Price /unit	Total cost
1.	300666604	valve, non return SV52FB 3-10	1	3	0	0	0	2.99	2	2661.25	5322.5
2.	300666611	valve, check type MK	1	3	1	0	0	1.99	2	196.15	392.3
3.	300667328	gasket and seat ring set 30-RK-45-TT-Dn80-INSTR.49	1	1	2	0	0	0.99	2	19.92	39.84
4.	300667419	Shackle	1	4	2	0	0	3.99	4	89.15	356.6
6.	485901928	pressure control valve, 2"	1	1	0	0	0	0.99	1	10827.97	10827.97
6.	485901929	valve, safety - 931 NM.80	1	1	0	0	0	0.99	1	1519.65	1519.65
7.	485901951	card dis-trasm-AGC-DTM.7	1	2	1	0	0	1.99	1	1350.05	1350.05
8.	485901952	stepper motor - AGC-DTM.78	1	2	0	0	0	0.99	2	6661.24	13322.48
9.	485901953	unit rvdrt -AGC-EDEW.76.01	1	2	0	0	0	0.99	2	2303.72	4607.44

10	485902510	E.L Motor for fan intake system WAD 12mm	1	1	0	0	0	0.99	1	4467.14	4467.14
11	485902512	gasket foe baypass flap type	4	5	6	0	0	1.99	4	260.13	1040.52
12	485902514	repair kit K0380(Goyen)	10	11	4	0	0	3.99	10	76.33	763.3
13	485902516	diaphragm repair kit 4516(Goyen)	26	54	24	60	0	30	30	183.4	5502
14	485902518	solenoid valve contro lbox	1	1	9	0	0	0.99	1	1093.57	1093.57
15	485902520	solenoid valve contro lbox	2	2	12	0	0	0.99	2	1217.37	2434.74
16	485902522	supervision print type 118	1	1	30	0	0	0.99	1	1506.24	1506.24
17	487901102	switch pressure - Y-110 MOD 358 (PS-471)	1	1	2	0	0	0.99	1	246.65	246.65
18	487901301	switch temperature - C.110A MDD 102(TS-480)	1	1	2	0	0	0.99	1	73.09	73.09
19	487901502	switch limit - 14.CE -101-1	1	2	1	0	0	1.99	2	230.14	460.28
20	732432903	2.5 mm	1	503	96	0	o	9.99	288	1.05	302.4
										55628.76	

Table (5.1) is the list for the sample items in rank order by percentage of Libyan dinar usage and classify them into A, B or C. As what has been mentioned in theoretical framework, the classification is using a model of 10-40-50 percentages of the items. This percentage is the approximate number and will vary from company to company. In

accordance with the real situation of the sampled twenty items in Abu- Attifel Field, they established 20-40-40 as the appropriate percentage of the items for the classification as shown in Table 5.2.

Table (5.2): Ranking of items, using a 20-40-40% ABC classification.

No	Item No.	Description	Reorder Quantity	Price/ unit	Total cost	Percent of value	Cumul ative value	Price /unit	Total cost
8	485901952	steppermtror -AGC-DTM.78	2	6661.24	13322.48	23.948	23.948	2661.25	5322.5
5	485901928	pressure control valve, 2"	1	10827.97	10827.97	19.464	43.413	196.15	392.3
13	485902516	diaphragm repair kit 4516(Goyen	30	183.4	5502	9.890	53.304	19.92	39.84
1	300666604	valve, non return SV52FB 3-10	2	2661.25	5322.5	9.567	62.872	89.15	356.6
9	485901953	unit rvdtd -AGC-EDEW.76.01	2	2303.72	4607.44	8.282	71.154	10827.97	10827.97
10	485902510	E.L Motor for fan intake system WAD 12mm	1	4467.14	4467.14	8.030	79.18	1519.65	1519.65
15	485902520	solenoid valve contro lbox	2	1217.37	2434.74	4.376	83.561	1350.05	1350.05
6	485901929	valve, safety - 931 NM.80	1	1519.65	1519.65	2.731	86.293	6661.24	13322.48
16	485902522	supervision print type 118	1	1506.24	1506.24	2.707	89.001	2303.72	4607.44
7	485901951	card dis-trasm-AGC-DTM.7	1	1350.05	1350.05	2.426	91.427	4467.14	4467.14
14	485902518	solenoid valve contro lbox	1	1093.57	1093.57	1.965	93.393	260.13	1040.52
11	485902512	gasket foe baypass flap type	4	260.13	1040.52	1.870	96.264	76.33	763.3
12	485902514	repair kit K0380(Goyen)	10	76.33	763.3	1.372	96.636	183.4	5502
19	487901502	switch limit -14.CE -101-1	2	230.14	460.28	0.827	97.463	1093.57	1093.57

2	300666611	valve, check type MK	2	196.15	392.3	0.705	98.168	1217.37	2434.74
4	300667419	Shackle	4	89.15	356.6	0.641	98.810	1506.24	1506.24
20	732432903	2.5 mm	288	1.05	302.4	0.543	99.353	246.65	246.65
17	487901102	switch pressure -Y-110 MOD 358 (PS-471)	1	246.65	246.65	0.443	99.796	73.09	73.09
18	487901301	switch temperature -C.110A MDD 102(TS-480)	1	73.09	73.09	0.131	99.928	230.14	460.28
3	300667328	gasket and seat ring set 30-RK-45-TT-Dn80-INSTR.49	2	19.92	39.84	0.071	100	1.05	302.4
55628.76 100									55628.76

ABC analysis is a type of technique, which provides the means for identifying those items that make the largest impact on a company's overall inventory cost performance. Following the ranking from the analysis, it can place different controls on items A, B and C to improve the total inventory performance. From Table (5.2) is showing that the first four items (Item No. 485901952, 485901928, 485902516 and 300666604) are the high priority A items. They should be controlled more closely on inventory records, and they need more frequent reviews in terms of forecasting, demand inquiry and order quantity determination. The next eight items (Item No. 485901953, 485902510, 485902520, 485901929, 485902522, 485901951, 485902518 and 485902512) are the medium priority B items.

They should have less control compared to A items and be reviewed less frequently. The last eight items (Item No. 485902514, 487901502, 300666611, 300667419, 732432903, 3487901102, 487901301 and 300667328) belong to the lowest priority C items. They should have the least control and be reviewed over a long time, at the same time C items can be ordered in large quantities and have more safety stocks.

5.11 Warehouse

Form the empirical findings, we got to know that AMOS - Maintenance Management uses one warehouses for their inventory storage.

5.11.1 Warehouse Layout

As what has been mentioned in theory part, warehouse visibility is very important to improve the efficiency on warehousing operations. There are several ways to strengthen the visibility inside the warehouse:

a. Location labeling on the warehouse floor

Distinct floor mark in warehouse can help forklift drivers to find the correct zones, regions or aisles easily. Usually, the bright yellow will be used for the floor mark color. At the same time, the grid of columns is one popular way for workers to identify the areas. The grid location labels can be affixed on all sides of columns. Figure (5.5) shows the example of column grid labeling. Compare with this example, we can observe from Figure (5.6) that Abu-Attifel warehouse is lack of this kind of identification labels.

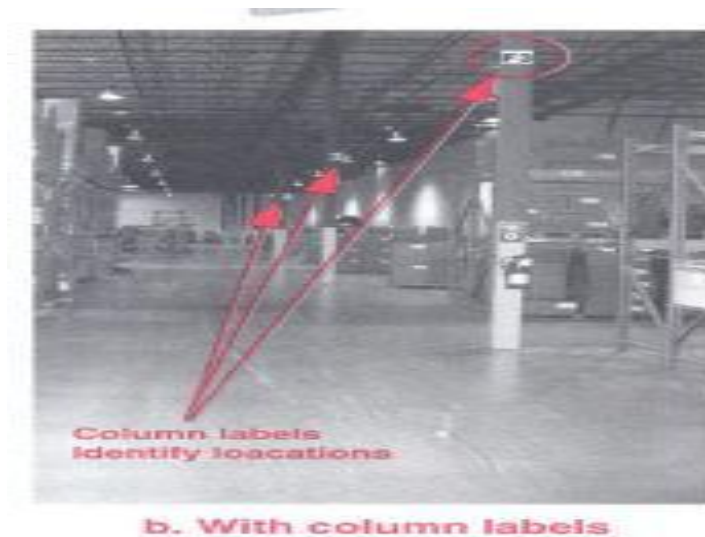


Figure (5.5): The example of column grid label. ⁽³³⁾



Figure (5.6): Abu- Attifel Warehouse.

b. Zone identification

According to authors' experience, one common solution for zone identification is to hang a "name card" above every specific zone. Maybe the flat "name card" can not be seen from every direction, especially in the large rooms. Then we can use the triangular signs above the racks. This kind of shingle is visible from all directions. Unfortunately, we did not find this zone identification signs in the Abu-Attifel warehouse.

c. Rack identification

Rack identification is the most useful and effective method for identify locations in pallet racks by three coordinates for aisle, column within the aisle, and level within the column.

When authors worked in Abu-Attifel warehouse, we encounter some problems about the rack identification.

There is no item location guide. Some items' number was shown on the label, like Figure. (5.7) on the side of rack, but some items can not be found in the appointed rack, shows us one suitable item location guide board on the side of racks.



Figure (5.7): The example of shingle of zone.



Figure (5.8): The example of item location guide. ⁽³³⁾

- Location addressing is inconsistent or not adequately displayed. From the Figure. (5.9) we can see the label on the rack shows item number is 512005, but after checking the goods on the pallet, it is not Item 512006. Figure (5.10) shows that most racks still did not have any kind of location addressing.



