Master's Thesis
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Multi Packages at Tetra Pak Parts
- a case study

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Summary

Title:	Multi Packages at Tetra Pak Parts – a case study
Subject:	Master's thesis, Department of Business Administration.
Authors:	Markus Jörgensen, Karl Wenehed, Daniel Widler
Tutor:	Christer Kedström
Case Company:	Tetra Pak Parts AB
Objectives:	Select articles and define their optimal quantity for a multi package. Examine where and in what ways a multi package will affect a company's warehousing.
Method:	A quantitative methods builds the foundation for the thesis. Interviews made on TPP constitute the empirical foundation. A descriptive approach has been made on the data received from TPP. We have developed our own method in defining optimal quantities for selected articles.
Conclusions:	The thesis has shown that the entire flow through TPP's warehouse will be more efficient by implementing a multi package. The multi package can replace the pre-packaging activity that exists at TPP today. It will have a great impact on the picking activity where the time-aspect in picking order-lines can be decreased considerably. The conclusion is that our developed method in defining optimal quantities for a multi package can be used on all concerning articles at TPP and also at other companies sharing the same problems.
Keywords:	Tetra Pak, Tetra Pak Parts, multi package, packaging, logistics, warehousing

1. Introduction

This chapter begins with the background to the problem followed by a pre-study and a problem discussion. Out of the problem discussion the objectives of this thesis are formulated. We end the chapter with a description of the delimitations, target group and a chapter outline.

1.1 Background

Companies today are constantly searching for new ways to improve their performance. The gains can be everything from lower costs to increased sales margins. The search for new ways of improving their business can work as a spark for companies in their development process.

In the traditional engineering industry, companies experience a sharpened competition. The need for increased efficiency and rationalising in all areas of the organisation has grown. Logistics can be described as one tool for creating value within an organisation.[1] It is of great importance to make sure that the flow through the organisation is effective and to prevent bottlenecks to arise.

The development in recent years in the technology used in warehousing has probably contributed to the fact that companies today better understand the importance of well working logistics. Warehouse management can be seen as a tool to integrate different departments within the organisation but also as a way of integrating individual departments themselves.

There are many areas within warehouse management where planning and decision-making have to be done together with several other functions. Within marketing and logistics the departments work together when it comes to deciding standards in areas such as delivery service. Another important area is the product development and the construction where production, marketing and logistics should cooperate. Some fundamental parts of a product's logistics cost are decided already at its design level.[2]

Today's warehousing is characterized by a modernisation, meaning that many of the activities that are performed manually today will be replaced by automated solutions. Despite this there are still going to be some activities that have to be performed manually and in the most

[1] Porter, 1985
[2] Persson & Virum, 1998

efficient way possible. A way to achieve this can be to rationalise these activities, which are not needed because of their time demand ineffectiveness.[3]

1.1.1 Parts Packaging Project

We have chosen to write this thesis about a problem within Tetra Pak Parts AB[4] (TPP) since we came in contact with them through Christer Kedström, associate professor at the School of Economics and Management, University of Lund. Åke Pettersson, strategic purchaser at TPP, introduced us to a project called PPP, and we thought the project was very interesting. He has shown great interest in our work and has helped us coping with all the different problems we have faced.

TPP is a part of Tetra Pak AB[5], a company that has been successful in the packaging industry since its start in the 1950's. Tetra Pak is divided into several subsidiaries including our case company, TPP.[6] We will more closely describe Tetra Pak and TPP in chapter 3.

The Parts Packaging Project[7] (PPP) aims at facilitating work for goods receipt, picking, packing and shipping for TPP's customers through optimal packaging and marking solutions of parts handled. The project can at the moment be divided into four main sub-projects[8]:

- Bar codes at receiving goods
- Durability markings
- Pre-packing for protection
- Multi-packages for facilitated picking

Each one of these projects will, when finished, contribute to the effectiveness of TPP's warehousing in different ways. We will focus on the problem concerning multi packaging for facilitated picking. A multi package is a pre-packed package that contains several units of the same *article*[9]. One objective with a multi package is to group articles, which today are difficult to handle, in an individually *optimised quantity*[10]. The main task for this project is to identify

[3] Suskind, 1995
[4] Tetra Pak Parts AB will be referred to as TPP throughout this thesis.
[5] Tetra Pak AB will be referred to as Tetra Pak throughout further this thesis.
[6] Interview Åke Pettersson 051101
[7] Parts Packaging Project will be referred to as PPP throughout this thesis.
[8] Internal material TPP, *Presentation of PPP*
[9] The term *articles* represents spare parts at TPP
[10] According to us an optimal quantity is the amount of units of an article that a multi package holds, defined from the data received from TPP

articles that are suitable for adjusted packaging size and then try to define suitable sets for these.[11]

TPP is currently modernising their warehouse and one way to make it more efficient is to implement a multi package in order to eliminate the bottlenecks present today. This modernisation is a way for TPP to make the handling of the goods in the warehouse more automatic, and to create a more efficient flow all the way from receiving to outgoing goods. Even though TPP is trying to modernise as much as possible there will still be some activities performed manually. The manual activity of picking articles and packing them will still exist and it is therefore of great interest for TPP to implement a multi package which will make these manual activities easier and faster to perform.

1.1.2 Pre-study

After being introduced to PPP we became interested in the project concerning multi packaging. In order to achieve a deeper insight of this subject we performed a pre-study. We did this by performing interviews at TPP with different persons at different positions.

Our first interview was with Pernilla Lindqvist in the Marketing & Sales department. Her opinion was that multi packages would make the warehousing at TPP more efficient. If the handling of goods becomes more efficient this would contribute to marketing and sales orders becoming processed faster than before. She also thought that multi packages mostly would affect the handling of goods and not so much the marketing and sales department, but that multi packages are of great importance to achieve a higher degree of effectiveness through the whole process. [12]

To get a view of how the warehouse works, in particular the picking activity, we interviewed Stephan Lindh. He is the person within PPP responsible for identifying all the different articles that might be multi packed and he is also one of the group coordinators for the picking activity. Lindh described the process of identifying the different articles and the importance of having an efficient warehousing. According to his experience he told us that multi packages would simplify his part of the warehousing immensely. He pointed to the fact that this was even more important today since TPP is in the process of reorganising areas of their warehousing in a project called Internal Logistics Development (ILD), which will make the process more automatic. In order to fully enjoy the benefits of this reorganisation it is of great magnitude to

[11] Internal material TPP, *Presentation of PPP*
[12] Interview Pernilla Lindqvist 241001

make sure that all the different areas of the warehouse is as well organised as possible and this can be achieved through multi packages. [13]

Finally, in order to get a more detailed view of the importance of multi packages, we interviewed Kjell Lundgren, sales manager of the Europe and Africa region. He believes that pre-packaging is of importance in order to make the time from receiving to outgoing goods as short as possible. The situation today is that some articles arrive at TPP only to be unpacked and then repacked in quantities that better suit TPP's customers. This is very time-consuming and Lundgren believes that the implementation of multi packages will benefit the handling of these articles very much. [14]

1.2 Problem Discussion

Tetra Pak is a well-known company operating worldwide. They do not only sell packaging material and machines to manufacture packages, but they also sell spare parts for serving the packaging machines. The unit of Tetra Pak responsible for the sale of spare parts is TPP. They operate in an environment, which is constantly changing and with more complex demands from its customers. TPP has to supply customers with spare parts for both old and new packaging machines. This means that TPP must maintain a large supply of spare parts in order to be able to serve all the various types of customers.

An efficient supply chain is as important to Tetra Pak as it is to its customers, therefore it is important that TPP delivers the ordered spare parts as quickly as possible. "*Minimal downtime and high machine availability have an immediate impact on the profitability of the plant*"[15]. This quotation undoubtedly explains why it is important for TPP to be efficiently organised and achieve an efficient supply chain. If TPP fails to deliver the ordered spare parts it will cause unwanted expenses for the customers since it will damage their products that were supposed to be packaged[16]. Because of this TPP plays an important role for the reputation and goodwill for the whole organisation of Tetra Pak.

There are several aspects that TPP must take into consideration. Different customers have different needs and therefore different demands on how many parts they wish to purchase on every occasion. Multi packaging is currently a minor activity at TPP. They do not multi pack according to any established method where the optimal quantities can be defined. The articles

[13] Interview Stephan Lindh 241001
[14] Interview Kjell Lundgren 261001
[15] www.tetrapak.com, 251101
[16] Interview Kjell Lundgren, 261001

that are multi packed today do not contribute to increased warehouse efficiency because they are not packed in optimal quantities.

The purpose of a multi package is to pack spare parts into optimal quantities. Multi packages can be seen as a tool, which can increase the efficiency of warehousing considerably, especially the picking activity. The main problem occurring for the picking personnel is to count the articles according to the orders. TPP needs to find suitable multi packages in order to satisfy both TPP and their customers. The lack of suitable multi packages makes the handling of articles in the warehouse a drawn-out, inefficient and expensive process for TPP. This is a bottleneck, which has to be diminished.

Finding the optimal quantity for a multi package for a certain article is related to many different aspects. Many articles stored at TPP's warehouse are not relevant for this issue. The articles differ widely concerning characteristics as size, design and their turnover rate in the warehouse. To identify an approach in finding articles that would gain benefits from a multi package has been an important and major area in our working process. From the articles identified by Stephan Lindh a selection of representative articles must be chosen.

Next step in implementing a multi package is to find the optimal quantity each package should contain. Once again, this is not only based on the ordered quantities but is also depending on the articles size and design. The question remains, how shall TPP find a method to estimate optimal quantities for their articles in the warehouse?

How will the selection of articles suitable for a multi package be made and how can a representative selection of articles for this thesis be done?

Is it possible to define optimal quantities for a multi package? Are there any established methods for doing this?

If an implementation of a multi package is done, how will this affect the different activities within TPP's warehouse?

1.3 Objectives

The objectives of this thesis are:

- Select articles and define their optimal quantity for a multi package.
- Examine where and in what ways a multi package will affect a company's warehousing.

In order fulfil these objectives we have used Tetra Pak Parts as a case company.

1.4 Target Group

This thesis is written foremost for teachers and students at the School of Economics and Management, University of Lund. Given that we are writing this thesis in cooperation with TPP, it is of course our intention that it shall be of great interest for them as well. Furthermore we hope that it can be of interest for other companies who might be in a similar situation as TPP and therefore can enjoy this thesis and find it useful.

To satisfy these groups a detailed report is required. A problem with this is that some parts of the report may tend to be of less interest and seem unnecessary for one part while the other part finds it interesting.

1.5 Chapter Outline

We have chosen to outline this thesis in the following way:

Chapter 1: This chapter gives an introduction to the background of the problem followed by a pre-study and a problem discussion that ends up in the objectives.

Chapter 2: Here the reader is introduced to the method and the course of action that is used in this thesis. A description of how we have approached the problem concerning multi packages is also presented.

Chapter 3: This chapter gives a description of Tetra Pak and our case company - TPP.

Chapter 4: The theoretical frame of reference is presented in this chapter.

Chapter 5: This chapter constitutes the empirical foundation. It describes the flow at TPP's warehouse, from receiving to outgoing goods.

Chapter 6 and 7: In these chapters the analysis of this thesis is presented. We present the optimal quantity for each selected article defined by using our model and the benefits an implementation of a multi package has on TPP's warehousing.

Chapter 8: This final chapter contains our conclusions and further research that might be interesting concerning this problem area.

2. Methodology

The first section of this chapter describes the scientific point of departure for the thesis followed by a short background of the authors. We will also present our approach to the problem and the course of action. The chapter ends with data capture, choice of method and the criticism of the sources.

2.1 Methodological Perspective

When writing a thesis it is important that the author uses a specific method of procedure. The method of collecting data and information is relevant for the level of credibility of a thesis. More precisely, methodology is the science about the tools that can be used when collecting information, which can lead to new knowledge.

This thesis aims to result in a review, which includes everything from problem discussion, objective and method to an analysis with our own conclusions. As an overall work process for this thesis we have chosen to work from a method often used in scientific research. We have taken this method from Conny Svenning and it consists of different steps that can be presented like this:[17]

1. Problem discussion
2. Literature studies
3. Deeper problem discussion
4. Investigation design
5. Data collection
6. Analysing the data
7. Discussion
8. Conclusions
9. Follow up

The first three steps in our working process had a more qualitative nature. Developing the problem discussion and analysing literature provided us with information of an area, which we lacked any deeper knowledge within.

[17] Svenning, 1997

Steps 4-9 are based on a quantitative method. A quantitative method aims to observe formal structure and to define it in a uniform way with figures on the parameters. This method is used for building some sort of statistical foundation for further analysis[18]. Our research is based mainly on these steps. This thesis is of a quantitative nature since the outcome will result in a general method in defining optimal quantities for articles and can be used on all the concerning articles at TPP. Not only TPP but also other companies can find our method useful.

2.2 Background of the Authors

This thesis is written by three students attending the School of Economics and Management, University of Lund, Markus Jörgensen, Karl Wenehed and Daniel Widler. We are all studying business administration with focus on marketing. Even though all of us are focused on marketing we have different educational backgrounds, which we think will affect our work process in a positive way. The writing of this thesis will be reflected by our different ways of thinking.

2.3 Approaching the Problem

Since this thesis is written for a case company it has a unique nature, this because every single case company needs a specific approach when finding a solution to a specific problem.

The first step in our approach was to search for previous researches within multi packages. This research was made in all kinds of databases available for us students attending the University of Lund and in numerous libraries, though the outcome provided us with no useful information. Multi packaging is a not a common form of packaging for industrial products, therefore very little is written about it. When searching for literature within this area the outcome results in books etc., concerning only packaging in general and theories about packaging materials. Multi packages as a tool to make warehousing more efficient have not been mentioned in any literature we have found. Since this thesis will concern finding an optimal quantity on selected articles and what effects the multi packages have on the flow in TPP's warehouse, we needed to find a theoretical frame of reference for these issues. This felt like Catch 22, if we could not find any suitable theoretical framework we would not be able to define optimal quantities for the selected articles either, and vice versa.

[18] Wallén, 1996

To build a relevant theoretical frame of reference, theories about logistics, packaging logistics and packages had to be found. This was very time-consuming but finally we felt ready to start working with the data provided by TPP. They did not only provide us with data, which had a complex nature, but also with a problem, which needed an even more complex approach. To gain an idea of how we should work with this data we made several calculations in Microsoft© Excel. These calculations provided us with a lot of results but nothing that was relevant in defining an optimal quantity for selected articles. Once again we found our selves in a dead end. When discussing this problem with Pierre Carbonnier at the Department of Statistics we all came to the same conclusion: there is no established statistical method for our problem. What we needed to do was to develop our own method in finding optimal quantities for selected articles.

The approach in building a trustworthy method was very time-consuming. We ran our data through both Microsoft© Excel and MINITAB© (a computer based statistical software). The battle was won by MINITAB©, this because MINITAB© gave us the opportunity to sort the data in a very successful way. The calculations made in MINITAB© that constitutes the foundation for defining the optimal quantities are presented in the analysis and the appendix.

2.4 Course of Action

The course of action consists of six different, and independent actions. Together they constitute the thesis. These actions are illustrated below in the figure.

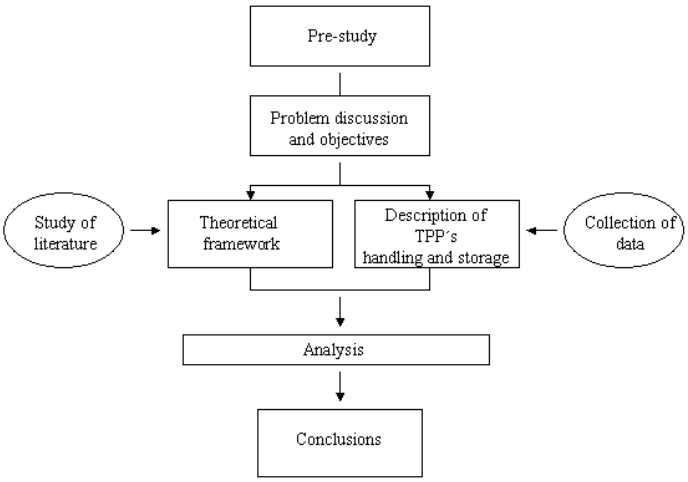

Figure 2.1 Course of action in this thesis

The first step was to conduct a pre-study in order to gain a deeper understanding of PPP. After the pre-study the problem discussion led us to formulate the objectives.

