Acknowledgement

With this Master thesis we complete the last stage in our Master of Science degree in Mechanical Engineering. The thesis is conducted at the department of Operational Development at Alfa Laval Lund AB and at the division of Production Management at the Faculty of Engineering at Lund University. Working with this thesis has been both interesting and given us valuable knowledge and experience about inventory management.

We are grateful to Alfa Laval for giving us this interesting assignment. We want to give a special thank to Richard Persson, our supervisor at Alfa Laval, who have given us a lot of help during our work. We also want to thank Martin Axelsson, Åke Skarstam, Peter Persson, Anders Granelli and Håkan Johansson for given us valuable information and help along the way.

At Lund University we would like to thank our supervisor Stefan Vidgren and adjunct professor Stig-Arne Mattson for their interest in our work, their support and guidance.

Ultimately we hope that this thesis will contribute with some valuable information to improve the inventory management at Alfa Laval's spare part DC's.

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Abstract

Title- Item classification for spare parts at Alfa Laval

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Key words- Item classification, spare parts, benchmarking, inventory management, ABC

Problem description- To decide what spare part item that should be kept in stock or not Alfa Laval, in the year of 2002, introduced a classification method based on picking frequency. Now it is time to make an overhaul of this method. Many different parameters are involved and Alfa Laval would like to have an evaluation of how their setup performs in comparison with other companies, universities and our own ideas.

Purpose- The main purpose of this master thesis is to make an overhaul of the present classification concept at Alfa Laval's DC's for spare parts. Another purpose is to increase customer satisfaction and to reduce or keep cost.

Method- Our approach in this thesis has been to do several cross section approaches. This means that several setups and differences of data have been compared with each other. We have gathered our data from interviews, questionnaires and observations performed with co-workers at Alfa Laval but also from theory and other companies.

Conclusions- We recommend Alfa Laval to keep more of the items in stock. This can be made without an increasing of costs if a new classification system and ABC method based on several criteria's is implemented. To improve the system further, we recommend Alfa Laval to introduce certain

limitations to lower the inventory levels. These limitations mainly comprise the order quantities and SS.

Sammanfattning

Titel-	Klassificering av Alfa Lavals reservdelssortiment.
Författare-	Ola Magnusson & Erik Frödå
Handledare-	Richard Persson, Project Manager, Alfa Laval AB Lund Stefan Vidgren, Licentiat, Institutionen för teknisk ekonomi och logistik vid Lunds Tekniska Högskola.
Nyckelord-	Klassificering, reservdelar, benchmarking, lagerstyrning, ABC
Problemformulering	För att bestämma vilka reservdelar som ska vara lagerlagda eller ej, introducerade Alfa Laval under 2002 ett klassificeringssystem som är baserat på plockfrekvens. Det är nu dags för en översyn av detta system. Många olika parametrar är inblandade och Alfa Laval skulle vilja få en utvärdering på hur väl deras metod står sig i jämförelse med andra företags, universitets och våra egna metoder.
Mål-	Huvudmålet med detta examensarbete är att göra en översyn av det nuvarande klassificeringskonceptet på Alfa Lavals distributionscenter för reservdelar. Ett annat mål är att öka kundernas belåtenhet och samtidigt minska eller bibehålla kostnadsnivån.
Metod-	Vi har valt att genomföra detta examensarbete med flera tvärsnittsansatser. Med detta menas att vi har jämfört många olika klassificeringsmetoder och deras olikheter av data med varandra. Vi har samlat underlag för våra bedömningar genom intervjuer, observationer och frågeformulär. Detta har mestadels gjorts på Alfa Laval men också på andra företag och genom studier inom teoretisk litteratur på området.
Slutsats-	Vi rekommenderar Alfa Laval att ha större del av sitt sortiment i lager. Detta kan göras utan ökade kostnader genom ett nytt sätt att klassificera, där fler kriterium än plockfrekvensen tas hänsyn till. För att

förbättra systemet ytterligare, rekommenderar vi att Alfa Laval inför begränsningar för att minska sina lagernivåer. Begränsningarna omfattar huvudsakligen orderkvantiteter och säkerhetslager.

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1. Introduction

The introduction chapter first contains a short description of the background to the problem. It continues with purposes, problem discussion, directives and delimitations.

1.1. Background

Alfa Laval is a company that develops, produce and sell products for heat transferring, separation and fluid handling on a worldwide market. The after sales market represents 25 % of their revenues.

In the year of 2002 Alfa Laval introduced a new classification system for their spare part inventory. Before this, the spare part supply system had been built up by multiple small warehouses located at the sales companies all over the world with a few larger centralized ones to supply them. In 2002 the number of warehouses was cut down and the world was divided up to three main business areas supplied by a few larger distribution centres (DC). Before 2002 there was no clear system that decided what should be kept in stock or not. The new system are based on that the products are divided in three main classes: stocked items (SI), non stocked items (NI) and request items (RI). Which class the items are assigned to depends on how many order lines (picks) the item have had during the last year.