Figure (5.9): Incorrect rack label.



Figure (5.10): Example 1 no label.

5.11.2 Warehouse Management System (WMS)

Base on the practical situation of Abu- Attifel’s warehouse, which store approximate 1000 thousand different kinds of items, author surprising why they did not use the barcode scanning system which can make the inventory control operation efficiently and accurately?

It is hard for them to consolidate them into one barcode label. Even the same item in one wooden box but they are in different colors. Figure (5.11) shows the same size of rubber plates in one big wooden box, but usually they are in different colors. If every independent small box has one barcode label, it takes time for workers to scan all of them. Nowadays, they input these data according to the packing list from suppliers with the shipment.



Figure (5.11): Example 2 no label.

5.12 Information System

To evaluate the information system-‘AMOS’, we will focus attention on its performance in inventory management for Abu-Attifel Field.

The biggest aid ‘AMOS’ is providing to the management is to update the inventory records for all the items every day so that they can capture the right data to

support their decisions regarding inventory. Without the support from ‘AMOS’, the management will face great difficulty in managing inventory effectively and efficiently. However, ‘AMOS’ cannot make right decisions about inventory for the management. Data are kept in the information system. But how to use and analyze data to establish an effective and efficient inventory control system is still placed on the management. If they are unable to do it in the right way, the information system will reap fewer benefits.

‘AMOS’ now has a disadvantage. The historical inventory record is replaced by new updates and cannot be retrieved any longer. We suggest these historical inventory records of each day should be kept in the database, which will be used to draw a graph for each item over the course of a whole year. The graph becomes a vivid measurement to demonstrate the inventory management performance. The management can easily identify whether there are overstock and stock-out for specific item, the occurrence frequency and degree.

Through the reviews the management will get more experience about the inventory control system, hence further improve inventory management for the near future.

5.13 Component/Equipment Technical Data

This part of study will focus on AMOS Monitoring System. This program has password if you desire to access the data, few employees have an access to this system, and one of them is the research because he works a maintenance planner. The Supply chain management is illustrated as following.

The preventive maintenance for all equipments were programmed in a certain date for maintenance works. All kind of spare parts, unskilled manpower, skilled manpower, technicians, experts, commissioners which usually hired from the manufacturer, Etc.

The AMOS Monitoring System helps the planner to know all the details regarding the spare parts/items which available in the Field Warehouse. The researcher has accessed to the AMOS Monitoring System during the writing the practical part of the

research while he was working on preparations of one of the equipment that has to be maintained based on scheduled program. The following figures were printout by the researcher named component called A-100- Maintenance – (Components -0007-Sulzer Type 7). The equipment is a Gas Turbine Machine for power station located at Abu-Attifel Field (A-100).

Figure (5.12) indicates the detailed data of the equipment (GT IN-0007). All data needed such as: Type, Type No., Stock Items, Serial No., Machine Code, Status, Function No., and Function Description.

Number	Title	Component	Priority	Resp. Discipline	Status	Due	Pl. Start	Started	Completed	Func. No.
W0-02-07-003481	GTIN-014 - 100000 RHS "E" SULZER TU	GTIN -0007	5	A25-Turbine Venc	Ready to Start	6/7/2027				PSS47
W0-02-05-002247	GTIN-H-D - 50000 RHS "D" SULZER TU	GTIN -0007	5	A25-Turbine Venc	Ready to Start	6/17/2017				PSS47
W0-02-05-002212	GTIN-H-C - 25000 RHS "C" SULZER TU	GTIN -0007	5	A25-Turbine Venc	Ready to Start	6/22/2012				PSS47
W0-03-12-001221	GT7 TO ELIMINATE OIL LEAK PRESEN	GTIN -0007	1	A20-Turbines	Approved	3/31/2012	3/31/2012			PSS47
W0-02-07-003293	GTIN-IN-07 - 3 YEAR REPLACING KIT O	GTIN -0007	5	A40-Instr. Section	Scheduled (print)	3/5/2012				PSS47
W0-03-12-000635	GT7 TO	GTIN-IN-07 - 3 YEAR REPLACING KIT OF BLOWOFF VALVE		A20-Turbines	Completed	2/16/2012	2/16/2012	3/31/2012	3/31/2012	PSS47
W0-03-12-000584	GT7 ENCLUSER FAN 2 EARTH FAULT	GTIN -0007	1	A31-Electrical	Scheduled (print)	2/12/2012	2/12/2012			PSS47
W0-03-11-000802	GT7 AIR INTAKE FILTERS DIRTY TO BEG	GTIN -0007	1	A20-Turbines	Scheduled (print)	2/25/2011	2/25/2011			PSS47

Number	Name	Type	Serial No.	Machine Code	Status	Func. No.	Func. Description
GTIN -0007	SULZER TYPE 7	TYPE 7	7053	DA044	In Use	PSS470MT007	GAS TURBINE GT07. EL

Figure (5.12): Printout of GTIN-0007 Technical Data using AMOS Monitoring System.

5.14 Work Order

The work order is one of the major problems that face the maintenance activities, if the work order system or chain was not followed and performed properly, later will have negative impact on SCM. Usually the work order is issued traditionally by operation crews who noticed or observed any problems. The operator or the assigned person has to hand writing the work order in case of any corrective maintenance.

Nowadays, computer systems play important roles in programming the maintenance activities. The work order will be issued automatically whenever there is a need for maintenance, this kind of programing is a combined network that links the operation, maintenance and warehouse together.

In the Equipment (GTIN-0007) case, was scheduled and planned for preventive maintenance 2012, May 13. But indeed this was delayed due to many problems existed such as: lack of foreigner manpower which supposed to be contracted, lack of spare parts which have to be ordered in early date. But due to Libya is facing problems (i.e. previous war, exiting of all foreigner contractors, specialized companies, sanction, etc.).

Figure (5.13) showing a printout of work order page using AMOS Monitoring System.

5.15 Discussion of finding

The samples were analyzed data from the program AMOS according to ABC technique was prepared as described in schedules foregoing. It has been shown that it is a good way to control inventory, according to what has been scientifically proven as an effective way to control and follow-up of inventory more effectively and efficiently instead of wasting time at the account of all varieties alone. This method through which the limited Items depending on the priorities of either A, B or C.

As it was pointed out to the stores and method of numbering the various places for easy access with ease, rather than waste time and effort in the long search for a particular item or inventory quantities on a regular basis and to activate the role of program AMOS and rely on the quantities in it instead of re-check and make sure a new spare parts each work order maintenance for each corrective or preventive in case of issuance or follow-up.

Chapter Six

Conclusions, Recommendations &Future studies

Chapter Six

Conclusions, Recommendations & Future studies

6.1 Introduction

Inventory management is critical for most companies, which have negative effects on the way inventory can be managed.

Many companies face great challenges in managing inventory when they seek developments. This dissertation is trying to connect theories with a real case and propose managerial solutions that Abu-Attifel, can implement to improve its inventory management.

6.2 Theoretical Conclusions

The theories about SCM, inventory management and IT included in theoretical framework are interrelated implicitly when they are applied to the case study in this dissertation. In other words, the option of an efficient inventory control system is affected by all of them, in different perspectives, and to different extent.

We also find that even though inventory management is critical businesses, the related theory on managing inventory facing rapidly fluctuating demands is sparse. And most studies about various inventory control techniques did not provide prerequisites and constraints in terms of their application. However, we do get inspiration from previous research and construct the suitable theoretical framework for this case study as following:

1. In order to allocate time and money on inventory in rationalization, ABC analysis model has been used to classify various items.

2. Periodic review policy is selected to help management to determine when they should place new orders for inventory replenishment.
3. The ‘desired covering period’ approach is chosen to determine the order quantity.
4. The logic why specific theories have been selected and the way in which they were applied to this case study may be seen as a little contribution to the theory evolution.

6.3 Practical Conclusions

The data in 2012 gathered from the main AMOS Monitoring System of twenty items reveal that demand variability is big in fact. After ABC classification, treatments become different for different category items. For instance, more attention needs to be paid to A items and less review on C items. It is an efficient approach to saving costs, time and efforts for management.

Following ABC classification, different review periods could be set in accordance with each category’s specific characteristic. A items have the first priority to be reviewed as they account for 20% of total amount of items, but with more than 50% of total dinar value.

More frequent review can help management to better control these items to minimize stock-out or excess stock occurrence.

It is concluded the EOQ model is not applicable to this case because the necessary inputs are not available. Instead, the desired covering period approach is applied regarding order quantity determination. We suggest that order quantity can vary for single replenishment based on the historical demand records, and the desired covering period is exactly the same as each item’s review period.

6.4 Recommendations

1. A good character, honest and trustworthy Personnel well verse with the Principles of effective store control.
2. The use of shelves as a storage facility by company is appropriate but this is not enough. Other storage facilities such racks and pallets should be employed in the stores. The use of these facilities will ensure maximum security against deterioration and breakages. For other heavy materials like these used in large electrical installations, stock yield should be provided with adequate pallets and fenced to facilitate control and security. The gates should be well constructed and lockable and a provision of fire prevention in case of any unforeseen contingencies.
3. Stock levels should be fixed for items and materials purchased and held in stores in order to help provisioning. These levels, (maximum, minimum and re-order levels) could be fixed based on the previous purchasing order and the result adjusted in the light of what is likely to occur in the future.
4. Supplier's delivery date and time should be fixed for the company. They should also be aware of the days and time during which they are expected to make deliveries and when facilities will be available to accept such deliveries and to avoid unnecessary delays, stock out and costs.
5. Other Employees should not be allowed into the warehouse unless it is strictly on business. The habit of employees using the store area for their breakfast break and this should be discouraged by company.
6. Warehouse system comprising all items of stock held in various stores located from the physical stock itself should be kept in the right location.
7. For easy identification of materials in the stores and to reduce fatigue, appropriate coding system should be employed. This can be done by using letters, figures or a combination of both. The system could be based upon the nature of the stores

items, the purpose for which items are bought, or on any other basis regarded as suitable for the business.