The next step was the theoretical frame of reference. In this step we tried to find literature that suited our subject field, both articles and books. We have searched for literature in libraries and on the Internet. When the collected literature had been reviewed a couple of books and articles came to constitute the theoretical frame of reference.

Parallel with our work on the theoretical frame of reference we also collected data and information about TPP. This information consists of personal interviews and several visits to TPP's warehouse in order to see how things work and to gain a deeper understanding of the issue. This will constitute the empirical foundation.

When all these steps were completed the next step was to form them into an analysis. The nature of the problems and the objectives forced us to divide the analysis into two sections.

When the analyses were finished we summarized the most interesting results in the conclusion. Finally these were controlled to meet the objectives

2.5 Data Capture

Our collection of data has mainly taken place at TPP and consists of face-to-face interviews and several visits at TPP's warehouse. The face-to-face interviews were conducted using open-ended questions. All interviews were recorded in order to recapitulate as much as possible when they were used. The selection of interviewed personnel was based on the knowledge and the position that the persons had and on recommendations from our supervisor at TPP, Åke Pettersson. This gave us an opportunity to interview the right persons immediately.

The data furthermore consists of literature, brochures and documents, which have been found in libraries and databases. A central part of the data consists of a Microsoft© Excel document provided by TPP.

2.6 Criticism of the Sources

There could be a criticism towards the literature used in this thesis since it does not discuss the phenomenon multi packages. Though, multi packages do not differ widely from other packages

when it comes to how they are distributed and the qualities they fulfil as packages. The theoretical frame of reference will therefore serve the purpose to constitute the foundation of a deeper understanding when it comes to discussing multi packages more specifically in the analysis.

A criticism could also be made towards the interviews made on TPP, this because the interviewed personnel could be reflected by the wish in establishing multi packages at TPP. Therefore it is possible that the interviews have not enlightened the negative effects of implementing multi packages. Though, we have constantly been aware of this and tried to stay as objective as possible when analysing the interviews.

3 Company Presentation

In this chapter we will introduce our case company, TPP by initially presenting a short historic resume of Tetra Pak. We will also present the organisational structure of TPP. This chapter is only of a descriptive nature; specific information regarding TPP's warehousing will be presented in the empirical chapter.

3.1 History of Tetra Pak[19]

Tetra Pak was founded in 1951 by the family Rausing. Ruben Rausing came, during his studies in the USA, in contact with the supermarkets and realised that the need for pre-packaged goods was going to spread to Europe. A company, Åkerlund and Rausing AB, was founded and became the first packaging company in Scandinavia. It also became the first company to develop milk packages, as we know them today. Ideas about creating a package demanding the lowest amount of raw materials while still upholding optimal hygiene led in 1943 to the tetraeder shaped package. For the next eight years experiments were conducted aiming at applying a thin coat of plastic to the paper to improve the sealing capabilities of the packages.

The first machine able to produce these kinds of packages was delivered in 1952 from Tetra Pak to a small dairy near Lund. Four years later, 1956, Tetra Pak transferred to an industrial area in the outskirts of Lund. They are still at this location today. A few years later, in 1959, their annual packaging volume exceeded one billion packages. During the same year the development of the package known as Tetra Brik was initiated and was introduced in 1963.

In 1965 Ruben Rausing sold Åkerlund and Rausing but he still maintained control over Tetra Pak where his son, Hans Rausing, was CEO. Ruben remained chairman of the board while his other son, Gad Rausing, was vice CEO. In the beginning of 1970 the manufacturing capacity exceeded 10 billion packages, by 1977 it exceeded 20 billion and by 1980 over 30 billon. In the same year parts of the management moved from Lund to Lausanne, Switzerland.

In 1985 Tetra Pak started their acquisition of companies beginning with Alfa Laval Logistics AB. Hans Rausing became the chairman of the board and Bertil Hagman was appointed CEO, the first outside the Rausing family. In 1991 Tetra Pak acquired the company Alfa Laval, one of the world's largest supplier of equipment and packaging machines to the food processing and agricultural industries. The Tetra Pak / Alfa-Laval group was formed but the two different

[19] Internal material "*Hur det hela började*"

companies continued to conduct activities separately until 1993 when Tetra Laval was formed. Together, between the two companies, the manufacturing capacity was in the vicinity of 60 billion packages.

3.2 Tetra Pak Today

Tetra Pak offers its customers different packaging alternatives in terms of shape, functionality and design. Below we will show a couple of different packages supplied by Tetra Pak. These different cartons are divided into four different business units: Tetra Rex, Tetra Brik, Tetra Classic and Tetra Top.[20]

Tetra Rex

Tetra Brik

Tetra Classic

Tetra Top

Tetra Pak does not only develop and supply packages, they also supply complete packaging lines to the dairy and beverage industry. Each of the above described business units are responsible for their own development and marketing of their packaging machines. Tetra Pak today delivers packaging material to over 165 countries around the world and had in January 2001 a turnover of €7,300 million.[21]

[20] www.tetrapak.com , 191001
[21] Internal material *Power Point presentation*

3.2.1 Tetra Pak Parts

A modern facility for processing and packaging milk or fruit juice is a highly complex installation. Professional maintenance makes it possible to maintain the high standards of reliability, hygiene and consistent quality called for when working with sensitive products. Minimal downtime and high machine availability have an immediate and positive impact on the profitability of the plant.[22]

TPP is responsible for supplying all customers using Tetra Pak / Alfa Laval machines with spare parts. To make this possible TPP has a number of distribution centres in Lund, Sweden, Greenwood, USA, Dubai, United Arab Emirates and in Singapore. The centre in Lund is the largest and most important, practically supplying the others with spare parts. TPP's product range consists of approximately 450,000 different spare parts (the warehouse in Lund holds about 65,000 different spare parts) and the total turnover is approximately €100 million.[23]

The market is increasing its demands on TPP all the time. The end customers call for greater availability and higher service levels to help make their operations more profitable. The market requires TPP to be an efficient supplier and to support them in maintaining customer satisfaction in a profitable way.[24]

The function of TPP is very important for Tetra Pak as a whole. Without TPP supplying customers with spare parts to keep their machines fully operational Tetra Pak cannot sell packaging material to them. Tetra Pak has a service policy that states that they will ensure their customers the full range of spare parts for any type of machine for infinity. This literally means every type of machine developed from the 1950s until today. TPP's function is to uphold this service policy.

[22] Internal material *Profitable availability*
[23] Intervju Åke Pettersson 051101
[24] Internal material *Profitable availability*

3.2.2 Organisational Structure of TPP

The chart in figure 3.1 illustrates the various departments within TPP. The Purchasing & Logistics department is responsible for the purchasing of spare parts, quality assurances of suppliers, creation of forecasts for the different products, claim handling and establishing of relationships with suppliers. Marketing & Sales is responsible for order handling and booking of transports.[25]

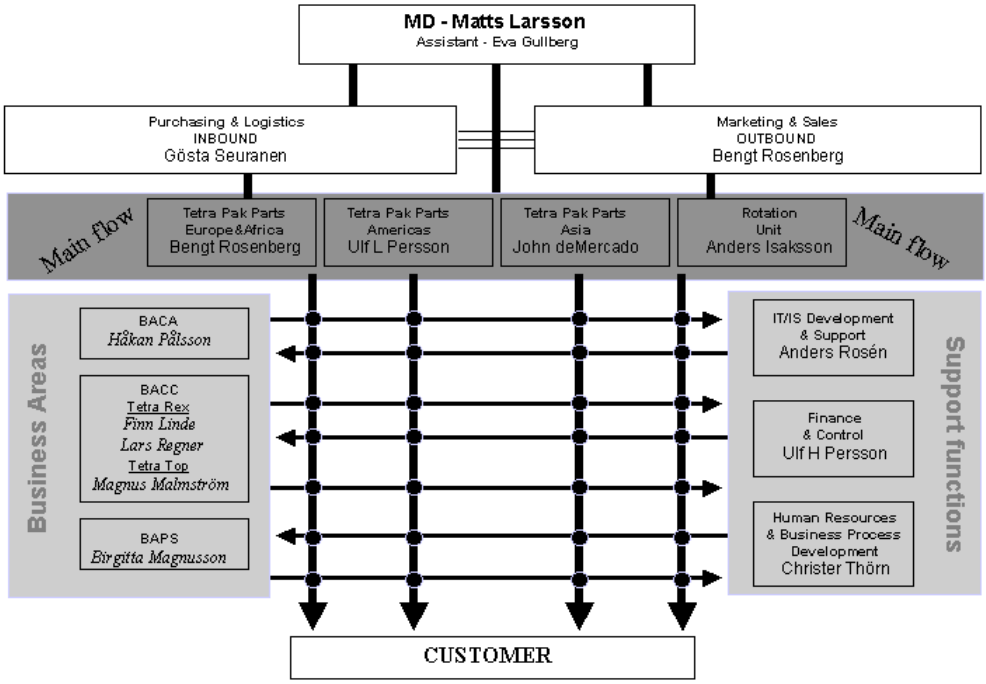

Figure 3.1 Organisational structure of Tetra Pak Parts

[25] Bonnevier Dudzik & Markovic, 2000

4 Theoretical Frame of Reference

In the theoretical frame of reference, theories that later will be used to analyse the empirical data, will be presented. This chapter will start by giving a short description of the role of packaging followed by packaging logistics. We will also introduce the reader to some classic logistics areas and the operative functions in a warehouse. We end this chapter with theories from Porter, the Wilson model and finally the Toyota Production System.

4.1 The Role of Packaging

According to The British Institution Glossary of Terms a packaging has the following qualities:[26]

"*The packaging is the ability, the science and the technology to prepare products for the market and retailers*"

The primary aims with packaging are:

- Protect and maintain the products
- Delimit a specific quantity
- Sell the products

The packaging protects the product against chemical, mechanical and physical damages during transport and storage. It also delimits and binds a specific amount, therefore facilitates the handling. The packaging will also market the product by giving the product and the producer an identity, communicate a message and inform the buyer about the product.[27]

The packaging is more than physical cardboard. It is a part of the entire marketing process, a link in the distribution process and a way to distribute the products to the customer at a low cost to a high quality. The packaging is rational, hygienic and saves a lot of physical work.[28] It also plays a significant role in the costs aspect of the product. The packaging follows the product through the chain all the way from production to consumption and has a great deal of impact on the handling, storing, transport and protection. If the packaging is correctly designed

[26] Conradsson, 1977
[27] Ibid
[28] Ibid

and used, it can give the product an added value and help create competitive strength in the market.[29]

An adaptation of packaging size to demand means lower costs due to increased rate of turnover and reduced rejection rate. This increased turnover rate reduces the cost for tied up capital and the reduced rejection rate is a result of the reduction of leftover products. The quantity of these "*consumption adapted*" products varies and packaging should therefore be flexible. An example of this is portion packaging multi-pack.[30]

4.2 Packaging Logistics

A definition of packaging logistics is:[31]

"Aiming at developing (creating) packages and packaging systems that support the objectives of logistics to plan, implement and control the efficient and effective materials flow"

A very valuable contribution from packaging logistics to logistics is the fact that it supplies form-utility, which makes it easier for the supplier to provide its customer or user with an undamaged product in an easy to handle package that can easily be disposed of. There are a couple of important building blocks for the creation of efficient packaging logistics:[32]

- Establish the frames for the packaging system
- Develop the physical packaging
- Design, create and build units
- Establish methods/equipment for packing and handling

The most interesting block for this thesis is the establishing of methods/equipment for packing and handling. This includes all activities from the design of the packages to the handling of the packages.

[29] Johansson et al, 1997
[30] Ibid
[31] Ibid
[32] Ibid

The demands on packaging are divided into three different categories: the flow function, the environmental function and the market function. The figure below shows this and how they can be further divided.[33]

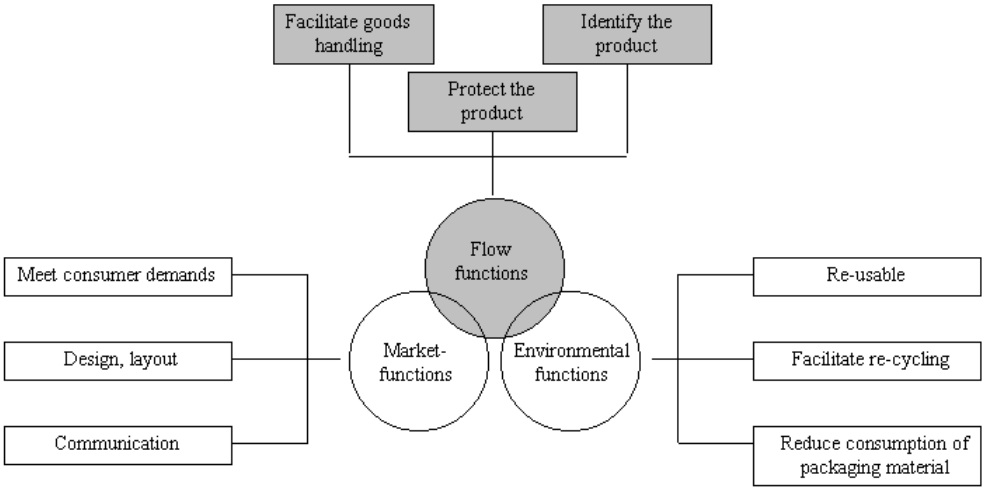

Figure 4.1 Main functions of packaging, Johansson et al, 1997 p 22

Each of the above mentioned functions can be subdivided into three new categories. The flow function (which is interesting for our thesis) is generally related to the logistics flow, i.e. handling and storing or transport. A function associated with packaging is the *protection of the product*. The packaging should protect the product from damage in the distribution environment.

The second flow function, *to facilitate the handling of the product*, is described as the contribution of the packaging to an efficient material flow by uniting and handling the product. This function has grown more important as goods handling has become more and more mechanised and automated. Examples of this is the use of lifting vehicles, trucks etc.

The final flow function, *identify the product* will make it easier for the product to reach the customer by providing space for address information. The packaging can also inform about and promote the product.

[33] Johansson et al, 1997

4.3 Classic Logistics Areas

To give a more lucid view of activities that are related to the logistics function, we will give some examples below of the most classic responsibility areas that goes under the idea logistics.

Transports and warehousing represents the core activities within logistics. Logistics can also be explained as a tool to create efficient material flows. A traditional explanation of logistics can be done by the seven R: s; *secure the accessibility of the Right products, in Right quantities, with the Right qualities, in the Right way, in Right time, to the Right customer and to the Right cost.* In other words, the aim of logistics is to create a greater value in time and space.[34]

The challenge with logistics is to create a system with high efficiency, in order to control the flow through the whole distribution channel, from supplier to end-user.[35]

Transport and warehousing have existed as long as mankind, but the modern understanding of its value is not older than approximately 50 years. The development and use of different mathematical optimisation methods for transport and warehousing gained interest after the World War 2.[36]

According to Persson & Virum there are a number of different activities that are important for a well working logistics system:[37]

- The first activity is transport, which may be the most typical logistics activity. Transport can be separated into two different levels: the physical level and the administrative level. The physical level means transporting as a tool to move the goods from one to another, e.g. from the producer to the wholesale dealer. The administrative level consists of planning, carry out, supervise and control the physical activity.

- The primary aim with warehousing is to guarantee that a predicted warehouse level is obtained. A large warehouse was earlier a sign that a company was stable and flourishing, this because the producers could not produce enough to satisfy the market.