After a few years Åke Skarstam and Richard Persson at the department of Operations Development thought that it was time to make a evaluation and perhaps further develop the classification system and worked out a specification for a master thesis. In this specification they also included what effect changes of some of the inventory level parameters would have and how universities and other companies handle similar situations.

Based on this specification we started to write our master thesis in September 2005.

1.2. Objectives

The main purpose of this master thesis is to make an overhaul of the present classification concept at Alfa Laval's DC's for spare parts. Another purpose is to increase customer satisfaction and to reduce or keep cost.

1.3. Problem discussion and directives

The main purpose of this master thesis is to make an overhaul of the present classification concept at Alfa Laval's DC's for spare parts. Another purpose is to increase customer satisfaction and to reduce or keep cost.

The aim of Alfa Laval's DC's is to supply the customers with a high level of service in a cost efficient way for both parties. There are an endless number of different possible combinations of approaches to reach this goal. Alfa Laval has chosen a quite simple inventory classification to decide if an item should be kept in stock or not. But even in a simple variant there are many parameters that can be more or less complex to control and understand.

Alfa Laval's specified goal for this project is to increase customer satisfaction and to reduce or keep cost. This goal should be achieved by analyzing five different questions.

- What will happen if Alfa Laval classify from the opposite way? E.g. 96 % of all picks will define items as SI, 97-99 % as NI and the rest as RI.

- What is the handling cost for items within each class?

- What is the effect of looking at statistics for more than 12 months?

- A lead time analyse. An item maybe does not need to be classified as SI if the lead time is short enough.

- Can Alfa Laval use other companies, the authors and universities ideas and if so, what are the plus and minus compared with our setup?

To be able to reach the goals we have included a lot of different factors that are essential to understand how complex the managing of a DC can be. When working with this thesis many different ideas has reached the surface and they are not always direct answers to the questions in the specification even though they are somehow connected. Often they are solutions which effect some of the parameters that affect the classification or the whole inventory management.

As a further step forward we have added a question that we think are relevant in this thesis.

- How can different parameters of the ABC-classification affect the cost and service of the items that are kept in stock?

This question aroused as a natural step of curiosity of what the effect could be when implementing different ideas one step further.

1.4. Delimitations

This thesis has almost only described issues that concern the spare part DC's of Alfa Laval. Some of the ideas and approaches of this thesis could perhaps be implemented on other parts of the supply chain, but this thesis just briefly takes them into account. The reason for this is that it would require a lot of more time than the 20 weeks we have for completing this thesis to get us acquainted with such a complex issue.

The data that has been used for calculations regarding the classification are solely from Alfa Laval's DC in Staffanstorp and therefore the results from our analyse may give different results for another DC.

This thesis does not make any final judgements of how much that should be kept in stock. The data which we have based our analyses on are far to insecure to make such a judgement. We have presented examples of how different levels can be decided and are letting the inventory management at Alfa Laval make their own evaluations.

We have not considered the effect the amount of stocked items has concerning the capacity of the DC. E.g. if doubling the number of items in stock it would most certainly not be enough room for them in the warehouse.

Finally we have made the assumption that the price of all items are constant, regardless of order quantity and if they are stocked or not.

2 Methodology

This chapter describes the methods that have been used when writing this thesis. The theory behind the chapter is mainly collected from different methodology literature.

2.1. Investigative approaches

In the planning and carrying out of an investigation it is important to do several decisions regarding the purpose, extent, what sources to use, what data gathering methods to use and which data that is necessary. (Lundahl, Skärvad, 1999)

The approach aims to the basic technical design of an investigation and indicates the depth in it. There are three ground categories in the approach. The *case study approach* represents a profound study of individual cases. To compare a group of cases at the same point of time is called a *cross section approach.* It is also possible to use a *time series approach*, which binds the investigation to the time development of one or several different occurrences. The choice of approach is often related to the investigators main interest in the analyzing and interpretation work.

There are several different dimensions in an investigation approach, were the first one refers to the depth of the investigation. The other dimension indicates whether the investigation is quantitative or qualitative and finally the third dimension shows if the investigation should be based on primary or secondary data. (Lekvall, Wahlbin, 2001)

Our approach in this thesis has been to do several cross section approaches. Different setups and differences of data have then been compared with each other.

2.2. Quantitative and qualitative methods

To use a quantitative method means that you are measuring something, e.g. size or length. This method concludes in numerical observations or lets itself being transformed into such. Experiments, observations, tests and question forms are some examples of this method. Often implementing quantitative examinations consists of three phases; the planning phase, the data collection phase and the analytic phase. The planning phase first step is to specify, with the help of a literature survey, the theories that are going to be investigated. When the specification is finished, a plan how to carry out the examination is made up. In the data collection phase one of the basic conditions to receive proper measurements is to strictly follow the made up plan. The analytic phase usually consists of one describing and one analytic step. The analyse helps to elucidate if the collected empirical material supports the theories that was specified in the planning phase. (Lundahl, Skärvad, 1999)

In most cases quantitative methods describes a few variables among a big representative selection. (Darmer, Freytag, 1995)

In our thesis we have used a quantitative method. We have basically followed the method as it is described above.