8. The Storekeeper in charge of the main store should be empowered to receive all in-coming materials irrespective of the sub-store they belong. He should always be informed of what he is expected to receive and when it is likely to arrive by giving him a copy of the order form. If this is applied, it will reduce time wasting in receive materials as well as unnecessary delays of suppliers in the absence of a store Officer.

6.5 Future Studies

1. Apply other models to control inventory such as EOQ to optimize the value.
2. Compare the AMOS system with other ERP system in Eni Gas Company to find which one the best to control inventory.

Appendix

AMOS - A-100 Field/A-100 - Maintenance - [Work Order [WO-02-06-001357 - CORE-002 - 12000 SERVICE NUOVO PIGNONE 2HB/1] [WO-04-12-000649 - TO REPAIR THE ...]

File Edit Options Maintenance Stock Purchase Budget Tools Window Help

Welcome Osama M. Elmajdup, 4/4/2012

Work Orders

General Details Additional Info Job Description Required Parts Required Disciplines Included Jobs Attachments Financials Permits to Work

Number: WO-02-07-003293 Triggered By: Frequency Created By: ATTLISSI

Title: GTIN-IN-07 - 3 YEAR REPLACING KIT OF BLOWOFF VAL History Template:

For Component: GTIN-0007 SULZER TYPE 7 Status: Scheduled (printer)

For Function: PSS470MT007 GAS TURBINE GT07, ELECTRIC POWER GENERA Type: Periodic

Frequency: 36 Month(s) Project:

Parent WO: Estimated Misc. Cost: LYD 0.00

Planning: Priority: 5 Est. Dur. (Hrs): 24.00

Due Date: 3/5/2012 Locked

Window (Days): 0 3/5/2012

Maint. Criteria: Fully isolated

Resp. Discipline: A40-Instr. Section

Output Format: Work Order

Work Classification: ☐ Unexpected Work

Maint. Type: Minor Job

Maint. Class: Non Critical

Maint. Cause: Preventive Activity

History: Created: 7/11/2007

Pl. Start:

Started:

Completed:

☐ Filed

Inst/Dept	Number	Title	Component	Priority	Resp. Discipline	Status	Due	Pl. Start
010/01	WO-02-07-003293	GTIN-IN-07 - 3 YEAR REPLACING KIT OF BLOWOFF VALVE	GTIN-0007	5	A40-Instr. Section	Scheduled	3/5/2012	

Work Orders Components

Ready

Start Document1 - Microsoft ... AMOS - A-100 Field/A... Microsoft Excel - WEEK 1... 8:26 AM

Figure (5.13): printout of work order page using AMOS Monitoring System.

AMOS - A-100 Field/A-100 - Maintenance - [Components [GTIN -0007 - SULZER TYPE 7]]

Welcome Osama M. Elmajdup, 4/4/2012

General | Type Details | Financial | Jobs | Parts | Counters | Attachments | Account Codes | W.O. | History | Maint. Log | Functions Performed

Number: GTIN -0007 Type Number: SULZER01-00004A Status: In Use

Name: SULZER TYPE 7

Maker: SULZER01 SULZER TURBO LTD

Type: TYPE 7 Component Class: Industr. Gas Turbine

Serial No.: 7053 Unplanned Maint. Template:

Location: AG-PS Power Station

Parent Comp.: GTIN -SULZ2 TYPE 7 (NEW POWER STATION)

Vendor: SULZER01 SULZER TURBO LTD

Function: PSS470MT007 GAS TURBINE GT07, ELECTRIC POWER GENE

Comp. Type Model:

Machine Code: DA044

Number	Name	Type	Serial No.	Machine Code	Status	Func. No.	Func. Description
GTIN -0007	SULZER TYPE 7	TYPE 7	7053	DA044	In Use	PSS470MT007	GAS TURBINE GT07, EL

Work Orders | Components

Ready CBM

Start Document1 - Microsoft ... AMOS - A-100 Field/A... Microsoft Excel - WEEK 1... 8:29 AM

Figure (5.14): Detailed data on work order page using AMOS Monitoring System.

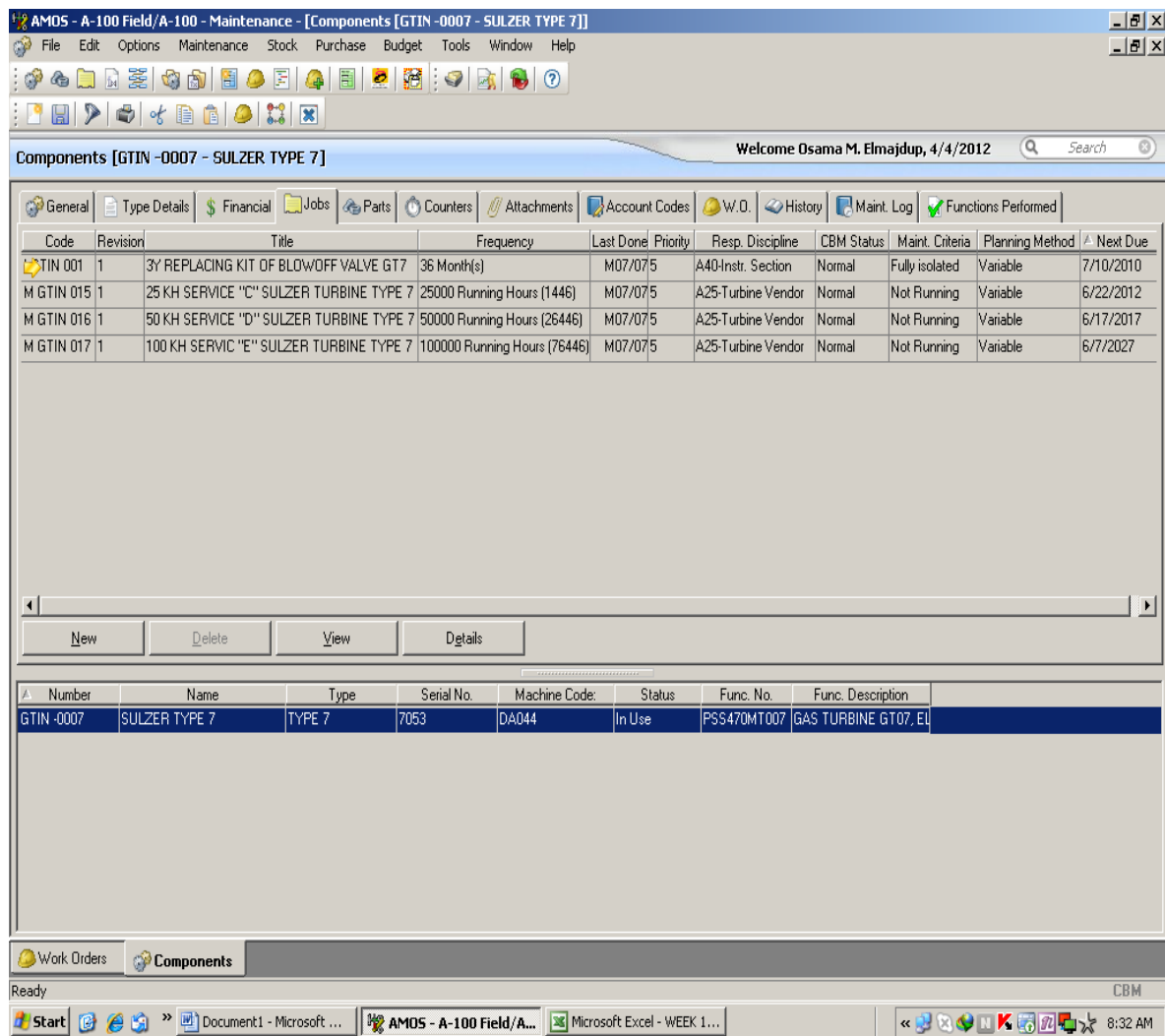


Figure (5.15): Type of items and spare parts need to ordered.

AMOS - A-100 Field/A-100 - Maintenance - [Components [GTIN -0007 - SULZER TYPE 7]]

File Edit Options Maintenance Stock Purchase Budget Tools Window Help

Welcome Osama M. Elmajdup, 4/4/2012 Search

Components [GTIN -0007 - SULZER TYPE 7]

General Type Details Financial Jobs Parts Counters Attachments Account Codes W.O. History Maint. Log Functions Performed

Component/Equipment Technical Data

Data Label	Data Value
Description	SULZER GAS TURBINE
Maker	SULZER
Maker Reference	7053/54
Maker Model	7
PO Order	365900NPS1
PO Date	000019830523
Drawing Code	SNAMPROGETTI MECHANICAL BOOK - SECTION B

Number	Name	Type	Serial No.	Machine Code	Status	Func. No.	Func. Description
GTIN -0007	SULZER TYPE 7	TYPE 7	7053	DA044	In Use	PSS470MT007	GAS TURBINE GT07. EL

Work Orders Components

Ready CBM

Start Document1 - Microsoft ... AMOS - A-100 Field/A... Microsoft Excel - WEEK 1... 8:29 AM

Figure (5.16): Component/Equipment Technical Data.