  Today, companies have realised that a large warehouse ties a lot of capital and it is not profitable to have more than you need in your warehouse. Therefore it is important for companies to run their warehouses more efficiently. With help from different calculation

[34] Persson & Virum, 1998
[35] Ibid
[36] Ibid
[37] Ibid

models and methods, they try to estimate incoming orders and how much they need to have as a buffer in the warehouse.

- Material management and packaging such as layout, equipment for shorter internal transports, design of packaging etc. includes the physical activities in the warehousing. This is an area with considerable consequences for transport and warehousing.

- Orders, order receiving, order treatment and delivery are some typical logistic activities. Furthermore, service activities towards the customers are often seen as important logistic activities.

- Prognostication is a central part of logistics and is often taken cared of by the logistic department at the companies. To reach a high level of reliable prognostications, a detailed analysis of the material flow and the demand has to be considered. Prognostication and warehouse management is therefore closely connected.

- Purchase of raw material and spare parts from suppliers are important logistics activities. This because shorter delivery-time and deliveries of the right quantity to the right price affects the warehousing companies' own price and quality on the products. The relationship between the supplier and the buyer is therefore very important.

4.4 The Operative Functions in a Warehouse

With all the excitement surrounding new technologies and business practices, it is easy to neglect the fundamentals. In many organisations, warehousing is taken for granted. The warehouse is treated simply as a place where the product is stored until it needs to be shipped to the customer.[38]

The actions in a warehouse can be divided into following activities:[39]

- Loading and unloading
- Receiving and handling the goods in the warehouse
- Warehousing and inventory
- Picking

[38] Suskind, 1995
[39] Persson & Virum , 1998

The deliveries to and from the warehouse are often handled by trucks or trains. What kind of transport used is based upon several factors, e.g. the character of the product, the transported volumes etc. When the products arrive to the warehouse, the quantity will be controlled to see if it measures with the ordered quantity. Some of the products are also examined to see if the products have been damaged during transport. After the quantity and quality control the products are inventoried and the stock balance is updated, which is followed by giving the products an identity number and a storage position number. On larger and more modernised warehouses this is performed by computer based systems. Warehousing is a widespread operation where several methods exist and where a technology solution varies. There are warehouses, which are operated completely manually and also warehouses, which operates fully automatic where computers can control the flow of the goods without any human interaction. The fully automatic warehouses have a more accurate stock balance, this because technology prevents the appearance of errors due to human elements.[40]

Warehouses of today require an optimising of the picking activity. Customers demand smaller orders, more often, and want them to be shipped immediately. With such harsh requirements, the role of order picking takes on great importance. After all, without efficient order picking, meeting customer demands is difficult. As a result, a company cannot afford to have anything less than the most efficient picking method in the facility. But with a large selection of technology, equipment and methods, finding the ideal picking solution can sometimes be a daunting task. In most cases, there is not one piece of automation or method of picking that is going to be the solution. More often, a combination of equipment and methods will improve the picking activity.[41]

All the equipment and methods in the world will go to waste if you are not investing time monitoring your picking activities.[42]

4.5 Modern Warehousing

Earlier, a company with a big scale warehouse was a sign that the company was doing well and stable. Today, the theories of warehousing have changed dramatically. Companies have realised the cost savings of reducing the warehousing. Instead of having warehouses spread all over small areas, the trend today is to merge all of them into a central unit who supply wide areas such as Europe, Asia etc. A greater cost awareness, cooperation in the distribution channel and the development of computer based information technology have all contributed to

[40] Persson & Virum, 1998
[41] Loudin, 2000
[42] Ibid

the development behind the new way of warehousing. The phenomenon with a central warehouse has increased the frequencies of transports. Since the central warehouse provides a very wide area the transports must be very efficient. To be able to provide customers the right product in the right place at the right time, the warehousing must be very sophisticated and organised in a structured way.[43]

It is a common thought that technology in the 21st century will abolish the presence of manpower in the warehouse, replacing the human workforce with robots and automation. This scenario is doubtful, since this was also the promise of the technology in the 20th century. To manage merged facilities with increasing volumes, the solution for warehousing will be more than just adding labour. Brockmann believes that in this century the use of automation, such as conveyors that move small totes and cases across long distances and sort them to the appropriate re-packing station, will increase. Furthermore, the use of automated picking equipment will increase in order to improve capacity of existing facilities without building additional space. The automation will also continue to replace humans for heavy lifting, non-value-added movement of goods etc. Automation has taken over the heavy, monotonous, and dangerous activities in the warehouse, but the flexibility and decision-making capabilities of a human is more difficult to replace.[44]

4.6 Porter's Value Chain

Michael Porter's theory describing the value chain defines a company's activities as value creating and value supporting, which describes them how they are created within a company. Most organisations engage in hundreds, even thousands, of activities in the process of converting inputs to outputs. These activities, that all businesses must undertake in some form, can be classified generally as either primary or support activities. The value creating functions are primarily refining the product. For instance, in the manufacturing industry this is a process starting with receiving the raw material, continuing with processing, marketing, selling, distributing of the product and finally after sale service. These activities will further on be supported by activities and skills as human resource management, technology development, capabilities, financial situation and other routines. The different activities will add value to the final output of a product.[45] This theory has been viewed as a useful tool to analyse the tasks and roles within the general process of achieving customer satisfaction. Further on it also

[43] Persson & Virum, 1998
[44] Brockmann, 1999
[45] Hooley & Saunders, 1993

evaluates and examines how value is created for customers. It can also be used as a tool to identify a company's core competences and consequently as a tool to decide outsourcing.[46]

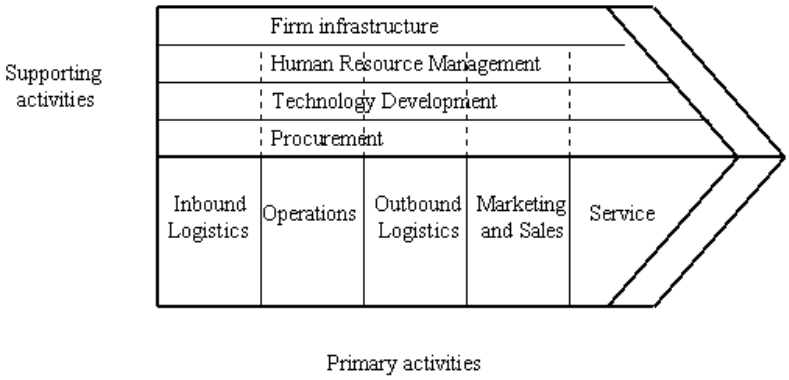

Figure 4.2 The Value Chain, Porter 1985

Inbound logistics is the process of managing the flow of products into the company. There are several examples of different strategies and philosophies concerning this issue and one well-known example is JIT – Just-In-Time. This is a method where a company coordinates its operations in a way that a product within the value chain is not manufactured before a demand arises[47]. It is important for every company to identify the strategy that best fits its capabilities, goals and requirements. Another crucial factor is how to manage and organise the supplies and at the same time achieve an efficient quality control.[48]

Operations have for a long time been viewed as the fundamental activity of business. This includes operations where the inbound products are changed in form, packaged and tested for appropriateness for sale. Operations have traditionally been seen as a value-adding process to a company's products. During this stage in the process it is possible to add value beyond the normal capital and manpower inputs by the continuance of high quality, flexibility and design.[49]

Outbound logistics is the process regarding the transport of the product from the producer to the buyer. This includes matters such as warehousing, distribution etc. During this stage value

[46] Grant, 1998
[47] Hines et al, 2000
[48] Grant, 1998
[49] Ibid

is added through fast and timely deliveries, low damage rates and various formulations of delivery mechanisms that satisfies the customers.[50]

Marketing and sales activities are part of the process of informing both current customers and potential customers about the products and services provided by the company. Another important activity in this stage of the process is to provide customers a reason to purchase the product and services, i.e. to promote and market the products and services[51].

Service includes all the activities, which are required in order to make sure that the product or service is working satisfying for the customer after it has been sold and delivered. This can involve training, consultation hotline, return of goods policies and other facilities. To achieve repeated sales it is of great importance to satisfy the customers.[52]

Porter also describes supporting activities such as: *procurement, human resource development, technological development* and *infrastructure*. These supporting activities are linked into each stage of the primary activities of the value chain.[53]

- *Infrastructure* serves the company's needs and ties its various parts together. It consists of functions or departments such as accounting, legal, finance, planning, public affairs, government relations, quality assurance and general management.

- *Human Resource Management* consists of all activities involved in recruiting, hiring, training, developing, compensating and dismissing or laying off personnel.

- *Technological Development* relates to the equipment, hardware, software, procedures and technical knowledge brought to bear in the firm's transformation of inputs into outputs.

- *Procurement* is the acquisition of inputs or resources for the company.

[50] Grant, 1998
[51] Ibid
[52] Ibid
[53] Ibid

4.7 Toyota Production System in the Warehouse

Kiichiro Toyoda, the chairman of the Toyota Motor Corporation, initially conceived the Toyota Production System[54] (TPS) and the engineer Taiichi Ohno led the enactment. It is both a philosophy and suite of practices, which have been developed since the 1950's. The TPS aims to eliminate all sources of wastes in the factory and to continuously improve the added value.[55]

The TPS is explained by two basic concepts. First, it explains that all efforts to achieve low cost production are made through reduction of costs by the elimination of wastes. This means creating a system, which will reduce wastes by assuming that anything other than the minimum amount of materials, equipment, parts and employees absolutely necessary for production only increases the costs. Secondly, it explains the importance of taking full use of the workers' capabilities. This is the foundation to the concepts of Just-In-Time production and the lean production. TPS combines low costs with high quality.[56] Ohno then developed an evaluating system to support the TPS, which consists of seven wastes in the factory:[57]

1. Overproduction	Regarded as the most serious waste.
2. Waiting	Time, which is being used ineffectively.
3. Transportation	Unnecessary movements of goods.
4. Inappropriate Processing	Overly complex solutions to simple procedures.
5. Unnecessary Inventory	Increases lead-time, prevents rapid identification of problems and increases space. Problems are hidden by inventory and it causes higher storage costs.
6. Unnecessary Motion	Involves the ergonomics of production such as when the employers have to stretch, bend, walk, etc.
7. Defects	Causes direct costs.

Toyota Motor Corporation later modified these seven wastes in the factory environment to apply to their parts distribution operations.[58]

1. Doing things faster than the necessary pace, creating piles of inventory, awaiting transportation to the customer and creating 'peaks' in the work load of employees
2. Unnecessary waiting as materials are not available or obstructed from picking
3. Conveyance

[54] Toyota Production System will furter on in this thesis be written TPS
[55] Kaplan et al, 1998
[56] www.toyotaproductionsystem.net, 080102
[57] Hines,et al, 2000
[58] Ibid

4. Inappropriate processing
5. Unnecessary inventory
6. Unnecessary motion and searching for products
7. Correction routines

The wastes in the warehouse are similar as the ones from the production even if they are not referred to exactly the same terminology. These wastes are physical, structural and procedural excesses, which add costs to the warehouse activities but add no value to the customer. It is important to identify a smooth flow through the warehouse. An important tool to decrease these wastes is to standardise and simplify the work routines.

4.8 The Wilson Model

Efficient warehousing aims at finding the optimal refill frequency, which gives the total lowest costs. The cost aspects that are relevant are the adjustment between warehousing costs and refill costs. The latter consists of order costs or adaptation costs. The figure below illustrates this:[59]

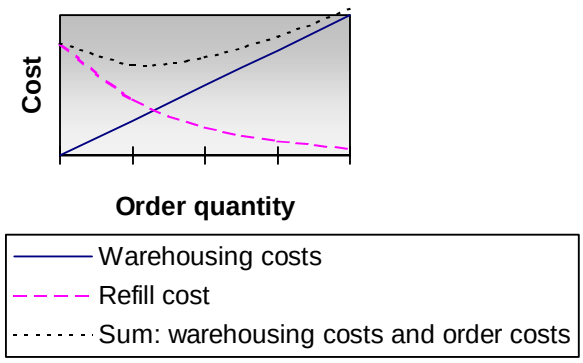

Figure 4.3 Cost adjustment for optimal refill frequency, Person & Virum, 1998 p140

This figure constitutes the basis of the Economic Order Quantity (EOQ), also called the Wilson model. The Wilson model is based on following assumptions:

[59] Person & Virum, 1998

total cost/year = warehousing cost + refill cost, where
warehousing cost/year = warehousing cost/unit * order quantity/2, also
refill cost/year = refill cost/occasion*yearly need/order quantity

Following symbols will be used:

q = order quantity
h = warehousing cost per unit and year
r = yearly need in number of units
s = refill cost/time
d= demand per time unit

The total yearly cost can therefore be expressed in the following way:

$$Total\cos t = \left(h * \frac{q}{2}\right) + \left(s * \frac{r}{2}\right)$$

To be able to find the lowest possible total cost and with that the optimal refill amount, the total cost-formula must be derived with reference on *q*. Following, the optimal order quantity can be achieved, traditionally this is called the Wilson model:[60]

$$q_{\text{opt}} = \sqrt{\frac{2 * r * s}{h}}$$

The Wilson model provides us with following figure:[61]

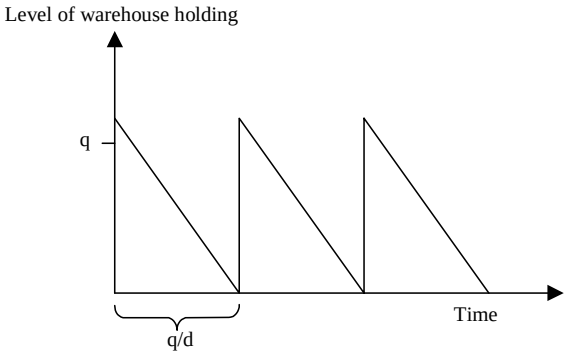

Figure 4.4 The Wilson Model, Axsäter, 1991 p 46

[60] Person & Virum, 1998
[61] Axsäter, 1991

As could be seen above this method shows that it is desirable to be able to measure future needs. The quality on the prognostics is determining for the possibility to achieve the accurate order quantity.

The Wilson model requires stability and continuity, which rarely is the case in a real warehouse management environment. In most practical situations this method is frequently used as an assistant tool in finding suitable order quantities.[62]

[62] Axsäter, 1991

5 The Empirical Foundation

In order to fully comprehend what an implementation of a multi package will mean to the efficiency of the handling of goods at TPP, it is important for the reader to achieve a deeper insight of how TPP's warehouse is structured today. The empirical foundation also accounts for how the data received from TPP has been processed. The information in this chapter has been achieved through interviews with key-persons at TPP and through our several visits to TPP's warehouse.

5.1 Warehousing at TPP

The warehouse at TPP is the central part of its organisation and today approximately 100 employees are working there. The work schedule at the warehouse is organised into a two-shift scheme. The first shift starts at 6.00 a.m. and ends at 2.00 p.m., the second is from 2.00 p.m. to 10.00 p.m.[63]

The importance of the unit in Lund has increased during the last years as the outbounded order-lines[64] have increased immensely. Today the order-lines are approximately 1,000,000/year and are forecasted to exceed 1,600,000 by the year of 2003[65]. The turnover of TPP's warehouse is strong and the total amount of weekly delivered articles is estimated to 2,000 (this is the amount of different articles and not the total amount of all articles delivered).[66] The total amount of stored articles is roughly 65,000 and the current supply of articles provided by TPP is approximately 450,000.[67] The high rate of articles is explained by the fact that Tetra Pak takes responsibility for providing spare parts for an infinite time for any type of packaging machine ever supplied by Tetra Pak. TPP's function is to sustain this service policy.[68] With the high rate of offered articles it is an impossible task for TPP to store all articles in the warehouse. However, to simplify the identification of the articles, they can be classified into two main groups:[69]

- Drawn articles

[63] Interview Stephan Lindh, 241001
[64] An order-line is an order from one customer and tells how much that is ordered on one certain occasion.
[65] Interview Åke Pettersson, 111201
[66] Interview Karolin Pettersson, 121101
[67] Interview Åke Pettersson, 111201
[68] Merkenius, 2000
[69] Ibid

- Components

The first group consists of articles, which have been designed by the Research and Development Department of the Tetra Pak group. These drawn articles are solely designed to suit the packaging machines offered by Tetra Pak and are consequently not offered to any other companies. Since Tetra Pak has designed these drawn articles, they have a legal right to choose any manufacturer or contractor they wish.