AMOS - A-100 Field/A-100 - Maintenance - [Stock Items [732432903 - 2.5 MM]]

Welcome Osama M. Elmajdup, 4/4/2012

Stock Items [732432903 - 2.5 MM]

General | Type Details | Vendors | Outstanding Forms | Stock Transactions | Components | Reserved on Work Orders | Attachments | Account Codes | Overview

Number: 732432903 Family Sh.Desc: ELECTRODES - BASIC
 Name: 2.5 MM Harmonized C: 831110.0/20
 Maker: UTP01 UTP See Code:
 Maker's Ref.: 000 000 692 452 Asset
 Preferred Vendor: PV 00876 WELDING ELECTRODES
 Vendor's Ref.: ☐ Perishable Item

Locations

Location	Current Stock	Expiry Date
A100 W/H / MAIN A100 W/H / A	503	

Total Stock: 503.00

Default Add Add Remove

Stock Details

☒ Stocked Item Stock Maximum: 0
 Stock Unit: NO Stock Minimum: 0
 Wanted: 0 Reorder Level: 9.99
 Reserved: 0 Reorder Quantity: 288

Prices

Stock Average: LYD 1.05
 Last Purchased: EUR 0.54 8/22/2006

Stock Class: 732 ELECTRODES - COATED S.S. & HARDFACING
 Document No.: Price Class: Criticality: Normal

Number	Name	Maker Code	Maker's Reference	Unit	Pref. Vendor Code	See Code	Default Location	Stock Class
732432903	2.5 MM	UTP01	000 000 692 452	NO	PV 00876		E78C - E78C-Area	732

Work Orders | Components | Stock Items

Ready CBM

Start suzular's parts from AMO... AMOS - A-100 Field/A... Microsoft Excel - WEEK 1... 8:50 AM

Figure (5.17): Financial data on work order page.

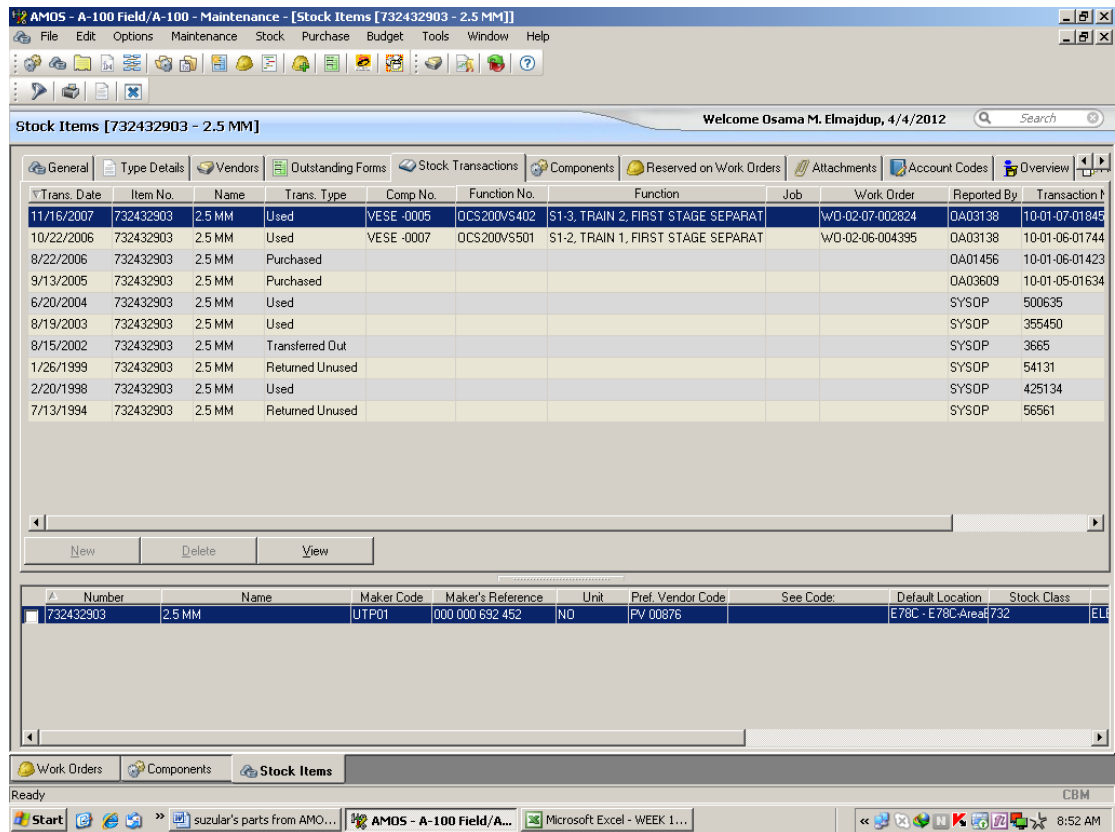


Figure (5.18): Stock items (page1).

AMOS - A-100 Field/A-100 - Maintenance - [Stock Items [522521001 - COMPLETE COOLER]]

Welcome Osama M. Elmajdup, 4/4/2012

Stock Items [522521001 - COMPLETE COOLER]

General | Type Details | Vendors | Outstanding Forms | Stock Transactions | Components | Reserved on Work Orders | Attachments | Account Codes | Overview

Number: 522521001 Family Sh.Desc: LUWA COOLER FINNI
 Name: COMPLETE COOLER Harmonized C. 841410.0/20
 Maker: LUWA01 LUWA See Code:
 Maker's Ref.: Asset
 Preferred Vendor: PV 00490 LUWA
 Vendor's Ref.: ☐ Perishable Item

Locations

A	Location	Current Stock	Expiry Date
★	A100 W/H / MAIN A100 W/H / A	0	

Total Stock: 0.00
 Default Add Add Remove

Stock Class: 522 COOLERS - COOLING TOWERS
 Document No.: Price Class: Criticality: Normal

Stock Details

☒ Stocked Item Stock Maximum: 0
 Stock Unit: NO Stock Minimum: 0
 Wanted: 0 Reorder Level: 0
 Reserved: 0 Reorder Quantity: 0

Prices

Stock Average: LYD 0.00
 Last Purchased: LYD 0.00

A	Number	Name	Maker Code	Maker's Reference	Unit	Pref. Vendor Code	See Code	Default Location	Stock Class
☐	522521001	COMPLETE COOLER	LUWA01		NO	PV 00490		DUMY - DUMY-Du522	CO

Work Orders | Components | Stock Items

Ready

Start | suzular's parts from AMO... | AMOS - A-100 Field/A... | Microsoft Excel - WEEK 1... | 8:53 AM

Figure (5.19): Stock items (page 2).

AMOS - A-100 Field/A-100 - Maintenance - [Stock Items [487901502 - SWITCH, LIMIT - 14.CE-101-1]]

File Edit Options Maintenance Stock Purchase Budget Tools Window Help

Welcome Osama M. Elmajdup, 4/4/2012

Stock Items [487901502 - SWITCH, LIMIT - 14.CE-101-1]

General Type Details Vendors Outstanding Forms Stock Transactions Components Reserved on Work Orders Attachments Account Codes Overview

Number: 487901502 Family Sh.Desc: SULZER - SWITCHES
 Name: SWITCH, LIMIT - 14.CE-101-1 Harmonized C. 903210.0/10
 Maker: SULZER01 SULZER TURBO LTD See Code:
 Maker's Ref.: 105 070 000 317 Asset
 Preferred Vendor: PV 00788 SULZER
 Vendor's Ref.:

Locations

Location	Current Stock	Expiry Date
A100 W/H / MAIN A100 W/H / A	2	

Total Stock: 2.00

Default Add Add Remove

Perishable Item

Stock Details

☒ Stocked Item Stock Maximum: 0
 Stock Unit: NO Stock Minimum: 0
 Wanted: 0 Reorder Level: 1.99
 Reserved: 0 Reorder Quantity: 2

Prices

Stock Average: LYD 230.14
 Last Purchased: LYD 230.14 5/14/2001

Stock Class: 487 SENSOR SWITCHES & THERMOELEMENTS
 Document No.: Price Class: Criticality: Normal

Number	Name	Maker Code	Maker's Reference	Unit	Pref. Vendor Code	See Code	Default Location	Stock Class
487901502	SWITCH, LIMIT - 14.CE-101-1	SULZER01	105 070 000 317	NO	PV 00788		C41L - C41L-AreaC487	SE

Work Orders Components Stock Items

Ready CBM

Start suzular's parts from AMO... AMOS - A-100 Field/A... Microsoft Excel - WEEK 1... 8:54 AM

Figure (5.20): Stock items (page 3).

AMOS - A-100 Field/A-100 - Maintenance - [Stock Items [487901301 - SWITCH, TEMPERATURE - C.110 A MOD 102 (TS-480)]]

File Edit Options Maintenance Stock Purchase Budget Tools Window Help

Welcome Osama M. Elmajdup, 4/4/2012

Stock Items [487901301 - SWITCH, TEMPERATURE - C.110 A MOD 102 (TS-480)]

General Type Details Vendors Outstanding Forms Stock Transactions Components Reserved on Work Orders Attachments Account Codes Overview

Number: 487901301 Family Sh.Desc: SULZER - SWITCHES
 Name: SWITCH, TEMPERATURE - C.110 A MOD 102 (TS-480) Harmonized C: 903210.0/10
 Maker: SULZER01 SULZER TURBO LTD
 Maker's Ref.: 000 004 582 118 SWITCH, TEMPERATURE - C.110 A MOD 102 (TS-480)
 Preferred Vendor: PV 00788 SULZER
 Vendor's Ref.:
☐ Perishable Item

Locations

A	Location	Current Stock	Expiry Date
★	A100 W/H / MAIN A100 W/H / A	1	

Total Stock: 1.00
 Default Add Add Remove

Stock Details

☒ Stocked Item Stock Maximum: 0
 Stock Unit: NO Stock Minimum: 0
 Wanted: 0 Reorder Level: 0.99
 Reserved: 0 Reorder Quantity: 1

Prices

Stock Average: LYD 73.09
 Last Purchased: LYD 73.09

Stock Class: 487 SENSOR SWITCHES & THERMOELEMENTS
 Document No.: Price Class: Criticality: Normal

A	Number	Name	Maker Code	Maker's Reference	Unit	Ref. Vendor Code	See Code	Default Location	Stock Class
☐	487901301	SWITCH, TEMPERATURE - C.110	SULZER01	000 004 582 118	NO	PV 00788		C47L - C47L-AreaC487	SE

Work Orders Components Stock Items

Ready CBM

Start » suzular's parts from AMO... AMOS - A-100 Field/A... Microsoft Excel - WEEK 1... 8:56 AM

Figure (5.21): Stock items (page 4).

AMOS - A-100 Field/A-100 - Maintenance - [Stock Items [487901301 - SWITCH, TEMPERATURE - C.110 A MOD 102 (TS-480)]]

File Edit Options Maintenance Stock Purchase Budget Tools Window Help

Welcome Osama M. Elmajdup, 4/4/2012

Stock Items [487901301 - SWITCH, TEMPERATURE - C.110 A MOD 102 (TS-480)]

General Type Details Vendors Outstanding Forms Stock Transactions Components Reserved on Work Orders Attachments Account Codes Overview

Number: 487901301 Family Sh.Desc: SULZER - SWITCHES
 Name: SWITCH, TEMPERATURE - C.110 A MOD 102 (TS-480) Harmonized C: 903210.0/10
 Maker: SULZER01 SULZER TURBO LTD
 Maker's Ref.: 000 004 582 118 SWITCH, TEMPERATURE - C.110 A MOD 102 (TS-480)
 Preferred Vendor: PV 00788 SULZER
 Vendor's Ref.:
☐ Perishable Item

Locations

A	Location	Current Stock	Expiry Date
★	A100 W/H / MAIN A100 W/H / A	1	

Total Stock: 1.00
 Default Add Add Remove

Stock Details

☒ Stocked Item Stock Maximum: 0
 Stock Unit: NO Stock Minimum: 0
 Wanted: 0 Reorder Level: 0.99
 Reserved: 0 Reorder Quantity: 1

Prices

Stock Average: LYD 73.09
 Last Purchased: LYD 73.09

Stock Class: 487 SENSOR SWITCHES & THERMOELEMENTS
 Document No.: Price Class: Criticality: Normal

A	Number	Name	Maker Code	Maker's Reference	Unit	Pref. Vendor Code	See Code	Default Location	Stock Class
☐	487901301	SWITCH, TEMPERATURE - C.110	SULZER01	000 004 582 118	NO	PV 00788		C47L - C47L-AreaC487	SE

Work Orders Components Stock Items

Ready CBM

Start » suzular's parts from AMO... AMOS - A-100 Field/A... Microsoft Excel - WEEK 1... 8:56 AM

Figure (5.22): Stock items (page 5).

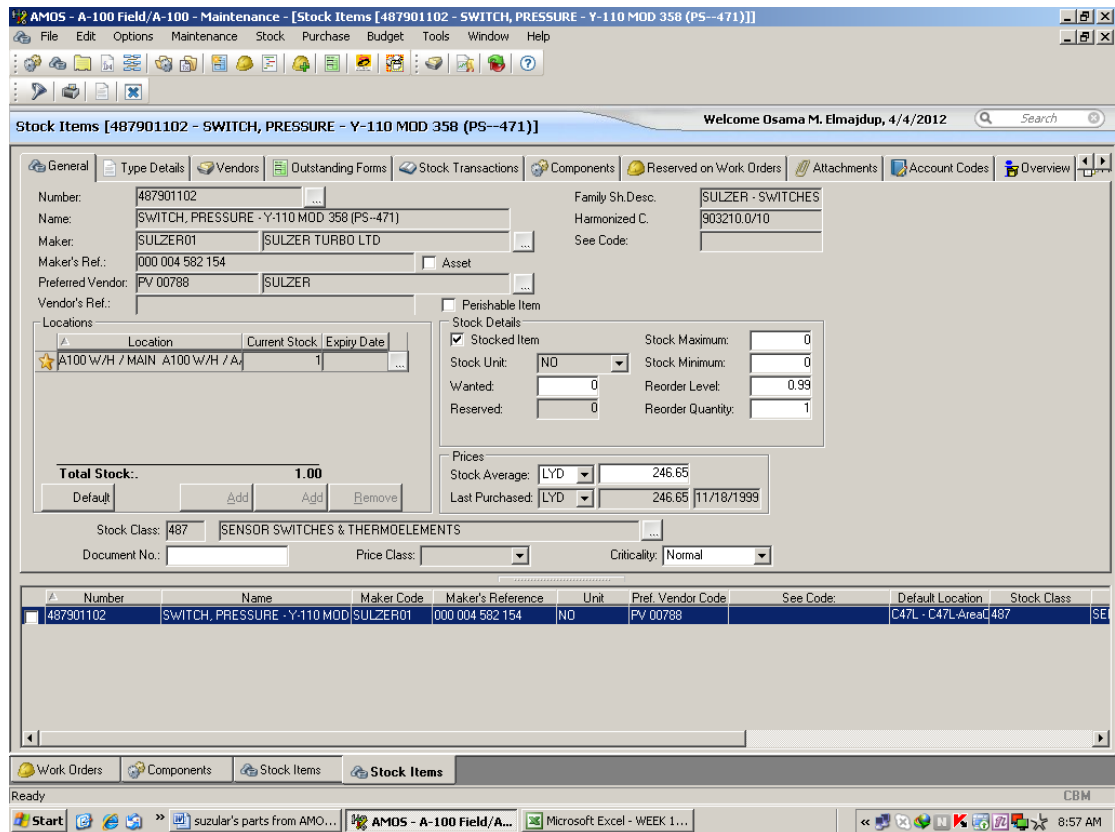


Figure (5.23): Stock items (page 6).

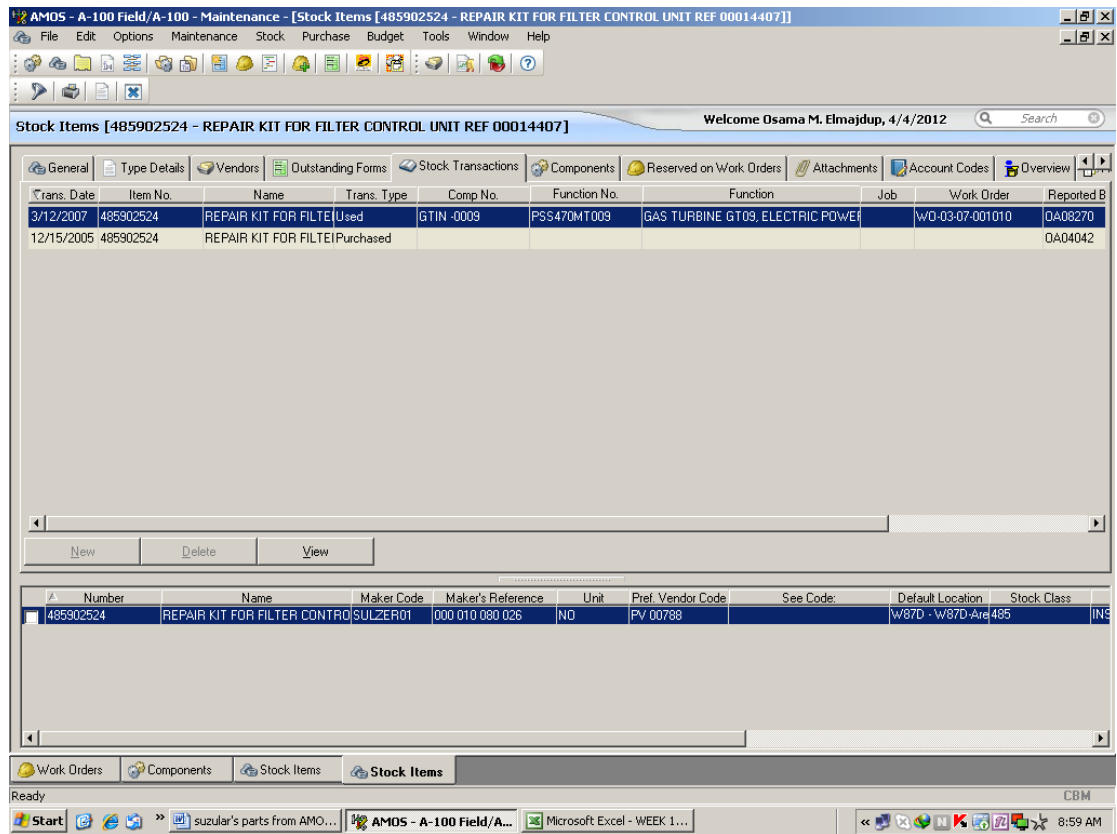


Figure (5.24): Stock items (page 7).