The second group of articles are components, which are articles that have not been designed by any unit within the Tetra Pak organisation. These articles are often standardised different to fit into numerous machines and designs. Components, as well as drawn articles, are acquired from external suppliers. Since both drawn articles and components differ in function and design, they also distinguish themselves in terms of demand and sales.[70]

5.2 The Flow

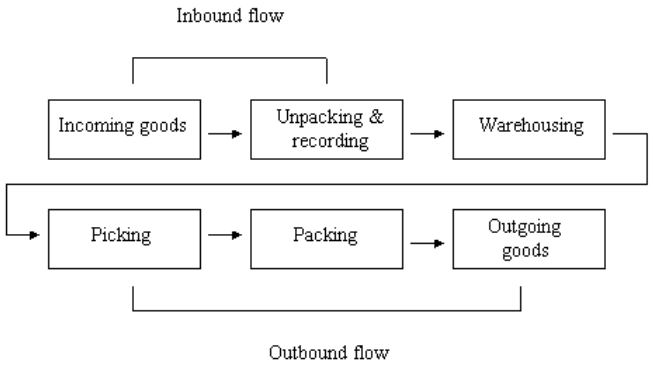

Figure 5.1 The flow of goods through TPP's warehouse

The warehouse of TPP can be divided into two areas: inbound and outbound flow. The inbound flow consists of incoming goods, unpacking and recording. The outbound flow consists of picking, packing and outgoing goods.

[70] Merkenius, 2000

5.2.1 Inbound Flow - Unpacking and Recording

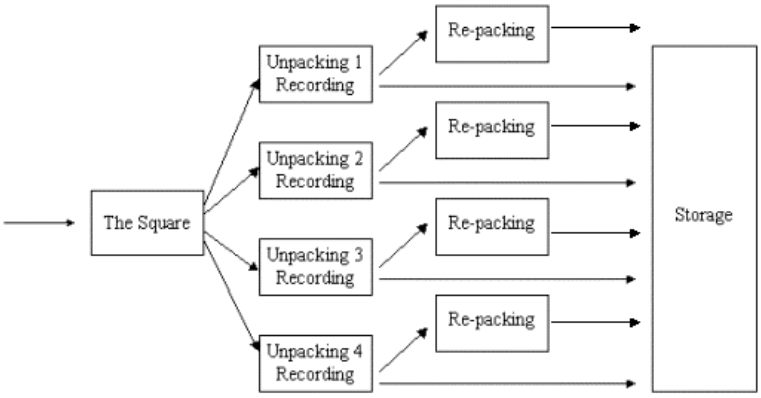

Figure 5.2 The inbound flow at TPP's warehouse.

The inbound flow consists of several activities. The first activity is to receive the *incoming goods*. When the goods are delivered to TPP's warehouse they will be transported to the received goods area, also known as 'the square', where they will remain until the next activity in the process, *the unpacking of the goods*. The department of receiving goods currently consists of approximately 25-30 employees and their responsibilities are to receive, inspect, record and unpack the goods from suppliers. There are currently four unpacking stations and each one of them is closely linked to an individual purchasing group, together they are linked to the same supplier to ensure stable quantity and quality controls. This will increase the knowledge of both articles and suppliers, which each unpacking station is handling.[71]

The function of the *recording* activity is to receive and record information that the articles have arrived to the warehouse and are ready to be ordered. At times when the unloading group is working under severe workload it might take longer time to unload and record the arrived goods. When this occurs it is necessary to locate the ordered articles directly at 'the square'. TPP has set up a goal for arrived goods, which states that an article shall be available to be ordered maximum eight hours after its arrival to 'the square'.[72]

When receiving goods are unpacked at the square some of the articles are required to be *re-packed*. This activity is performed manually. TPP differentiates between three kinds of re-packaging: protection packaging, set packaging and multi packaging. The protection packaging

[71] Interview Karolin Pettersson, 121101
[72] Interview Kjell Lundgren, 261001

is made particularly for articles that can be harmful to its environment or articles that must be protected from extreme or external conditions. A set packaging is a combination of several articles into one package, i.e. articles, which are sold as one unit. A multi package can be anything that holds several units of an article. This is currently a minor activity at TPP.[73]

When the unpacking and re-packing of the articles is processed, they will be transported to the storage area, where the picking personnel will assort the articles into their storage positions. At present this is performed manually and the first task to perform is to separate articles, which are too large to fit in the Paternoster modules, instead these articles will be stored in a different location of the warehouse. The Paternoster module is a large storing unit, which rotates automatically in order for the personnel to locate the articles. Each article is stored on several positions in the Paternoster module. The motive for this is to simplify for the picking staff to locate the ordered article.[74]

TPP is currently working on modernising their warehouse. The new modern system, ILD (Internal Logistics Development), is planned to be in function in the beginning of June 2002.[75] The new process will be a more automatic system, where the goods are automatically transported to their storage positions. This only concerns the smaller articles.[76]

5.2.2 Outbound Flow - Picking and Packing

When the articles have been sorted out to their storage positions, they are available for the next activity of TPP's warehouse, the picking activity, where the orders from the customers are processed. The picking personnel will pick the orders according to the batches that are printed automatically whenever a new order has to be prepared. The picking is performed manually and is very time-consuming. The articles will when necessary be packed in small plastic bags and placed on tables on the Paternoster module. When an article has been picked from its storage position in the Paternoster module, the batch and the articles' storage position will be scanned and recorded in to the computer system. This is done in order to update the stock balance in the warehouse. When the picked orders have reached a certain quantity the personnel will collect and sort the articles on a cart with 16 boxes organised according to their destination. Then they will be transported to their designated packing stations.[77]

[73] Interview Karolin Pettersson, 121101
[74] Ibid
[75] Interview Åke Pettersson, 111201
[76] Interview Karolin Pettersson, 121101
[77] Interview Jan-Inge Andersson, 131201

The activity of *packing* the articles into shipments is divided into different workstations depending on the destinations. The personnel at the packing activity are responsible for their own stations. When the packing is done at one station the personnel will aid the other stations. The shipments will be placed on shelves, sorted by destinations, while waiting to be shipped.[78]

5.3 The Articles

The project of restructuring TPP's warehouse began in spring 2001. In this project, various activities are involved and they all contribute to increase the efficiency of TPP's warehousing. One of these activities is the implementation of multi packages. Since TPP's warehouse consists of approximately 65,000 articles it may seem very difficult to identify all the articles that are needed to be multi packed. In this very moment there are approximately 215 identified articles that need a multi package and these are all stored in the Paternoster modules. Stephan Lindh has identified these articles and they must fulfil following criteria:[79]

- Small
- Difficult to count
- Time-consuming to pick and pack.

Lindh is continuously working with identifying articles needed to be multi packed and each time he identifies an article, which fulfils the criteria, he adds it to a list. This list has then been compiled into a Microsoft© Excel file. In our work with finding articles suitable for this thesis we have analysed the huge amount of data documented by him. Though, we have used different criteria than Lindh. Our criteria for selecting articles suitable for our research can be found in section 5.3.2.

5.3.1 The Data from TPP

The data (the Excel file) received from TPP consists of articles that need to be multi packed, how often they are ordered and in what quantities. The combination of these variables results in a tremendous amount of data. To exemplify the great amount of data, the total amount of orders only on the 215 identified articles exceed over 65,000 order-lines. Consequently, this means that it is not possible for us to analyse all articles in our research. With the data from TPP we have chosen a representative selection of articles based on various criteria. These

[78] Interview Joakim Johansson, 301101
[79] Interview Stephan Lindh, 241001

criteria consist of the amount of order-lines and the diffusion of ordered quantities within each article. The great amount of information forced us to narrow the number of analysed articles down to six. The numbers of order-lines on the six articles we have used exceeds 18,000.

The data from TPP consists of statistics from the year 2000.

5.3.2 Our Criteria for Selecting Articles

To bring an article into our research it has to fulfil the following criteria:

- The article must have more than one thousand order lines.
- It must have a high turnover rate at the warehouse.
- Its diffusion of ordered quantities within each article must be grouped evenly at certain quantities.

When analysing the data we found a lot of useful information. The first thing we had to do was to sort the articles' order quantity in a descending scale. To be able to condense the data to a reachable level we had to remove articles that were below one thousand order-lines (an order-line is an order from one customer and tells us how much that was ordered on one certain occasion). The reason why we removed these articles was that we wanted to look at articles that are frequently being handled at TPP, this because it will create a higher credibility to our thesis to apply a hypothesis of multi packages on articles that have a high turnover rate.

If the articles exceeded one thousand order-lines we looked at the diffusion of ordered quantities within each article. In this early phase we tried to descriptively identify articles that had diffusions, which were beneficial to be packed in a multi package. For example, if an article's order-lines were grouped evenly at certain quantities; we found incitements to bring them into our research. We have done a statistical research of the entire material but as we mentioned before, the material had such a wide span that we were forced to manually condense a representative selection.

The articles we have chosen, following the before mentioned procedure, are:

- Spring 1143216-0
- Washer 2033-8
- Pressure Roller 232979-0
- Gasket 32 315250-10

- Pin 456011-0
- Cone Tube 90028-20

After identifying the articles that we found interesting for our research, we began working with statistical methods. The data had a complicated nature, which made it difficult to define an optimal quantity for multi packages in a statistical way. To gain an idea about how we should move on, we contacted Pierre Carbonnier at the Department of Statistics at the University of Lund. He explained that it is very difficult to make a statistical approach on this kind of data. He told us that the data we had was more of a descriptive nature, which means that to distinguish a certain pattern you have to examine it visually.[80] To define optimal quantities for the selected articles a new method had to be developed by us since there is no established method for this issue. Our method will be described in chapter 6.

[80] Interview Pierre Carbonnier, 261101

6. Analysing the Data

In this chapter our method in defining optimal quantities for selected articles will be presented. We will first present our method and the design of a multi package followed by an example how an optimal quantity is defined. The chapter ends with a defining each selected article's optimal quantity.

6.1 Our Method for Defining Optimal Quantities for Selected Articles

As mentioned before, the data we received from TPP had a very wide range. What we first had to do was to find a method in selecting articles suitable for our research. This method presented in section 5.3.2.

An optimal quantity of a multi package should make the handling of the articles in the warehouse process more efficient. The most time-consuming activity today at TPP's warehouse is picking the articles. The purpose with a multi package is to reduce the picking time for one order-line. Though, even if an order-line consists of a high or low quantity, picking the articles takes a very long time. Since approximately 90% of all order-lines consist of relatively low quantities the contents of the multi packages should be based on this percentage. The 10% of order-lines that exceed the 90% are most commonly very high quantities.

Since one of the purposes with a multi package is to decrease the lead-time in picking the articles in the warehouse, the aim should be on rationalising the time-aspect in order-lines. All the optimal quantities for each selected article will therefore be based on the same criteria; looking at the diffusion below approximately 90% within each article. This because since one of the purposes with a multi package is to reduce the lead-time from order to delivery, it is important that the multi package have an efficient impact on as many order-lines as possible. In our case, the optimal quantities we have found have a time-efficient impact on 90% of all order-lines within each article. Although the remaining 10% have been observed to make sure that it does not affect the optimal quantity for each concerned article.

After limiting the data to approximately 90% of all order-lines in each selected article we tried to distinguish certain patterns e.g. if the order-lines are clustered around specific quantities. These patterns made a foundation for further discussion if an optimal quantity should be based

on these clusters. Since a relative high percentage of all order-lines could be found around the 10 lowest quantities they constitute an argument when it comes to designing the multi package.

When an article's optimal quantity for a multi package was defined we had to identify yet another package, a *unit package*. A unit package should hold numerous multi packages. The purpose with unit packages is to make the picking of high quantities more efficient.

An optimal quantity for an article is based on more than just the ordered quantity of an article. Several issues such as size, design, material etc. are relevant when you are multi packing an article. To get an insight of what kind of articles we were working with we needed to physically analyse them. Analysing the articles and observing how they are handled at the warehouse gave us a deeper knowledge of how they shall be multi packed.

6.2 Designing a Multi Package

Our suggestion of the design of a multi package is based upon the collected data that we received from TPP and observations of picking the articles at the warehouse.

Since all articles are rather small, the best way to multi package them would be in plastic bags. A cardboard package would not be space efficient in this matter, since the articles are stored in the Paternoster modules. A plastic bag is easier to store in the restricted storing space in the Paternoster modules, since it does not hold any unused space. As already mentioned, a unit package holding several multi packages should also be implemented, this to rationalise picking high quantities. These unit packages will also be plastic bags according to the same argument mentioned above. Figure 6.1 illustrates how the multi packages will constitute a unit package.

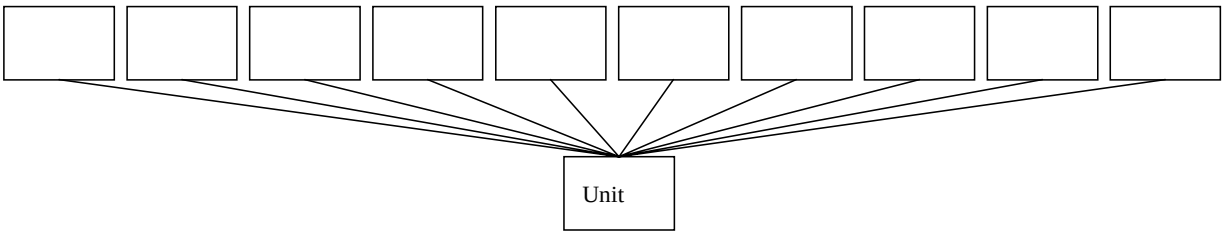

Figure 6.1 The constitution of a unit package.

Our suggestion of a multi package is based on the criteria that it should be a tool to convince the customers to order quantities in amounts that are profitable according to the optimal quantity in a multi package. When TPP implements the multi package there might be a problem in convincing the customers to order the articles in the multi packed quantities. Ordering only one or two units of an article should always be possible. Breaking a multi package in this purpose is only made to serve the customer needs. It is harder to convince customers to buy more than they need when it comes to smaller quantities but it may be easier when it larger quantities. In this thesis we put up the idea of breaking multi packages when it comes to quantities that are lower than the optimal quantity. Though, this is not the fact when it regarding larger amounts. If a customer wants to order 13 units of an article, which is multi packed in e.g. 5 units the customer has to order either 10 or 15 units.

Though, striving for not breaking multi packages for lower quantities shall be obtained.

6.3 Processing the Data Through MINITAB©

To gain a statistical foundation for our thesis we had to process the data through MINITAB©. We imported data from each article we found interesting from Microsoft© Excel to MINITAB©. In MINITAB© we calculated the tally for each article. The outcome of the calculations provided us with numerous statistical information of the ordered quantities for each article, which has helped us immensely in defining the optimal quantities. This material is presented in the appendix.