AMOS - A-100 Field/A-100 - Maintenance - [Stock Items [485902522 - SUPERVISION PRINT TYPE 118-1328665-1]]

Welcome Osama M. Elmajdup, 4/4/2012

Stock Items [485902522 - SUPERVISION PRINT TYPE 118-1328665-1]

General | Type Details | Vendors | Outstanding Forms | Stock Transactions | Components | Reserved on Work Orders | Attachments | Account Codes | Overview

Number: 485902522
 Name: SUPERVISION PRINT TYPE 118-1328665-1
 Maker: SULZER01
 Maker's Ref.: 000 010 080 025
 Preferred Vendor: FV 00788
 Vendor's Ref.:
 Family Sh.Desc: MISCELLANEOUS INS
 Harmonized C.: 902890.0/25
 See Code:
☐ Asset
☐ Perishable Item

Locations

A	Location	Current Stock	Expiry Date
★	A100 W/H / MAIN A100 W/H / A	1	

Total Stock: 1.00
 Default Add Add Remove

Stock Details

☒ Stocked Item
 Stock Unit: NO
 Wanted: 0
 Reserved: 0
 Stock Maximum: 0
 Stock Minimum: 0
 Reorder Level: 0.99
 Reorder Quantity: 1

Prices

Stock Average: LYD 1,506.24
 Last Purchased: SWF 1,460.00 12/15/2005

Stock Class: 485 INSTRUMENTATION AUXILIARIES FOR MACHINES
 Document No.: Price Class: Criticality: Normal

A	Number	Name	Maker Code	Maker's Reference	Unit	Pref. Vendor Code	See Code	Default Location	Stock Class
■	485902522	SUPERVISION PRINT TYPE 118-1328665-1	SULZER01	000 010 080 025	NO	FV 00788		W94C - W94C-Are	485

Work Orders | Components | Stock Items

Ready

Start | suzular's parts from A... | AMOS - A-100 Field/... | Bonjour :) - Inbox - Ya... | Usa | 10:18 AM

Figure (5.25): Stock items (page 8).

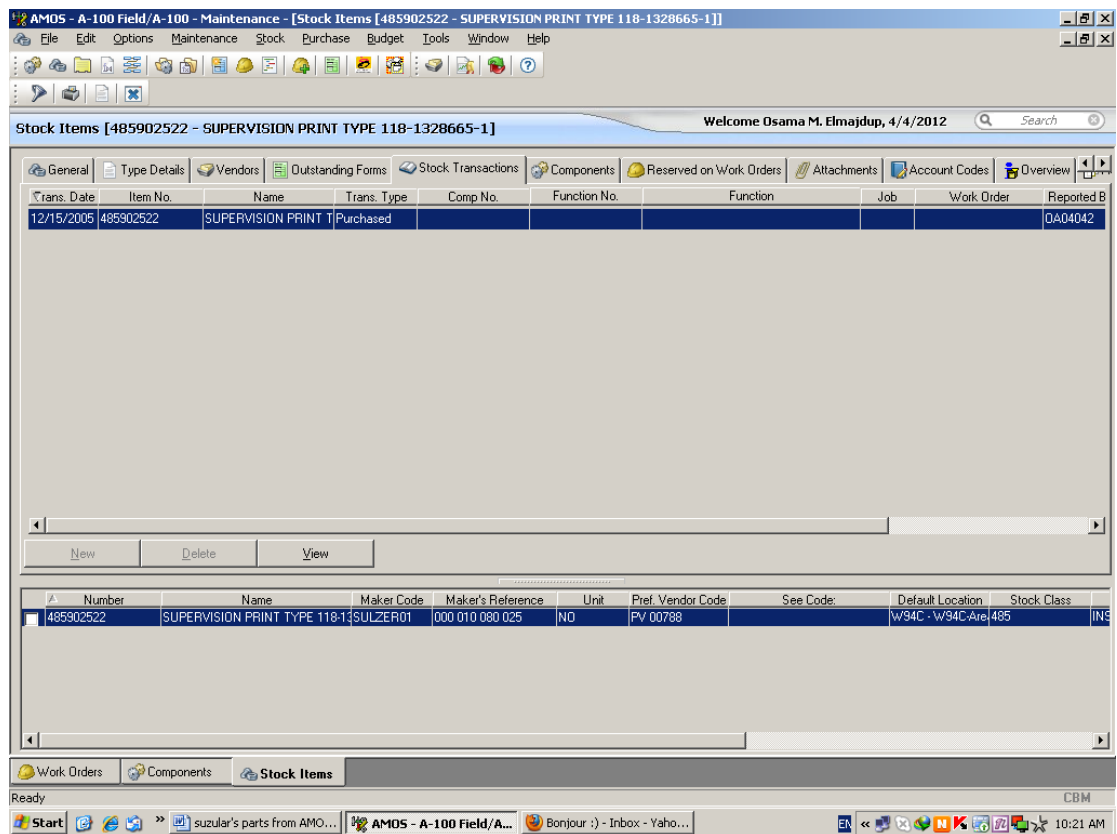


Figure (5.26): Stock items (page 9).

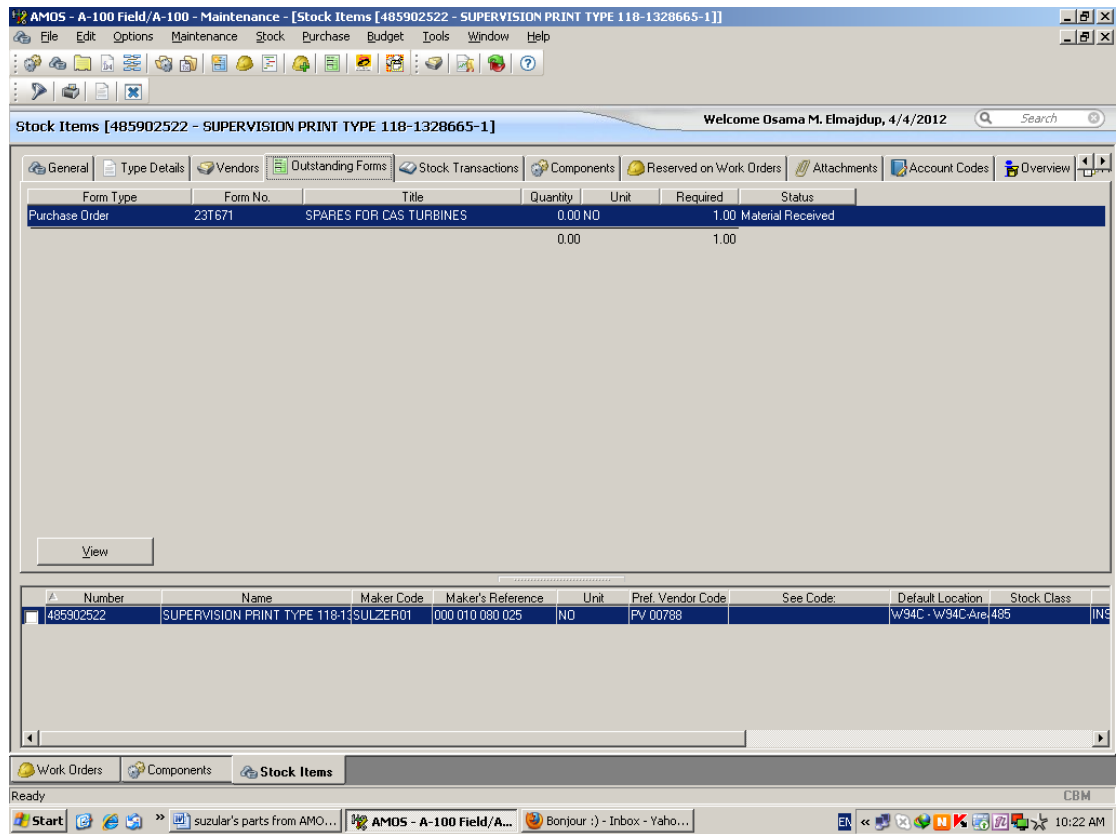


Figure (5.27): Stock items (page 10).

AMOS - A-100 Field/A-100 - Maintenance - [Stock Items [485902520 - SOLENOID VALVE CONTROL BOX;4-WAY RCA-8V4]]

File Edit Options Maintenance Stock Purchase Budget Tools Window Help

Welcome Osama M. Elmajdup, 4/4/2012

Stock Items [485902520 - SOLENOID VALVE CONTROL BOX;4-WAY RCA-8V4]

General Type Details Vendors Outstanding Forms Stock Transactions Components Reserved on Work Orders Attachments Account Codes Overview

Number: 485902520 Family Sh.Desc: MISCELLANEOUS INS
 Name: SOLENOID VALVE CONTROL BOX;4-WAY RCA-8V4 Harmonized C.: 902890.0/25
 Maker: SULZER01 SULZER TURBO LTD See Code:
 Maker's Ref.: 000 010 080 024 Asset
 Preferred Vendor: PV 00788 SULZER
 Vendor's Ref.: Perishable Item

Locations

Location	Current Stock	Expiry Date
A100 W/H / MAIN A100 W/H / A	2	

Total Stock: 2.00

Default Add Add Remove

Stock Class: 485 INSTRUMENTATION AUXILIARIES FOR MACHINES

Document No.: Price Class: Criticality: Normal

Stock Details

☒ Stocked Item Stock Maximum: 0
 Stock Unit: NO Stock Minimum: 0
 Wanted: 0 Reorder Level: 0.99
 Reserved: 0 Reorder Quantity: 2

Prices

Stock Average: LYD 1,217.37
 Last Purchased: SWF 1,180.00 12/15/2005

Number	Name	Maker Code	Maker's Reference	Unit	Pref. Vendor Code	See Code	Default Location	Stock Class
485902520	SOLENOID VALVE CONTROL BOX;4-WAY RCA-8V4	SULZER01	000 010 080 024	NO	PV 00788		W830 - W83D-Are	485

Work Orders Components Stock Items

Ready

Start suzular's parts from AMO... AMOS - A-100 Field/A... Bonjour :) - Inbox - Yaho... 10:23 AM

Figure (5.28): Stock items (page 11).