The data presented below serves the purpose to exemplify our procedure in finding the optimal quantity for selected articles. We will use Cone Tube as an example:

Tally for Cone Tube

Ordered quantities of Cone tube	Order-lines	CumCnt	Percent	CumPct
1	**143**	**143**	**4,28**	**4,28**
2	**167**	**310**	**5,00**	**9,28**
3	**193**	**503**	**5,78**	**15,06**
4	**102**	**605**	**3,05**	**18,12**
5	**259**	**864**	**7,76**	**25,88**
6	**194**	**1058**	**5,81**	**31,69**
7	**29**	**1087**	**0,87**	**32,55**
8	**62**	**1149**	**1,86**	**34,41**
9	**4**	**1153**	**0,12**	**34,53**
10	**584**	**1737**	**17,49**	**52,02**
11	8	1745	0,24	52,26
12	93	1838	2,79	55,05
13	7	1845	0,21	55,26
14	13	1858	0,39	55,65
15	73	1931	2,19	57,83
16	38	1969	1,14	58,97
17	3	1972	0,09	59,06
18	10	1982	0,30	59,36
19	1	1983	0,03	59,39
20	**342**	**2325**	**10,24**	**69,63**
21	1	2326	0,03	69,66
22	2	2328	0,06	69,72
23	1	2329	0,03	69,75
24	8	2337	0,24	69,99
25	36	2373	1,08	71,07
26	3	2376	0,09	71,16

27	1	2377	0,03	71,19
28	26	2403	0,78	71,97
29	2	2405	0,06	72,03
30	**120**	**2525**	**3,59**	**75,62**
31	1	2526	0,03	75,65
32	7	2533	0,21	75,86
33	2	2535	0,06	75,92
34	3	2538	0,09	76,01
35	4	2542	0,12	76,13
36	2	2544	0,06	76,19
37	1	2545	0,03	76,22
38	1	2546	0,03	76,25
39	1	2547	0,03	76,28
40	**54**	**2601**	**1,62**	**77,90**
42	1	2602	0,03	77,93
44	1	2603	0,03	77,96
45	1	2604	0,03	77,99
47	2	2606	0,06	78,05
48	5	2611	0,15	78,20
50	**157**	**2768**	**4,70**	**82,90**
51	1	2769	0,03	82,93
52	2	2771	0,06	82,99
53	3	2774	0,09	83,08
54	3	2777	0,09	83,17
55	1	2778	0,03	83,20
56	2	2780	0,06	83,26
58	1	2781	0,03	83,29
59	1	2782	0,03	83,32
60	**118**	**2900**	**3,53**	**86,85**
61	1	2901	0,03	86,88
62	1	2902	0,03	86,91
64	1	2903	0,03	86,94
66	2	2905	0,06	87,00
69	3	2908	0,09	87,09
70	**3**	**2911**	**0,09**	**87,18**
72	1	2912	0,03	87,21
73	1	2913	0,03	87,24
75	2	2915	0,06	87,30
76	1	2916	0,03	87,33
88	1	2917	0,03	87,36
90	**1**	**2918**	**0,03**	**87,39**
92	2	2920	0,06	87,45
96	1	2921	0,03	87,48
98	3	2924	0,09	87,57
100	**97**	**3021**	**2,91**	**90,48**
120	3	3024	0,09	90,57
124	1	3025	0,03	90,60
128	1	3026	0,03	90,63
130	1	3027	0,03	90,66
138	5	3032	0,15	90,81
140	1	3033	0,03	90,84
150	13	3046	0,39	91,22
165	1	3047	0,03	91,25
171	1	3048	0,03	91,28
180	1	3049	0,03	91,31
188	1	3050	0,03	91,34
195	1	3051	0,03	91,37
198	1	3052	0,03	91,40
200	50	3102	1,50	92,90
203	1	3103	0,03	92,93
205	3	3106	0,09	93,02
208	1	3107	0,03	93,05
210	1	3108	0,03	93,08
220	2	3110	0,06	93,14
224	1	3111	0,03	93,17
250	8	3119	0,24	93,41
255	1	3120	0,03	93,44
258	2	3122	0,06	93,50
260	1	3123	0,03	93,53
293	1	3124	0,03	93,56
300	41	3165	1,23	94,79
320	1	3166	0,03	94,82
322	1	3167	0,03	94,85
330	1	3168	0,03	94,88
340	1	3169	0,03	94,91
350	3	3172	0,09	95,00
356	1	3173	0,03	95,03
362	1	3174	0,03	95,06
376	1	3175	0,03	95,09
400	12	3187	0,36	95,45
409	1	3188	0,03	95,48
430	1	3189	0,03	95,51
431	1	3190	0,03	95,54
440	1	3191	0,03	95,57
450	5	3196	0,15	95,72
454	1	3197	0,03	95,75
458	1	3198	0,03	95,78
474	1	3199	0,03	95,81
482	1	3200	0,03	95,84
495	1	3201	0,03	95,87
500	46	3247	1,38	97,24
502	1	3248	0,03	97,27
505	1	3249	0,03	97,30
520	1	3250	0,03	97,33
538	1	3251	0,03	97,36
551	1	3252	0,03	97,39
552	1	3253	0,03	97,42
561	1	3254	0,03	97,45
569	1	3255	0,03	97,48
588	1	3256	0,03	97,51
600	2	3258	0,06	97,57
652	1	3259	0,03	97,60
668	2	3261	0,06	97,66
696	1	3262	0,03	97,69
700	6	3268	0,18	97,87
750	4	3272	0,12	97,99
761	1	3273	0,03	98,02
772	1	3274	0,03	98,05
797	2	3276	0,06	98,11
800	6	3282	0,18	98,29
973	1	3283	0,03	98,32
1000	27	3310	0,81	99,13
1004	1	3311	0,03	99,16
1032	1	3312	0,03	99,19
1062	1	3313	0,03	99,22
1147	1	3314	0,03	99,25
1242	1	3315	0,03	99,28
1258	1	3316	0,03	99,31
1314	1	3317	0,03	99,34
1349	2	3319	0,06	99,40
1450	1	3320	0,03	99,43
1457	1	3321	0,03	99,46
1473	1	3322	0,03	99,49
1500	4	3326	0,12	99,61
1523	1	3327	0,03	99,64
1546	1	3328	0,03	99,67
1548	1	3329	0,03	99,70
1640	1	3330	0,03	99,73
1683	1	3331	0,03	99,76
1757	1	3332	0,03	99,79
1806	1	3333	0,03	99,82
1862	1	3334	0,03	99,85
1934	1	3335	0,03	99,88
2000	3	3338	0,09	99,97
2815	1	3339	0,03	100,00

Number of order-lines = 3339

A Cone Tube is extremely small, not larger than 2-3 mm. It is stored together with thousands of other Cone Tubes, which makes them very difficult to pick. The normal procedure in picking these articles is to weigh them in order to get the accurate amount. This procedure is very inefficient since you need a special scale to do this and this scale is located on different locations in the warehouse, which makes the procedure irrational.

Looking at the data one can see that 90,48% of all order-lines holds an amount of 100 units or less. Therefore it is of greater importance to implement a multi package on these units than doing it on the 9,52% that exceed 100 ordered units. Since one of the purposes with a multi package is to decrease the lead-time in picking the articles in the warehouse, the aim should be on rationalising the time-aspect in order-lines.

Quantities of Cone Tube	**Cumulative order-lines**	**Cumulative percentage of order-lines**
1 – 9	1153	34,53%
Quantities clustered evenly at 10, 20 – 100	1476	44,20%
Remaining quantities	392	11,75%
Sum of order-lines and percentage	**3021**	**90,48%**

The data tells us that the most frequent order-lines are clearly clustered in quantities as 10, 20, 30 etc. up to 100. The sum of these clusters reach 44,20%. Following, they are clustered evenly at quantities as 100, 200 etc. up to 1,000. Since there are very order-lines between the mentioned clusters, it makes it easy to design a multi package for this article. 34,53% of the order-lines lay below 10 units, which is a relative high percentage, but to be able to make the picking of high quantities more efficient the multi package can not hold too few units.

To rationalise the handling of Cone Tube a multi package holding 10 units should be implemented. Further, the multi packages should be stored in a 10-packed unit package.

6.4 Optimal Quantities for the Selected Articles

In this section the optimal quantities for each selected article will be presented according to our method presented in section 6.1 and the example in 6.43. The tally for each selected article can be found in the appendix.

6.4.1 Spring (1143216-0)

The incitement to multi pack Springs is not based on their size, but the fact that they are hard to handle. In order to pick one Spring it is often required to separate them from each other since they get tangled up, and it is very time-wasting to sort them out. The Spring is an interesting article according to the fact that it has relatively many order-lines but the ordered quantities are not so widely spread. Therefore, we make an exception and do not limit the data to 90 %.

Units of Springs	**Cumulative order-lines**	**Cumulative percentage of order-lines**
1	161	11,79%
Quantities clustered evenly at 2, 4, 6 - 300	1025	75,03%
Uneven quantities at 3, 5 – 77	180	13,18%
Sum of order-lines and percentage	**1365**	**100%**

The data of Springs tell us that 75,03% of the order-lines are clustered at even quantities, consequently 24,97% are uneven quantities. The percentage of 1 ordered Springs constitutes 11,79% of all order-lines. Therefore a multi package for Springs should only hold a small amount of units. According to high percentages, both in even and low ordered quantities, the multi package should hold 2 units. Even though it is a low number for a multi package we think it will increase the efficiency considerably. This because it will provide the picking process with the opportunity to pick both high and low quantities in a time-efficient matter since the multi package prevents the Springs from tangling up. Another interesting aspect is that a multi package of Springs can only hold a small amount of units. If a multi package of this article would be packed in a high number of units it would generate the same problem as before since they will get tangled up.

A multi package of Spring should hold 2 units and there is no need of a unit package of Springs due to the fact that the spread of order-lines is low.

6.4.2 Pressure Roller (232979-0)

The Pressure Roller is the most ordered article among those that were documented in the analysed data. The numbers of ordered Pressure Rollers reach over 6,000 order-lines. The Pressure Rollers are very thin and therefore very difficult to separate from each other. This makes the procedure with picking them difficult, since you always end up picking too many.

Units of Pressure Rollers	**Cumulative order-lines**	**Cumulative percentage of order-lines**
1-9	1068	17,50%
Quantities clustered evenly at 10, 20 – 100	3727	61,08%
Remaining quantities	731	11,98%
Sum of order-lines and percentage	**5526**	**90,56%**

Given that the Pressure Roller is characterised by a very high number of order-lines the optimal quantity for a multi package must hold an amount that will help picking high quantities. The optimal quantity is still based on the order-lines below 90,56% even though there is such a wide span of order-lines above this limit. The order-lines that are clustered at even quantities, such as 10, 20 – 100, reach 61,08%.

Since the percentage of the remaining quantities between these clusters is low (11,98%), a multi package holding 10 units will be the most optimal. This is the most efficient amount when it comes to picking the order-lines according to the data. The unit package will consist of 10 multi packages.

17,50% of the order-lines lies below the optimal quantity. Picking these order-lines result in breaking a multi package. There is no possibility to multi pack the article in a smaller amount according to the 17,50%, since it would not benefit the order-lines with a higher quantity.

A multi package of Pressure Roller should hold 10 units and the unit package should contain 10 multi packages.

6.4.3 Gasket 32 (315250-10)

Units of Gaskets	**Cumulative order-line**	**Cumulative percentage of order-lines**
1-9	558	21,26%
Quantities clustered evenly at 10, 20 – 100	1316	50,14%
Quantities clustered evenly at 150, 200 – 500	321	12,22%
Remaining quantities	198	7,54%
Sum of percentage and order-lines	**2393**	**91,16%**

When storing Gaskets today, they are usually tied up in a group of five. Untying and sorting them out from each other is a very inefficient process. Looking at the statistical data one can see that 21,26% of all ordered Gaskets lies below 10 units. Though, the ordered quantities of Gaskets have a wide diffusion. The ordered quantities up to 91,16% of all order-lines reach 500 units. To be able to satisfy the picking of this spread of order-lines the multi package must hold an amount that makes this procedure efficient. The data tells us that the orders are clustered in quantities that will make them easier to handle if the Gasket is multi packed in an amount of 10 units. Following, they should be packed in groups of ten in a unit package to make the picking of larger quantities more efficient.

This means that only 20% of all order-lines will be followed by breaking a multi packaging or picking from one that is already broken in order to satisfy the order-lines that lie below the optimal quantity.

A multi package of Gasket should hold 10 units and the unit package should contain 10 multi packages.

6.4.4 Washer (2033-8)

Quantities of Washers	Cumulative order-lines	Cumulative percentage of order-lines
1-4	200	8,22%
Quantities clustered evenly at 5, 10, 15 - 50	1229	50,51%
Quantities clustered evenly at 60, 70 -100	106	4,36%
Quantities at 14, 24, 34	412	16,90%
Remaining quantities (not 14,24,34)	295	12,16%
Sum of order-lines and percentage	**2242**	**92,15%**

The article Washer is frequently ordered in bulky quantities. Washers ordered in quantities from 1-4 represent 8,22 % of the total amount of all order-lines. Looking further, one can see that even quantities as 5, 10, 15, 20 etc. represents a high percentage of the ordered quantities (50,51). Quantities as 14, 24, and 34 represent 16,90% and the total order-lines up to 50 units of Washer represents 86,15% of all order-lines. To be able to satisfy all these different order-lines and still be able to implement a multi package, the optimal quantity should be 5 units in each multi package. Further, to make the handling of larger quantities as efficient as possible a unit package holding ten 5-unit multi packages should be implemented.

A multi package of Washer should hold 5 units and the unit package should contain 10 multi packages.

6.4.5 Pin (456011-0)

Units of Pins	Cumulative order-lines	Cumulative percentage of order-lines
1-9	370	17,08%
Quantities clustered evenly at 10, 20 – 100	1286	59,37%
Quantities clustered evenly at 150, 200 – 300	167	7,71%
Remaining quantities	157	7,25%
Sum of percentage and order-lines	1980	**91,41%**

Multi packing Pin is rather complicated. When limiting the order-lines to 91,41% we reach a quantity around 300 units. The multi package must support both these high quantities as well as the lower quantities. The tally tells us that 17,08% of all the order-

lines lies around 1-9 units and clustered quantities as 10, 20 etc. up to 100 reach 59,37%. Next interesting clusters can be found at quantities as 150, 200 up to 300 (7,71%).

Since a multi package of this article should increase the efficiency of the handling of the wide spread of quantities in this article a multi package of Pin should hold 10 units and the unit package should contain 10 multi packages.

6.4.6 Cone Tube (90028-20)

According to the example mentioned in section 6.3 Cone Tube should be packed in a 10-unit multi package and in a 10-pack unit package.

7. Analysing the Effects of a Multi Package

In this chapter we will use both the theoretical frame of reference and the empirical foundation to analyse the effects that a multi package has on TPP's warehousing according to our research.

7.1 The effects on TPP's warehouse

In the analysis in chapter 6 we defined the quantities that the articles should be multi packed in and why they should be multi packed. In this analysis we will show in what way multi packages can help make the warehousing, especially the picking activity, more efficient. We will do this with help from Michael Porter's concept, TPP's demands and general models. We will use our own definition of the flow in the warehouse, from inbound to outbound goods, but it has large similarities with Porter's definition of the flow.

There are several benefits for TPP to implement a multi package. According to our research we have found that the greatest improvement in efficiency will be achieved in the outbound flow. There are several activities in this flow that will be performed much faster and more effective with the implementation of a multi package.

All interviewed persons are working at different departments within TPP and have a very clear point of view how a multi package will affect the handling of the articles in the warehouse. Since they work at different departments their opinions about where and how these effects will appear have been very different. We have found it interesting to listen to them describing in what way they think a multi package will contribute in making the daily work at their department more effective.

Jan-Inge Andersson, working with the picking activity, described the importance of a well working and effective picking activity not only to satisfy the current customers, but also to be prepared for the increasing demands that future customers may have. Andersson also said that the benefits with a multi package will not only appear at the Paternoster modules but also from picking articles at other warehouse areas.[81]

[81] Interview Jan-Inge Andersson, 141201

Margaretha Ivarsson, Manager at the Parts Processing Development, described the great importance of making the picking as effective as possible in order to make the amount of *faulty deliveries* as low as possible.[82]

Kjell Lundgren, Sales Manager of the Europe and Africa region, points to the fact that it is important for TPP to receive the articles in a sufficient package from the suppliers in order to achieve an effective flow through the warehouse. Lundgren also says that multi packaging is a way of decreasing *the internal lead-times* of the picking activity.[83]

Robert Merkenius, Supply Manager, told us that the lack of a proper multi package today is a bottleneck through the entire warehouse flow. According to Merkenius, TPP's *quality assurement* towards their customers will improve as a result of the implementation of a multi package. Furthermore he is of the opinion that the inventory process will be facilitated with the implementation.[84]

We will below analyse the effects of a multi package on different activities on TPP's warehousing beginning with the inbound activities. Here the effects of a multi package on *receiving goods* and *pre-packaging* will be shown. Following this the effects on the outbound activities will be presented. Here we will describe the effects of a multi package when it comes to *satisfying customers, faulty deliveries, flexibility* and *the flow through the warehouse* After this an analysis of TPP's warehousing will be done with the help from the Wilson model and the TPS.

7.1.1 Inbound Activities

- The effects of a multi package will not have a great impact on the receiving goods activity. We have found that the main benefit will occur when sample tests are taken from the arriving goods (to make sure that it contains the right amount of articles). It will be easier to count the articles with the implementation of a multi package.

- Through our research we can see that there will be some activities not needed anymore for TPP with the implementation of a multi package. The employees are today pre-packing some of the articles due to a few crucial aspects such as protection, safety and customers' demands. If this activity is outsourced to the suppliers the articles will arrive at TPP in multi packages and they will no longer require the

[82] Interview Margaretha Ivarsson, 141201
[83] Interview Kjell Lundgren, 261001
[84] Interview Robert Merkenius, 231101

manually performed re-packing of articles.[85] We believe that this will rationalise the receiving goods activity considerably and the flow through the warehouse will be faster. Our opinion is that an implementation of multi packages will simplify the activities of TPP's inbound logistics through faster and more efficient control of the receiving goods and consequently increase the added value to the customers.

7.1.2 Outbound Activities

- We believe that it is of great importance for TPP to make the picking activity as efficient as possible in order to meet the customers' demands. This to always be prepared for possible increases in order volume and due to the fact that TPP might receive new customers with different demands. We can also find support for this in what Suskind writes in his article. He says that without efficient order picking it will be hard to meet the customers' demands[86].

- Another interesting aspect is the fact that it might be possible to decrease the amount of faulty deliveries even more with the implementation of a multi package. This is something that Ivarsson and her department works very hard with and multi packages can contribute to make their work a lot easier and more efficient. Today only 0,36% of all deliveries are made with some kind of error, which is a great improvement from 1996 when the number was 4,86%[87]. We think that these 0,36% can improve even more with the help from a multi package.

- Our research have led us to strongly believe that with the implementation of a multi package the picking of the articles in the Paternoster module will be much faster. Instead of weighing or counting the articles to get the right amount the picking crew, with the implementation of multi packages can easier and faster pick the right amount of the article. We base our opinion on the observations of how the picking is done today. All of our performed interviews points to the fact that the implementation of multi packages greatly will improve this activity.

- Furthermore, our research has shown that a multi package will help make the picking of articles not stored in the Paternoster modules more efficient. This is because the personnel no longer will have to count the articles when they are up in their lifts. Instead of having to go down to weigh them or count them one by one at their storage

[85] Interview Åke Pettersson, 100102
[86] Suskind, 1995
[87] Internal material, *Material regarding discrepancies*

position, they can immediately get the right amount, which we believe will decrease the picking time greatly.

- We have also found support for that multi packages are an important denominator in order to facilitate the handling of the articles in a warehouse in order to achieve an efficient and fast flow through the warehouse. It would be of great interest for TPP to get the articles packed in sufficient sizes and packages directly from the suppliers.

- The packing and outgoing goods activities will only slightly be affected by the implementation of a multi package. The only thing that we can see will change is the fact that the picked articles will reach the packing activity faster than before. This might increase the pressure of the packing crew to work faster in order to maintain the faster pace achieved by the picking activity.

- The contribution to the added value of the implementation of a multi package is a shorter time span between the receiving of an order to the time it has been shipped. This will also add value to the final product through more satisfied customers.

7.2 The Wilson Model

Another way of exploring the effects of a multi package is to look at the Wilson model and in what way a multi package can affect the result. In this thesis the Wilson model will only be used to show what kind of cost effects a multi package will have on TPP's warehouse. Though, our objective is not to make a cost-analysis of the implementation of a multi packages.

As mentioned in the theoretical frame of reference the Wilson model aims at finding the total lowest warehousing cost and refill cost. The assumptions for the Wilson model are continuity and stability. Though in a warehouse for spare parts continuity and stability is very unusual and the variety of demanded spare parts is very high. This because, the future demands for spare parts are impossible to prognosticate since one can never know when a machinery will brake down and the need for an actual spare part will arise. Implementing multi packages can increase the continuity at TPP's warehouse since the customers have to order in the multi packed quantities. This makes it easier for TPP to order more accurate quantities from their suppliers but it does not eliminate the difficulties in prognosticating future demand for an actual spare part. The Wilson model is therefore not applicable on TPP's warehouse, nor on any spare part warehouse, even though multi packages will increase the stability and continuity slightly.

7.3 The Toyota Production System

The TPS in a warehouse describes seven different wastes occurring in the warehouse process. An implementation of a multi package is an important tool for TPP to decrease these wastes.

Waste	Affected by a multi package
Stress Piles of inventory Transportation to customer Peaks in workload	Yes Partly Yes Yes
Waiting	Yes
Conveyance	Partly
Inappropriate processing	Yes
Unnecessary inventory	Partly
Unnecessary motion and searching for products	Yes
Correction routines	No

Figure 7.1 The effects of a multi packages on the wastes in TPP's warehouse

An implementation of a multi package will help decrease the *stress* for the employees, the *waiting for transportation* to the customer and the '*peaks' in the workload* of employees. The *piles of inventory* in the warehouse will only partly be affected since a multi package will not have that great impact on the receiving goods activity. It will also decrease the *waiting time* through the entire flow, from the picking to the package and shipping activities. Since a multi package makes all the activities within TPP's warehousing more time-efficient it means that the articles are *available for the next step in the flow faster*.

It is a fact that a multi package will contribute to decreasing the *unnecessary motions* since it will make the handling of the articles more effective. This due to the fact that it will be easier and faster to count the plastic bags instead of counting or weighing every single article in order to find the right amount of articles. The method of weighing the articles is a perfect example of *inappropriate processing*, which means that a complex

solution is being used to a simple problem. *Unnecessary inventory* arises from the fact that it is hard to know exactly how many articles that are stored in the warehouse. There might be more articles stored than necessary, which can lead to an increase in costs. We believe that if a complete overview of the warehouse management could be achieved, this would lead to a leaner warehouse, less capital tied up and consequently increase the profitability.

8. Conclusions

In this thesis we have presented our own model for defining the optimal quantities for a multi package of six different articles. We believe that our analysis has proven that the optimal quantity for each concerned article can be defined upon with the use of this model. This model can be used on the remaining articles in TPP that need to be multi packed.

Multi packing spare parts is not a unique problem and although we have developed the method using TPP as a case company we believe that it is applicable on other companies in the same situation as TPP. Due to this fact we believe that our method has a high level of validity.

The implementation of a multi package will have positive effects on TPP's warehousing. We have shown that there will be improvements in both inbound and outbound activities of the warehouse and that the greatest benefits will be achieved in the outbound activities. In its entirety the warehouse process will be affected positively by the multi package.

The main benefit with a multi package on the inbound activities is that the activity concerning pre-packaging will no longer fulfil a purpose. This pre-packing activity can be outsourced to the suppliers and will then made according to an established method in order to receive appropriate quantities. This will save both time and capital for TPP since they do not have to pre-pack the articles themselves as the received pre-packed articles are packed in accurate quantities.

The implementation of a multi package will have its greatest impact on the outbound activities and the greatest benefit is shown at the picking activity. The picking of the articles will be much faster since the personnel do not have to count or weigh every article separately. It will also contribute to the fact that it will be easier to get exactly the right quantities since they are pre-packed in multi packages. These improvements could contribute in decreasing the time pressure on the personnel and therefore also help lowering the faulty deliveries.

Furthermore, we have shown that a multi package will facilitate the handling of the products through the warehouse to achieve a more efficient handling of them and its contribution to the entire flow is of great importance.

We have used the Wilson model to see in what way a multi package will contribute to cost-efficiency to the TPP warehousing. We have found that the Wilson model in this case is not applicable.

Finally we have shown that with the implementation of a multi package the wastes, according to the TPS theory, will decrease.

The positive effects from the implementation of a multi package have led us to draw the conclusion that multi packages will have a great impact on the different activities within TPP's warehousing. We strongly believe that an implementation of a multi package and defining an optimal quantity for it is of great interest for TPP. It will contribute in making both the handling of articles as well as the flow through the warehouse much more efficient.

8.1 Further research

Our thesis has focused on defining optimal quantities for multi packages and the benefits to TPP. During our research we have discussed questions that might occur in order to make sure that they are taken into consideration, it would still be possible to implement multi packages at TPP.

Interesting for TPP are the supplier and customer aspects. Will the suppliers have the possibility to supply TPP with the multi packages and what will the costs be? What will TPP's customers think of the fact that they will have to order multi packed quantities? Will this be a problem? Will TPP have to make price reductions to convince their customers to order in these quantities and how will this effect the present collaboration TPP has with their customers today?

These are both interesting aspects that can be investigated further. The answers of these questions can together with our research contribute to clarify the complex problem with an implementation of a multi package.

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Appendix

Tally for Discrete Variables: Spring

Spring	Count	CumCnt	Percent	CumPct
1	**161**	**161**	**11,79**	**11,79**
2	312	473	22,86	34,65
3	57	530	4,18	38,83
4	325	855	23,81	62,64
5	47	902	3,44	66,08
6	46	948	3,37	69,45
7	4	952	0,29	69,74
8	89	1041	6,52	76,26
9	13	1054	0,95	77,22
10	49	1103	3,59	80,81
11	9	1112	0,66	81,47
12	14	1126	1,03	82,49
13	8	1134	0,59	83,08
14	7	1141	0,51	83,59
15	19	1160	1,39	84,98
16	14	1174	1,03	86,01
17	3	1177	0,22	86,23
18	7	1184	0,51	86,74
20	53	1237	3,88	90,62
21	1	1238	0,07	90,70
22	3	1241	0,22	90,92
24	10	1251	0,73	91,65
25	5	1256	0,37	92,01
26	1	1257	0,07	92,09
30	32	1289	2,34	94,43
32	1	1290	0,07	94,51
33	1	1291	0,07	94,58
34	3	1294	0,22	94,80
35	1	1295	0,07	94,87
36	5	1300	0,37	95,24
38	1	1301	0,07	95,31
39	1	1302	0,07	95,38
40	10	1312	0,73	96,12
42	1	1313	0,07	96,19
43	2	1315	0,15	96,34
44	1	1316	0,07	96,41
45	2	1318	0,15	96,56
46	1	1319	0,07	96,63
49	1	1320	0,07	96,70
50	14	1334	1,03	97,73
51	1	1335	0,07	97,80
52	2	1337	0,15	97,95
53	1	1338	0,07	98,02
56	1	1339	0,07	98,10
60	4	1343	0,29	98,39
61	2	1345	0,15	98,53
62	1	1346	0,07	98,61
64	1	1347	0,07	98,68
66	1	1348	0,07	98,75
68	2	1350	0,15	98,90
70	2	1352	0,15	99,05
77	2	1354	0,15	99,19
80	2	1356	0,15	99,34
100	5	1361	0,37	99,71
116	1	1362	0,07	99,78
150	1	1363	0,07	99,85
244	1	1364	0,07	99,93
300	1	1365	0,07	100,00

Number of order-lines = 1365

Tally for Discrete Variables: Washer

Washer	Count	CumCnt	Percent	CumPct
1	**26**	**26**	**1,07**	**1,07**
2	**109**	**135**	**4,48**	**5,55**
3	**39**	**174**	**1,60**	**7,15**
4	**26**	**200**	**1,07**	**8,22**
5	**27**	**227**	**1,11**	**9,33**
6	32	259	1,32	10,65
7	7	266	0,29	10,93
8	12	278	0,49	11,43
9	2	280	0,08	11,51
10	**430**	**710**	**17,67**	**29,18**
11	8	718	0,33	29,51
12	42	760	1,73	31,24
13	23	783	0,95	32,18
14	**196**	**979**	**8,06**	**40,24**
15	**92**	**1071**	**3,78**	**44,02**
16	9	1080	0,37	44,39
17	1	1081	0,04	44,43
18	17	1098	0,70	45,13
19	4	1102	0,16	45,29
20	**423**	**1525**	**17,39**	**62,68**
21	3	1528	0,12	62,80
22	2	1530	0,08	62,89
23	7	1537	0,29	63,17
24	**22**	**1559**	**0,90**	**64,08**
25	**19**	**1578**	**0,78**	**64,86**
26	7	1585	0,29	65,15
27	5	1590	0,21	65,35
28	6	1596	0,25	65,60
29	3	1599	0,12	65,72
30	**78**	**1677**	**3,21**	**68,93**
32	1	1678	0,04	68,97
33	3	1681	0,12	69,09
34	**194**	**1875**	**7,97**	**77,07**
35	**1**	**1876**	**0,04**	**77,11**
36	28	1904	1,15	78,26
37	15	1919	0,62	78,87
39	6	1925	0,25	79,12
40	**66**	**1991**	**2,71**	**81,83**
41	1	1992	0,04	81,87
42	4	1996	0,16	82,04
43	1	1997	0,04	82,08
45	**2**	**1999**	**0,08**	**82,16**
46	1	2000	0,04	82,20
47	1	2001	0,04	82,24
48	4	2005	0,16	82,41
50	**91**	**2096**	**3,74**	**86,15**
51	1	2097	0,04	86,19
52	2	2099	0,08	86,27
53	1	2100	0,04	86,31
54	2	2102	0,08	86,40
55	1	2103	0,04	86,44
56	1	2104	0,04	86,48
58	3	2107	0,12	86,60
59	1	2108	0,04	86,64
60	**21**	**2129**	**0,86**	**87,51**
61	1	2130	0,04	87,55
62	1	2131	0,04	87,59
63	4	2135	0,16	87,75
64	3	2138	0,12	87,88
66	1	2139	0,04	87,92
67	1	2140	0,04	87,96
68	1	2141	0,04	88,00
69	3	2144	0,12	88,12
70	**7**	**2151**	**0,29**	**88,41**
72	2	2153	0,08	88,49
73	1	2154	0,04	88,53
74	5	2159	0,21	88,74
75	1	2160	0,04	88,78
76	1	2161	0,04	88,82
79	1	2162	0,04	88,86
80	**10**	**2172**	**0,41**	**89,27**
82	1	2173	0,04	89,31
85	1	2174	0,04	89,35
90	**2**	**2176**	**0,08**	**89,44**
100	**66**	**2242**	**2,71**	**92,15**
104	1	2243	0,04	92,19
120	1	2244	0,04	92,23
125	1	2245	0,04	92,27
150	9	2254	0,37	92,64
155	1	2255	0,04	92,68
167	1	2256	0,04	92,73
168	1	2257	0,04	92,77
170	1	2258	0,04	92,81
183	4	2262	0,16	92,97
187	1	2263	0,04	93,01
190	1	2264	0,04	93,05
198	1	2265	0,04	93,09
200	25	2290	1,03	94,12
209	1	2291	0,04	94,16
210	2	2293	0,08	94,25
220	2	2295	0,08	94,33
238	1	2296	0,04	94,37
250	1	2297	0,04	94,41
252	1	2298	0,04	94,45
272	1	2299	0,04	94,49
274	1	2300	0,04	94,53
280	1	2301	0,04	94,57
300	19	2320	0,78	95,36
325	1	2321	0,04	95,40
335	1	2322	0,04	95,44
337	1	2323	0,04	95,48
340	1	2324	0,04	95,52
348	1	2325	0,04	95,56
357	1	2326	0,04	95,60
363	1	2327	0,04	95,64
364	1	2328	0,04	95,68
366	2	2330	0,08	95,77
372	1	2331	0,04	95,81
385	1	2332	0,04	95,85
388	1	2333	0,04	95,89
390	1	2334	0,04	95,93
400	6	2340	0,25	96,18
419	1	2341	0,04	96,22
441	1	2342	0,04	96,26
450	1	2343	0,04	96,30
479	1	2344	0,04	96,34
500	27	2371	1,11	97,45
527	1	2372	0,04	97,49
528	1	2373	0,04	97,53
529	1	2374	0,04	97,58
535	1	2375	0,04	97,62
548	1	2376	0,04	97,66
560	1	2377	0,04	97,70
600	2	2379	0,08	97,78
680	1	2380	0,04	97,82
700	1	2381	0,04	97,86
800	1	2382	0,04	97,90
900	1	2383	0,04	97,94