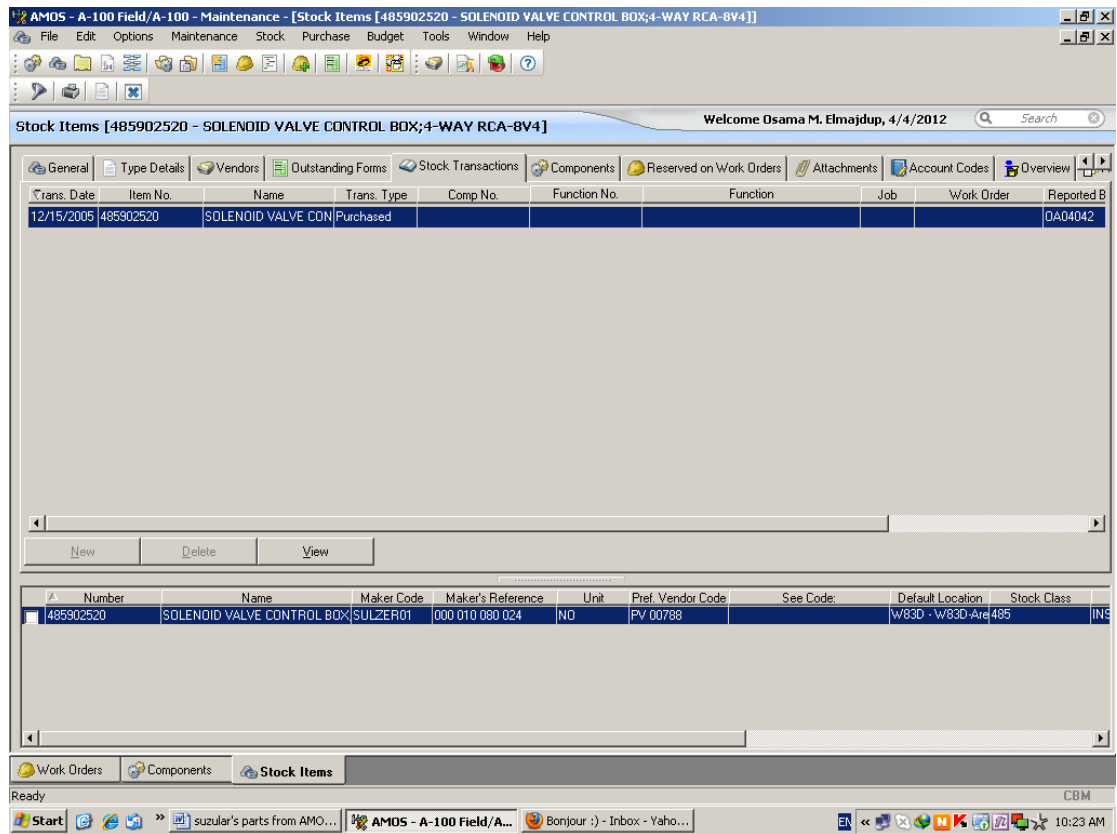


Figure (5.29): Stock items (page 12).

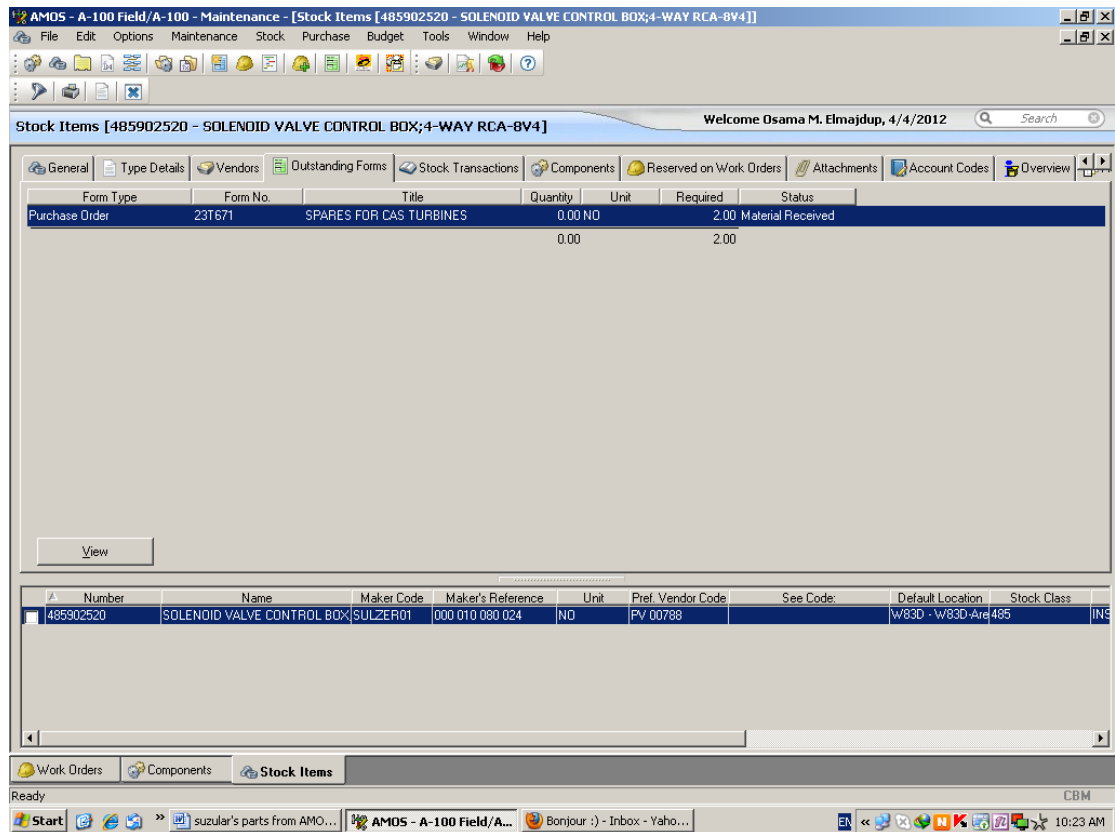


Figure (5.30): Stock items (page 13).

AMOS - A-100 Field/A-100 - Maintenance - [Stock Items [485902518 - SOLENOID VALVE CONTROL BOX;6-WAY RCA3-8V6]]

File Edit Options Maintenance Stock Purchase Budget Tools Window Help

Welcome Osama M. Elmajdup, 4/4/2012

Stock Items [485902518 - SOLENOID VALVE CONTROL BOX;6-WAY RCA3-8V6]

General Type Details Vendors Outstanding Forms Stock Transactions Components Reserved on Work Orders Attachments Account Codes Overview

Number: 485902518 Family Sh.Desc: MISCELLANEOUS INS
 Name: SOLENOID VALVE CONTROL BOX;6-WAY RCA3-8V6 Harmonized C.: 902890.0/25
 Maker: SULZER01 SULZER TURBO LTD See Code:
 Maker's Ref.: 000 010 080 023 Asset
 Preferred Vendor: PV 00788 SULZER
 Vendor's Ref.: Perishable Item

Locations

A	Location	Current Stock	Expiry Date
★	A100 W/H / MAIN A100 W/H / A	1	

Total Stock: 1.00
 Default Add Add Remove

Stock Details

☒ Stocked Item Stock Maximum: 0
 Stock Unit: NO Stock Minimum: 0
 Wanted: 0 Reorder Level: 0.99
 Reserved: 0 Reorder Quantity: 1

Prices

Stock Average: LYD 1,093.57
 Last Purchased: SWF 1,060.00 12/15/2005

Stock Class: 485 INSTRUMENTATION AUXILIARIES FOR MACHINES
 Document No.: Price Class: Criticality: Normal

A	Number	Name	Maker Code	Maker's Reference	Unit	Ref. Vendor Code	See Code	Default Location	Stock Class
☐	485902518	SOLENOID VALVE CONTROL BOX;6-WAY RCA3-8V6	SULZER01	000 010 080 023	NO	PV 00788		W830 - W83D-Are	485 INS

Work Orders Components Stock Items

Ready

Start suzular's parts from AMO... AMOS - A-100 Field/A... Bonjour :) - Inbox - Yaho... 10:24 AM

Figure (5.31): Stock items (page 14).