1000	13	2396	0,53	98,48
1043	1	2397	0,04	98,52
1200	1	2398	0,04	98,56
1217	1	2399	0,04	98,60
1309	1	2400	0,04	98,64
1320	1	2401	0,04	98,68
1400	1	2402	0,04	98,73
1481	1	2403	0,04	98,77
1500	18	2421	0,74	99,51
1597	1	2422	0,04	99,55
1800	1	2423	0,04	99,59
1832	1	2424	0,04	99,63
1924	1	2425	0,04	99,67
1950	1	2426	0,04	99,71
1969	1	2427	0,04	99,75
1979	1	2428	0,04	99,79
2000	1	2429	0,04	99,84
2056	1	2430	0,04	99,88
2259	1	2431	0,04	99,92
2626	1	2432	0,04	99,96
3000	1	2433	0,04	100,00

Number of order-lines = 2433

Tally for Discrete Variables: Pressure Roller

Pressure	Count	CumCnt	Percent	CumPct
1	**194**	**194**	**3,18**	**3,18**
2	**348**	**542**	**5,70**	**8,88**
3	**55**	**597**	**0,90**	**9,78**
4	**133**	**730**	**2,18**	**11,96**
5	**135**	**865**	**2,21**	**14,18**
6	**141**	**1006**	**2,31**	**16,49**
7	**14**	**1020**	**0,23**	**16,72**
8	**41**	**1061**	**0,67**	**17,39**
9	**7**	**1068**	**0,11**	**17,50**
10	**1117**	**2185**	**18,31**	**35,81**
11	11	2196	0,18	35,99
12	43	2239	0,70	36,69
13	6	2245	0,10	36,79
14	10	2255	0,16	36,96
15	84	2339	1,38	38,33
16	90	2429	1,47	39,81
17	6	2435	0,10	39,90
18	12	2447	0,20	40,10
19	2	2449	0,03	40,13
20	**949**	**3398**	**15,55**	**55,69**
21	8	3406	0,13	55,82
22	5	3411	0,08	55,90
23	4	3415	0,07	55,97
24	14	3429	0,23	56,19
25	205	3634	3,36	59,55
26	8	3642	0,13	59,69
27	16	3658	0,26	59,95
28	8	3666	0,13	60,08
29	6	3672	0,10	60,18
30	**531**	**4203**	**8,70**	**68,88**
31	2	4205	0,03	68,91
32	14	4219	0,23	69,14
33	4	4223	0,07	69,21
34	8	4231	0,13	69,34
35	33	4264	0,54	69,88
36	5	4269	0,08	69,96
37	3	4272	0,05	70,01
38	2	4274	0,03	70,04
39	4	4278	0,07	70,11
40	**243**	**4521**	**3,98**	**74,09**
42	1	4522	0,02	74,11
43	1	4523	0,02	74,12
44	6	4529	0,10	74,22
45	11	4540	0,18	74,40
46	1	4541	0,02	74,42
47	1	4542	0,02	74,43
48	32	4574	0,52	74,96
49	1	4575	0,02	74,98
50	**417**	**4992**	**6,83**	**81,81**
51	1	4993	0,02	81,83
52	1	4994	0,02	81,84
53	2	4996	0,03	81,87
54	1	4997	0,02	81,89
55	4	5001	0,07	81,96
56	3	5004	0,05	82,01
57	3	5007	0,05	82,06
58	2	5009	0,03	82,09
60	**48**	**5057**	**0,79**	**82,87**
61	1	5058	0,02	82,89
62	1	5059	0,02	82,91
63	3	5062	0,05	82,96
65	3	5065	0,05	83,01
66	2	5067	0,03	83,04
68	3	5070	0,05	83,09
70	**30**	**5100**	**0,49**	**83,58**
72	2	5102	0,03	83,61
74	1	5103	0,02	83,63
75	2	5105	0,03	83,66
78	2	5107	0,03	83,69
79	10	5117	0,16	83,86
80	**46**	**5163**	**0,75**	**84,61**
81	2	5165	0,03	84,64
82	3	5168	0,05	84,69
85	1	5169	0,02	84,71
89	1	5170	0,02	84,73
90	**1**	**5171**	**0,02**	**84,74**
91	1	5172	0,02	84,76
95	2	5174	0,03	84,79
96	5	5179	0,08	84,87
98	2	5181	0,03	84,91
100	**345**	**5526**	**5,65**	**90,56**
101	3	5529	0,05	90,61
102	1	5530	0,02	90,63
105	4	5534	0,07	90,69
107	1	5535	0,02	90,71
110	2	5537	0,03	90,74
111	2	5539	0,03	90,77
114	2	5541	0,03	90,81
115	3	5544	0,05	90,86
116	1	5545	0,02	90,87
120	5	5550	0,08	90,95
121	1	5551	0,02	90,97
122	2	5553	0,03	91,00
124	1	5554	0,02	91,02
125	3	5557	0,05	91,07
126	1	5558	0,02	91,08
130	4	5562	0,07	91,15
132	1	5563	0,02	91,17
138	2	5565	0,03	91,20
139	1	5566	0,02	91,22
140	1	5567	0,02	91,23
142	2	5569	0,03	91,27
149	1	5570	0,02	91,28
150	31	5601	0,51	91,79
152	2	5603	0,03	91,82
153	1	5604	0,02	91,84
155	2	5606	0,03	91,87
156	3	5609	0,05	91,92
157	1	5610	0,02	91,94
158	1	5611	0,02	91,95
160	7	5618	0,11	92,07
164	2	5620	0,03	92,10
166	1	5621	0,02	92,12
170	1	5622	0,02	92,13
172	1	5623	0,02	92,15
175	1	5624	0,02	92,17
180	2	5626	0,03	92,20
182	1	5627	0,02	92,22
190	1	5628	0,02	92,23
194	1	5629	0,02	92,25
196	2	5631	0,03	92,28
200	140	5771	2,29	94,58
204	1	5772	0,02	94,59
205	1	5773	0,02	94,61
206	1	5774	0,02	94,62
207	1	5775	0,02	94,64
210	1	5776	0,02	94,66
213	1	5777	0,02	94,67
216	1	5778	0,02	94,69
217	1	5779	0,02	94,71

220	2	5781	0,03	94,74
221	1	5782	0,02	94,76
224	1	5783	0,02	94,77
225	1	5784	0,02	94,79
226	1	5785	0,02	94,80
227	1	5786	0,02	94,82
228	1	5787	0,02	94,84
233	1	5788	0,02	94,85
235	1	5789	0,02	94,87
238	1	5790	0,02	94,89
239	1	5791	0,02	94,90
240	1	5792	0,02	94,92
241	1	5793	0,02	94,94
250	5	5798	0,08	95,02
261	1	5799	0,02	95,03
264	1	5800	0,02	95,05
269	1	5801	0,02	95,07
270	1	5802	0,02	95,08
274	1	5803	0,02	95,10
277	1	5804	0,02	95,12
279	1	5805	0,02	95,13
289	1	5806	0,02	95,15
300	102	5908	1,67	96,82
325	1	5909	0,02	96,84
328	1	5910	0,02	96,85
341	1	5911	0,02	96,87
344	1	5912	0,02	96,89
350	5	5917	0,08	96,97
354	1	5918	0,02	96,98
355	1	5919	0,02	97,00
365	1	5920	0,02	97,02
375	1	5921	0,02	97,03
379	1	5922	0,02	97,05
400	59	5981	0,97	98,02
405	2	5983	0,03	98,05
408	4	5987	0,07	98,12
410	3	5990	0,05	98,16
414	1	5991	0,02	98,18
426	4	5995	0,07	98,25
463	1	5996	0,02	98,26
464	1	5997	0,02	98,28
485	1	5998	0,02	98,30
495	1	5999	0,02	98,31
497	1	6000	0,02	98,33
500	22	6022	0,36	98,69
505	1	6023	0,02	98,71
519	1	6024	0,02	98,72
524	1	6025	0,02	98,74
530	3	6028	0,05	98,79
540	3	6031	0,05	98,84
549	1	6032	0,02	98,85
550	4	6036	0,07	98,92
555	1	6037	0,02	98,93
557	1	6038	0,02	98,95
565	1	6039	0,02	98,97
579	1	6040	0,02	98,98
583	1	6041	0,02	99,00
600	4	6045	0,07	99,07
619	1	6046	0,02	99,08
631	1	6047	0,02	99,10
650	1	6048	0,02	99,12
655	1	6049	0,02	99,13
667	1	6050	0,02	99,15
689	1	6051	0,02	99,16
700	1	6052	0,02	99,18
707	1	6053	0,02	99,20
757	1	6054	0,02	99,21
773	1	6055	0,02	99,23
800	2	6057	0,03	99,26
804	1	6058	0,02	99,28
805	1	6059	0,02	99,30
811	1	6060	0,02	99,31
819	1	6061	0,02	99,33
820	1	6062	0,02	99,34
834	1	6063	0,02	99,36
863	1	6064	0,02	99,38
864	1	6065	0,02	99,39
871	1	6066	0,02	99,41
875	1	6067	0,02	99,43
880	1	6068	0,02	99,44
900	3	6071	0,05	99,49
909	1	6072	0,02	99,51
947	1	6073	0,02	99,52
967	2	6075	0,03	99,56
992	1	6076	0,02	99,57
999	1	6077	0,02	99,59
1000	8	6085	0,13	99,72
1007	1	6086	0,02	99,74
1008	1	6087	0,02	99,75
1011	1	6088	0,02	99,77
1031	1	6089	0,02	99,79
1034	1	6090	0,02	99,80
1040	1	6091	0,02	99,82
1049	1	6092	0,02	99,84
1058	1	6093	0,02	99,85
1059	1	6094	0,02	99,87
1074	1	6095	0,02	99,89
1077	1	6096	0,02	99,90
1100	2	6098	0,03	99,93
1120	1	6099	0,02	99,95
1178	1	6100	0,02	99,97
1840	1	6101	0,02	99,98
2000	1	6102	0,02	100,00

Number of order-lines = 6102

Tally for Discrete Variables: Gasket 32

Gasket 32	Count	CumCnt	Percent	CumPct
1	**127**	**127**	**4,84**	**4,84**
2	**170**	**297**	**6,48**	**11,31**
3	**87**	**384**	**3,31**	**14,63**
4	**45**	**429**	**1,71**	**16,34**
5	**99**	**528**	**3,77**	**20,11**
6	**11**	**539**	**0,42**	**20,53**
7	**8**	**547**	**0,30**	**20,84**
8	**10**	**557**	**0,38**	**21,22**
9	**1**	**558**	**0,04**	**21,26**
10	**90**	**648**	**3,43**	**24,69**
11	4	652	0,15	24,84
12	6	658	0,23	25,07
13	2	660	0,08	25,14
14	2	662	0,08	25,22
15	15	677	0,57	25,79
16	2	679	0,08	25,87
18	5	684	0,19	26,06
19	1	685	0,04	26,10
20	**286**	**971**	**10,90**	**36,99**
24	2	973	0,08	37,07
25	30	1003	1,14	38,21
26	2	1005	0,08	38,29
27	1	1006	0,04	38,32
28	2	1008	0,08	38,40
29	1	1009	0,04	38,44
30	**84**	**1093**	**3,20**	**41,64**
32	2	1095	0,08	41,71
34	1	1096	0,04	41,75
35	1	1097	0,04	41,79
38	1	1098	0,04	41,83
40	**92**	**1190**	**3,50**	**45,33**
43	1	1191	0,04	45,37
44	1	1192	0,04	45,41
47	1	1193	0,04	45,45
49	1	1194	0,04	45,49
50	**270**	**1464**	**10,29**	**55,77**
52	3	1467	0,11	55,89
55	2	1469	0,08	55,96
56	2	1471	0,08	56,04
57	2	1473	0,08	56,11
58	1	1474	0,04	56,15
60	**20**	**1494**	**0,76**	**56,91**
62	1	1495	0,04	56,95
64	1	1496	0,04	56,99
65	1	1497	0,04	57,03
66	1	1498	0,04	57,07
70	**4**	**1502**	**0,15**	**57,22**
71	1	1503	0,04	57,26
72	2	1505	0,08	57,33
74	1	1506	0,04	57,37
75	2	1508	0,08	57,45
79	1	1509	0,04	57,49
80	**12**	**1521**	**0,46**	**57,94**
83	1	1522	0,04	57,98
85	1	1523	0,04	58,02
89	2	1525	0,08	58,10
90	**5**	**1530**	**0,19**	**58,29**
92	1	1531	0,04	58,32
93	1	1532	0,04	58,36
94	2	1534	0,08	58,44
96	1	1535	0,04	58,48
97	6	1541	0,23	58,70
99	1	1542	0,04	58,74
100	**453**	**1995**	**17,26**	**76,00**
101	1	1996	0,04	76,04
105	2	1998	0,08	76,11
106	1	1999	0,04	76,15
108	3	2002	0,11	76,27
109	2	2004	0,08	76,34
110	1	2005	0,04	76,38
112	1	2006	0,04	76,42
114	2	2008	0,08	76,50
116	1	2009	0,04	76,53
120	5	2014	0,19	76,72
122	4	2018	0,15	76,88
124	1	2019	0,04	76,91
125	1	2020	0,04	76,95
128	1	2021	0,04	76,99
130	3	2024	0,11	77,10
131	2	2026	0,08	77,18
133	1	2027	0,04	77,22
140	1	2028	0,04	77,26
148	1	2029	0,04	77,30
150	**74**	**2103**	**2,82**	**80,11**
151	1	2104	0,04	80,15
170	1	2105	0,04	80,19
173	1	2106	0,04	80,23
180	1	2107	0,04	80,27
190	1	2108	0,04	80,30
195	1	2109	0,04	80,34
198	3	2112	0,11	80,46
200	**99**	**2211**	**3,77**	**84,23**
201	3	2214	0,11	84,34
204	1	2215	0,04	84,38
208	1	2216	0,04	84,42
216	1	2217	0,04	84,46
219	1	2218	0,04	84,50
221	1	2219	0,04	84,53
222	1	2220	0,04	84,57
225	1	2221	0,04	84,61
228	2	2223	0,08	84,69
237	1	2224	0,04	84,72
245	1	2225	0,04	84,76
249	1	2226	0,04	84,80
250	**3**	**2229**	**0,11**	**84,91**
253	1	2230	0,04	84,95
254	1	2231	0,04	84,99
271	1	2232	0,04	85,03
272	1	2233	0,04	85,07
276	1	2234	0,04	85,10
277	1	2235	0,04	85,14
278	1	2236	0,04	85,18
280	1	2237	0,04	85,22
281	1	2238	0,04	85,26
284	1	2239	0,04	85,30
300	**33**	**2272**	**1,26**	**86,55**
333	1	2273	0,04	86,59
341	1	2274	0,04	86,63
349	1	2275	0,04	86,67
358	1	2276	0,04	86,70
381	1	2277	0,04	86,74
394	1	2278	0,04	86,78
400	**25**	**2303**	**0,95**	**87,73**
415	1	2304	0,04	87,77
454	1	2305	0,04	87,81
496	1	2306	0,04	87,85