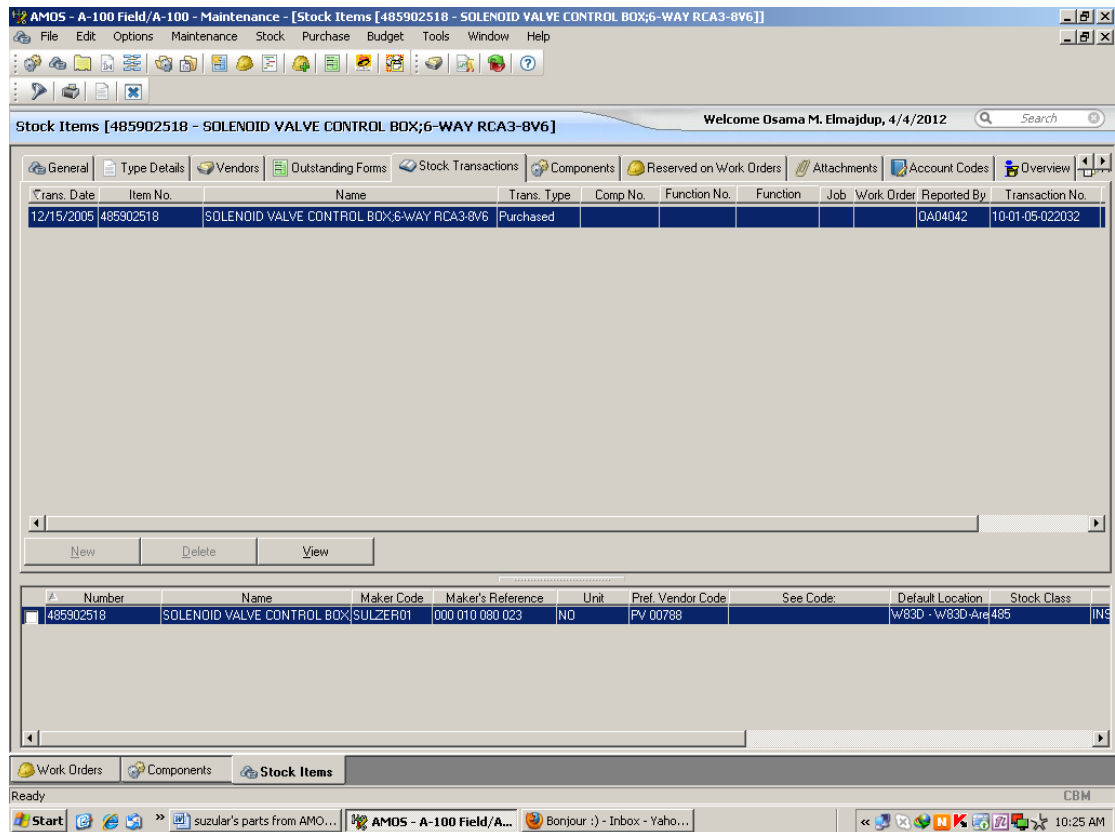


Figure (5.32): Stock items (page 15).

Reference

- 1- **Tony Wild**, (1997). “Best Practice in Inventory Management”, John Wiley & sons, Inc, Canada.
- 2- **Onwubolu**, G. C., & Dube, B. C. (2006). Implementing an Improved Inventory Control System in a Small Company: A Case Study. *Production Planning & Control*.
- 3- **Suresh P.** et. Al (2005). *Inventory and Supply Chain Management with Forecast Updates*. University of Texas, Business Media, Inc.
- 4- **Lam, J.**, & Postle, R. (2006). Textile and apparel supply chain management in Hong Kong. *International Journal of Clothing Science and Technology*, 18(4), 265-277.
- 5- **Quayle**, M. (2003). A study of supply chain management practice in UK industrial SMEs. *Supply Chain Management: An International Journal*, 8(1), 79-86.
- 6- **Quayle**, M. (2000). Supplier Development for UK Small and Medium-sized Enterprises. *Journal of Applied Management Studies*, 9(1), 117-133.
- 7- **ENSR** (2004). *Highlights for the 2003 Observatory*. European Commission, Brussels.
- 8- **Hakansson**, H., & Persson, G. (2004). *Supply Chain Management: The Logic of Supply Chains and Networks*. *The International Journal of Logistics Management*, 15(1), 11-26.
- 9- **Coyle**, J. J., Bardi, E. J., & Langley, C. J. Jr. (2003). *The Management of Business Logistic: A Supply Chain Perspective* (7th ed.). Mason: South-Western.

- 10- **Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E.** (2004). *Managing The Supply Chain: The Definitive Guide For The Business Professional*. New York: McGraw-Hill.
- 11- **Goldsby, T., & Martichenko, R.** (2005). *Lean Six Sigma Logistics: Strategic Development to Operational Success*. Boca Raton: J. Ross Publishing, Inc.
- 12- **Toomey, J. W.** (2000). *Inventory Management: Principles, Concepts and Techniques*. Norwell: Kluwer Academic Publishers.
- 13- **Lin, E.** (1980). *Inventory Control System for Small Business*. *American Journal of Small Business*, 4(4), 11-19.
- 14- **Ballou, R. H., Gilbert, S. M., & Mukherjee, A.** (2000). New managerial challenges from supply chain opportunities. *Industrial Marketing Management*, 29, 7-18.
- 15- **Tagg, S.** (1999). Supply chain management: A new challenge for researchers and managers in logistics. *International Journal of Logistics Management*, 10(2), 41-53.
- 16- **Lummus, R. R. and. Vokurka, R. J.** (1999), "Defining Supply Chain Management: A Historical Perspective and Practical Guidelines", *Industrial Management & Data Systems*, 99(1), pp. 11-17.
- 17- **Levi, D. and Kaminsky, P. and Levi, E.** (2003), "Designing and Managing the Supply Chain", 3rd ed. McGraw-Hill.
- 18- **Cooper, M.C., & Ellram, L.M.** (1993). Characteristics of supply chain management and the implications for purchasing and logistics strategy. *International Journal of Logistics Management*.
- 19- **Bowersox, D.J., Closs, D.J., & Stank, T.P.** (1999). *21st Century logistics: making supply chain integration a reality*. Oak Brook, IL: The Council of Logistics Management.

- 20- **ISM** (2007). Supply chain management Retrieved on January 15, 2013, from <http://www.ism.ws/GlossaryTermDetail.cfm?Term ID=1932>.
- 21- **Mentzer**, J., DeWitt, W., Keebler, J., Min, S., Nix, N., Smith, C. and Zacharia, Z. (2001). Defining supply chain management. *Journal of Business Logistics*, 22 (2), p.1-25.
- 22- **Tan**, K.C., Lyman, S.B. and Wisner, J.D. (2002). Supply chain management: a strategic perspective. *International Journal of Operations & Production Management*, 22 (6), p.614-631.
- 23- **Tan**, K.C., Handfield, R.B. and Krause, D.R. (1998). Enhancing firm's performance through quality and supply base management: an empirical study. *International Journal of Production Research*, 36 (10), p.13-37.
- 24- **Farley**, G.A. (1997). Discovering supply chain management: a roundtable discussion. *APICS – The Performance Advantage*, 7 (1), p.38-39.
- 25- **Lee**, H.L. and Billington, C. (1992). Managing supply chain inventory: pitfalls and opportunities. *Sloan Management Review*, 33 (3), p.65-73.
- 26- **Tan**, K.C., Kannan, V.R. and Handfield, R.B. (1998b). Supply chain management: supplier performance and firm performance. *International Journal of Purchasing & Materials Management*, 34 (3), p.2-9.
- 27- **Morgan**, J. and Monczka, R.M. (1995). Alliances for new products. *Purchasing*, 18 (1), p.103-109.
- 28- **Edward Sweeney** (2002), *The Four Fundamentals of Supply Chain Management*, Dublin Institute of Technology. Practitioner Journals. Available on <http://arrow.dit.ie/nitloth> . Accessed date: 01.01.2013.
- 29- **Lambert**, D. J., Cooper, M. C., & Pagh, J. D. (1998). Supply chain management, implementation issues and research opportunities. *International Journal of Logistics Management*, 9(2), 1-19.

- 30- **Bloomberg**, D., LeMay, S., & Hanna, J. (2002). Logistics. Upper Saddle River: Prentice Hall.
- 31- **Aissaoui**, N., Haouari, M., & Hassini, E. (2007). Supplier Selection and Order Lot Sizing Modeling: A Review. Computer & Operations Research, 34, 3516-3540.
- 32- **Gadde**, L-E., & Mattsson, L-G. (1987). Stability and Change in Network Relationships. International Journal of Research in Marketing, 4(1), 29-41.
- 33- **Quayle**, M., & Quayle, S. (2000). The Impact of Strategic Procurement in the UK Further and Higher Education Sectors. The International Journal of Public Sector Management, 13(3), 260- 284.
- 34- **Davenport**, T. H. (2000). Mission Critical: Realizing the Promise of Enterprise Systems. Boston: Harvard Business School Press.
- 35- **Lambert**, D.M. (2004). The eight essential supply chain management processes. Supply Chain Management Review, 8 (6), 18 – 26.
- 36- **Yang Shengxue**, 2007, the Integration Model of the Internal Supply Chain.
- 37- **Stevenson**. G, 1998, Integrating the **Supply Chain**, International Journal of Physical Distribution and Materials Management.
- 38- **Al-Mashari** M., ERP systems: A research agenda, Industrial Management & Data Systems, MCB University Press, 2002.
- 39- **Dimitris** N. Chorafas, Integrating ERP, CRM, SCM, and Smart Material. Auer Bach pub, 2001.
- 40- **J.Michael Tarn**, Davide C.Yen, Marcuse Beaumont, Exploring the rationales for ERP and SCM integration, paper in emerald, 2003.
- 41- **Henk A.Akkermans**, Paul Bogerd, Enver Yucesan, Luk N. Van Wassenhove, the impact of ERP on supply Chain Manegement: Delphi Study, paper in ELSEVIER, 2002.

- 42- **Nick Siragher**, Enterprise resource planning – the end of the line for the sales automation market and a major step towards sales process definition standard, paper in emerald, 2000.
- 43- Peter Kelle, Asli Akbulut, the role of ERP tools in supply chain information shairing, cooperation, and cost optimization, paper in ELSEVIER, 2004.
- 44- **Thomas H.Davenport**, Jeffrey D.Brooks, Enterprise systems and the supply chain, paper in emerald, 2004.
- 45- **Baganha**, M. P. and Cohen, M. A. (1998). The stabilizing effect of inventory in supply chains. Operations Research, 46(3), S72-S83
- 46- **Cachon**, G. P. and Fisher, M. (2000). Supply chain inventory management and the value of shared information. Operations Research. 46(8), 1032-1048.
- 47- **Agip Gas Website**
- 48- <http://www.rightgroup.net/Solutions%20Manufacturing/Supply%20chain%20management.aspx>