500	**87**	**2393**	**3,31**	**91,16**
503	1	2394	0,04	91,20
504	1	2395	0,04	91,24
510	1	2396	0,04	91,28
527	1	2397	0,04	91,31
528	2	2399	0,08	91,39
531	1	2400	0,04	91,43
555	1	2401	0,04	91,47
569	1	2402	0,04	91,50
570	1	2403	0,04	91,54
590	1	2404	0,04	91,58
598	1	2405	0,04	91,62
600	32	2437	**1,22**	92,84
670	1	2438	0,04	92,88
687	1	2439	0,04	92,91
688	1	2440	0,04	92,95
700	16	2456	0,61	93,56
714	1	2457	0,04	93,60
735	1	2458	0,04	93,64
760	1	2459	0,04	93,68
768	1	2460	0,04	93,71
772	1	2461	0,04	93,75
781	1	2462	0,04	93,79
796	1	2463	0,04	93,83
800	13	2476	0,50	94,32
833	2	2478	0,08	94,40
900	10	2488	0,38	94,78
976	1	2489	0,04	94,82
988	1	2490	0,04	94,86
989	1	2491	0,04	94,90
1000	50	2541	1,90	96,80
1024	1	2542	0,04	96,84
1100	1	2543	0,04	96,88
1106	1	2544	0,04	96,91
1200	1	2545	0,04	96,95
1287	1	2546	0,04	96,99
1295	1	2547	0,04	97,03
1300	1	2548	0,04	97,07
1343	1	2549	0,04	97,10
1368	1	2550	0,04	97,14
1372	1	2551	0,04	97,18
1400	1	2552	0,04	97,22
1417	1	2553	0,04	97,26
1421	1	2554	0,04	97,30
1423	1	2555	0,04	97,33
1448	1	2556	0,04	97,37
1472	1	2557	0,04	97,41
1500	6	2563	0,23	97,64
1516	1	2564	0,04	97,68
1557	1	2565	0,04	97,71
1642	1	2566	0,04	97,75
1645	1	2567	0,04	97,79
1751	1	2568	0,04	97,83
1890	1	2569	0,04	97,87
1912	1	2570	0,04	97,90
1954	1	2571	0,04	97,94
1956	1	2572	0,04	97,98
2000	14	2586	0,53	98,51
2130	1	2587	0,04	98,55
2300	1	2588	0,04	98,59
2301	1	2589	0,04	98,63
2358	1	2590	0,04	98,67
2600	2	2592	0,08	98,74
2700	3	2595	0,11	98,86
2800	2	2597	0,08	98,93
2840	1	2598	0,04	98,97
2854	1	2599	0,04	99,01
2857	1	2600	0,04	99,05
2949	1	2601	0,04	99,09
2970	1	2602	0,04	99,12
2975	1	2603	0,04	99,16
3000	4	2607	0,15	99,31
3190	1	2608	0,04	99,35
3242	1	2609	0,04	99,39
3270	1	2610	0,04	99,43
3331	1	2611	0,04	99,47
3340	1	2612	0,04	99,50
3390	1	2613	0,04	99,54
3449	1	2614	0,04	99,58
3500	1	2615	0,04	99,62
3530	1	2616	0,04	99,66
3650	1	2617	0,04	99,70
3750	1	2618	0,04	99,73
3770	1	2619	0,04	99,77
3893	1	2620	0,04	99,81
4000	2	2622	0,08	99,89
4784	1	2623	0,04	99,92
5255	1	2624	0,04	99,96
6000	1	2625	0,04	100,00

Number of order-lines = 2625

Tally for Discrete Variables: Pin

PIN	Count	CumCnt	Percent	CumPct
1	**2**	**2**	**0,09**	**0,09**
2	**40**	**42**	**1,85**	**1,94**
3	**5**	**47**	**0,23**	**2,17**
4	**241**	**288**	**11,13**	**13,30**
5	**13**	**301**	**0,60**	**13,90**
6	**27**	**328**	**1,25**	**15,14**
7	**4**	**332**	**0,18**	**15,33**
8	**36**	**368**	**1,66**	**16,99**
9	**2**	**370**	**0,09**	**17,08**
10	**167**	**537**	**7,71**	**24,79**
12	21	558	0,97	25,76
14	3	561	0,14	25,90
15	3	564	0,14	26,04
16	8	572	0,37	26,41
17	1	573	0,05	26,45
18	5	578	0,23	26,69
20	**342**	**920**	**15,79**	**42,47**
23	1	921	0,05	42,52
24	7	928	0,32	42,84
25	20	948	0,92	43,77
26	1	949	0,05	43,81
27	3	952	0,14	43,95
28	1	953	0,05	44,00
29	1	954	0,05	44,04
30	**141**	**1095**	**6,51**	**50,55**
32	27	1122	1,25	51,80
33	2	1124	0,09	51,89
34	1	1125	0,05	51,94
35	1	1126	0,05	51,99
36	1	1127	0,05	52,03
38	1	1128	0,05	52,08
40	**111**	**1239**	**5,12**	**57,20**
46	1	1240	0,05	57,25
48	1	1241	0,05	57,29
49	1	1242	0,05	57,34
50	**187**	**1429**	**8,63**	**65,97**
60	**14**	**1443**	**0,65**	**66,62**
61	1	1444	0,05	66,67
62	2	1446	0,09	66,76
63	1	1447	0,05	66,81
64	1	1448	0,05	66,85
65	1	1449	0,05	66,90
66	5	1454	0,23	67,13
70	**14**	**1468**	**0,65**	**67,77**
71	2	1470	0,09	67,87
75	12	1482	0,55	68,42
80	**11**	**1493**	**0,51**	**68,93**
82	1	1494	0,05	68,98
85	1	1495	0,05	69,02
90	**4**	**1499**	**0,18**	**69,21**
100	**295**	**1794**	**13,62**	**82,83**
119	1	1795	0,05	82,87
120	1	1796	0,05	82,92
122	1	1797	0,05	82,96
135	1	1798	0,05	83,01
150	**5**	**1803**	**0,23**	**83,24**
155	1	1804	0,05	83,29
160	1	1805	0,05	83,33
193	1	1806	0,05	83,38
200	**119**	**1925**	**5,49**	**88,87**
209	1	1926	0,05	88,92
210	2	1928	0,09	89,01
214	1	1929	0,05	89,06
221	1	1930	0,05	89,10
227	1	1931	0,05	89,15
228	1	1932	0,05	89,20
250	**5**	**1937**	**0,23**	**89,43**
254	1	1938	0,05	89,47
255	1	1939	0,05	89,52
257	1	1940	0,05	89,57
266	1	1941	0,05	89,61
283	1	1942	0,05	89,66
300	**38**	**1980**	**1,75**	**91,41**
310	1	1981	0,05	91,46
319	1	1982	0,05	91,51
320	1	1983	0,05	91,55
332	1	1984	0,05	91,60
350	2	1986	0,09	91,69
360	1	1987	0,05	91,74
400	15	2002	0,69	92,43
437	1	2003	0,05	92,47
450	2	2005	0,09	92,57
472	1	2006	0,05	92,61
482	1	2007	0,05	92,66
494	1	2008	0,05	92,71
500	39	2047	1,80	94,51
503	1	2048	0,05	94,55
530	1	2049	0,05	94,60
545	1	2050	0,05	94,64
546	1	2051	0,05	94,69
548	1	2052	0,05	94,74
551	1	2053	0,05	94,78
553	1	2054	0,05	94,83
563	1	2055	0,05	94,88
570	1	2056	0,05	94,92
574	3	2059	0,14	95,06
581	1	2060	0,05	95,11
594	1	2061	0,05	95,15
600	20	2081	0,92	96,08
612	1	2082	0,05	96,12
614	1	2083	0,05	96,17
628	1	2084	0,05	96,21
633	1	2085	0,05	96,26
644	1	2086	0,05	96,31
650	1	2087	0,05	96,35
700	6	2093	0,28	96,63
709	1	2094	0,05	96,68
713	1	2095	0,05	96,72
740	1	2096	0,05	96,77
800	10	2106	0,46	97,23
824	1	2107	0,05	97,28
900	7	2114	0,32	97,60
997	1	2115	0,05	97,65
998	1	2116	0,05	97,69
1000	18	2134	0,83	98,52
1099	1	2135	0,05	98,57
1100	1	2136	0,05	98,61
1101	1	2137	0,05	98,66
1200	1	2138	0,05	98,71
1250	5	2143	0,23	98,94
1295	1	2144	0,05	98,98
1300	1	2145	0,05	99,03
1352	1	2146	0,05	99,08
1355	1	2147	0,05	99,12
1500	3	2150	0,14	99,26
1507	1	2151	0,05	99,31

1689	1	2152	0,05	99,35
1808	1	2153	0,05	99,40
1829	1	2154	0,05	99,45
1838	1	2155	0,05	99,49
1899	1	2156	0,05	99,54
1959	1	2157	0,05	99,58
1978	1	2158	0,05	99,63
2000	5	2163	**0,23**	99,86
2064	1	2164	0,05	99,91
2219	1	2165	0,05	99,95
2500	1	2166	0,05	100,00

Number of order-lines = 2166

Tally for Discrete Variables: Cone Tube 2.5mm

Cone tub 2.5mm	Count	CumCnt	Percent	CumPct
1	**143**	**143**	**4,28**	**4,28**
2	**167**	**310**	**5,00**	**9,28**
3	**193**	**503**	**5,78**	**15,06**
4	**102**	**605**	**3,05**	**18,12**
5	**259**	**864**	**7,76**	**25,88**
6	**194**	**1058**	**5,81**	**31,69**
7	**29**	**1087**	**0,87**	**32,55**
8	**62**	**1149**	**1,86**	**34,41**
9	**4**	**1153**	**0,12**	**34,53**
10	**584**	**1737**	**17,49**	**52,02**
11	8	1745	0,24	52,26
12	93	1838	2,79	55,05
13	7	1845	0,21	55,26
14	13	1858	0,39	55,65
15	73	1931	2,19	57,83
16	38	1969	1,14	58,97
17	3	1972	0,09	59,06
18	10	1982	0,30	59,36
19	1	1983	0,03	59,39
20	**342**	**2325**	**10,24**	**69,63**
21	1	2326	0,03	69,66
22	2	2328	0,06	69,72
23	1	2329	0,03	69,75
24	8	2337	0,24	69,99
25	36	2373	1,08	71,07
26	3	2376	0,09	71,16
27	1	2377	0,03	71,19
28	26	2403	0,78	71,97
29	2	2405	0,06	72,03
30	**120**	**2525**	**3,59**	**75,62**
31	1	2526	0,03	75,65
32	7	2533	0,21	75,86
33	2	2535	0,06	75,92
34	3	2538	0,09	76,01
35	4	2542	0,12	76,13
36	2	2544	0,06	76,19
37	1	2545	0,03	76,22
38	1	2546	0,03	76,25
39	1	2547	0,03	76,28
40	**54**	**2601**	**1,62**	**77,90**
42	1	2602	0,03	77,93
44	1	2603	0,03	77,96
45	1	2604	0,03	77,99
47	2	2606	0,06	78,05
48	5	2611	0,15	78,20
50	**157**	**2768**	**4,70**	**82,90**
51	1	2769	0,03	82,93
52	2	2771	0,06	82,99
53	3	2774	0,09	83,08
54	3	2777	0,09	83,17
55	1	2778	0,03	83,20
56	2	2780	0,06	83,26
58	1	2781	0,03	83,29
59	1	2782	0,03	83,32
60	**118**	**2900**	**3,53**	**86,85**
61	1	2901	0,03	86,88
62	1	2902	0,03	86,91
64	1	2903	0,03	86,94
66	2	2905	0,06	87,00
69	3	2908	0,09	87,09
70	**3**	**2911**	**0,09**	**87,18**
72	1	2912	0,03	87,21
73	1	2913	0,03	87,24
75	2	2915	0,06	87,30
76	1	2916	0,03	87,33
88	1	2917	0,03	87,36
90	**1**	**2918**	**0,03**	**87,39**
92	2	2920	0,06	87,45
96	1	2921	0,03	87,48
98	3	2924	0,09	87,57
100	**97**	**3021**	**2,91**	**90,48**
120	3	3024	0,09	90,57
124	1	3025	0,03	90,60
128	1	3026	0,03	90,63
130	1	3027	0,03	90,66
138	5	3032	0,15	90,81
140	1	3033	0,03	90,84
150	13	3046	0,39	91,22
165	1	3047	0,03	91,25
171	1	3048	0,03	91,28
180	1	3049	0,03	91,31
188	1	3050	0,03	91,34
195	1	3051	0,03	91,37
198	1	3052	0,03	91,40
200	50	3102	1,50	92,90
203	1	3103	0,03	92,93
205	3	3106	0,09	93,02
208	1	3107	0,03	93,05
210	1	3108	0,03	93,08
220	2	3110	0,06	93,14
224	1	3111	0,03	93,17
250	8	3119	0,24	93,41
255	1	3120	0,03	93,44
258	2	3122	0,06	93,50
260	1	3123	0,03	93,53
293	1	3124	0,03	93,56
300	41	3165	1,23	94,79
320	1	3166	0,03	94,82
322	1	3167	0,03	94,85
330	1	3168	0,03	94,88
340	1	3169	0,03	94,91
350	3	3172	0,09	95,00
356	1	3173	0,03	95,03
362	1	3174	0,03	95,06
376	1	3175	0,03	95,09
400	12	3187	0,36	95,45
409	1	3188	0,03	95,48
430	1	3189	0,03	95,51
431	1	3190	0,03	95,54
440	1	3191	0,03	95,57
450	5	3196	0,15	95,72
454	1	3197	0,03	95,75
458	1	3198	0,03	95,78
474	1	3199	0,03	95,81
482	1	3200	0,03	95,84
495	1	3201	0,03	95,87
500	46	3247	1,38	97,24
502	1	3248	0,03	97,27
505	1	3249	0,03	97,30
520	1	3250	0,03	97,33
538	1	3251	0,03	97,36
551	1	3252	0,03	97,39
552	1	3253	0,03	97,42
561	1	3254	0,03	97,45
569	1	3255	0,03	97,48
588	1	3256	0,03	97,51
600	2	3258	0,06	97,57
652	1	3259	0,03	97,60
668	2	3261	0,06	97,66
696	1	3262	0,03	97,69

700	6	3268	0,18	97,87
750	4	3272	0,12	97,99
761	1	3273	0,03	98,02
772	1	3274	0,03	98,05
797	2	3276	0,06	98,11
800	6	3282	0,18	98,29
973	1	3283	0,03	98,32
1000	27	3310	0,81	99,13
1004	1	3311	0,03	99,16
1032	1	3312	0,03	99,19
1062	1	3313	0,03	99,22
1147	1	3314	0,03	99,25
1242	1	3315	0,03	99,28
1258	1	3316	0,03	99,31
1314	1	3317	0,03	99,34
1349	2	3319	0,06	99,40
1450	1	3320	0,03	99,43
1457	1	3321	0,03	99,46
1473	1	3322	0,03	99,49
1500	4	3326	0,12	99,61
1523	1	3327	0,03	99,64
1546	1	3328	0,03	99,67
1548	1	3329	0,03	99,70
1640	1	3330	0,03	99,73
1683	1	3331	0,03	99,76
1757	1	3332	0,03	99,79
1806	1	3333	0,03	99,82
1862	1	3334	0,03	99,85
1934	1	3335	0,03	99,88
2000	3	3338	0,09	99,97
2815	1	3339	0,03	100,00

Number of order-lines = 3339