A qualitative method distinguishes of that it does not use figures. The primary purpose is to describe, analyse and understand individuals or groups, not to concentrate on proving if the information has a general validity or not. A pure qualitative examination does not care how the world is, but how it is being experienced. There for its mainly suitable for examine people's experiences of phenomenons like sickness, success, working organization or payroll systems. The examinations are based on what people have said, written, thought, done and the results of human decisions and acts. (Lundahl, Skärvad, 1999)

Just like in the quantitative method, the evaluation of the result is also important in a qualitative method. According to Knutsson (1998), the best way to do this is to work according to the criteria's reliability, transmutability and confirmation.

Qualitative methods investigate a large number of variables among a small number of respondents. (Darmer, Freytag, 1995)

To achieve a higher validity in the material of an examination, it is possible to use a combination of the two methods, a method triangulation. The combination has its downsides when a recurrence of the examination could be hard to achieve and a combination of methods is often more resource demanding. (Darmer, Freytag, 1995)

2.3. The Gathering of Data and Information

Data that already exist is often referring to secondary data, as someone else has gathered earlier for a different purpose. Data that you collect by yourself is called primary data, as you gather it yourself for a specific purpose. As the secondary data already exists and is simple and cheap to use, you try to use this type of information source as much as possible. If that is insufficient you have to complete it with primary data. (Eriksson & Wiedershiem-Paul, 1997)

2.3.1. Primary Data

These methods could be used separate or in combination and carried out at different rates of standardisation.

Interviews are methods of collecting data were an interviewer asks questions or raises a dialogue with the respondents. In every survey it is important to clarify what type of interview that will be carried out, how respondents should be identified and contacted, what interview technique that should be used and also how the interview material should be registered, compiled and analysed. It is also important to clarify the problem and purpose of the interview to the respondent in order to receive the desirable result. (Lundahl, Skärvad, 1997)

Observations imply that the investigator observes a course of events relevant to the investigation during a specific time. There are several types of observations that affect the observed object in different ways. The degree of participation by the observer can vary from very intensive interaction to non-existing interaction. If the observed objects are fully informed about the observation you talk about an open or undisguised observation. The opposite is a hidden or disguised observation. . (Eriksson & Wiedershiem-Paul, 1997)

Questionnaires are used to collect standardized information. Different respondents answer the same kind of questions, which can be formulated either with pre-made answers or with open possibilities to answer the question. The answers of a questionnaire are delivered in a written form. This makes it extra critical to formulate the right types of questions. You have to know exactly what types of answers you are searching for, since there is difficult to elucidate the answers afterwards. (Eriksson & Wiedershiem-Paul, 1997)

The primary data gathered in this thesis consist of interviews, questionnaires and observations performed mainly with co-workers at Alfa Laval. A benchmarking was carried out in the following way: A total number of 18 companies in the manufacturing industry were contacted by email with a request of participating in a benchmarking about spare part logistics. A question form with 23 questions were sent out and on which 11 of the companies answered. The questions were put together in cooperation with Richard Persson. The answers were gathered in an excel-file for easier comparison. All the participating companies received a copy of the benchmarking results when it was finished.

2.3.2. Secondary Data

Secondary data refers to data and information that is already documented by another person or organization and not collected or compiled mainly for our own investigation. It could refer to books, items, websites, databases, annual reports and different types of records and notes. Like in all forms of data gathering it is important to secure that the secondary materials precision, validity, reliability and relevance, are in relationship with the purpose and problem approach of the investigation. (Lundahl, Skärvad, 1997)

The analyses and data gathering will also be described further on in this thesis.

2.4. Statistical Credibility

To gain credibility, an investigation must measure what it is intended to. It must be free from randomised measurement faults and the statistical decline should be random.

2.4.1. Validity

The definition of validity defined by Eriksson & Wiedershiem-Paul (1997) is the ability of a measurement instrument to measure what it is intended to measure. There could be aspects to a subject that are not included in the measurement that perhaps needs to be included to give a trustworthy conclusion. E.g., if an intelligence test measure the ability to remember things, it has measured an important aspect on intelligence, but not all aspects.

It is appropriate to separate between two aspects of validity, internal- and external.

Internal validity relates to the conformity between concept and the operational (measurable) definitions of these. Thus it is possible to investigate the internal validity without collecting empirical data.

There are three types of validity problems: (Lundahl, Skärvad, 1997).

- The measurement tool only includes a part of the definition. The tool measures to little.
- The measurement tool only includes a part of the definition and in addition something else.
- The measurement tool includes the whole definition and in addition something else. The tool measures too much.

External validity relates to the conformity between the measurable values you receive by using an operational definition and the reality. The external validity is independent of the internal validity and it is not possible to evaluate it without knowing how the empirical data has been collected and how it looks like.

2.4.2. Reliability

Validity is the most important demand on a measurement tool. If the tool does not measure what it refers to, it does not matter if the measurement itself is any good. To determine if the measurement is good it has to be reliable. With reliability you concern the absence of randomised measurement faults. An investigation with good reliability is characterized of a measurement, which is not affected by who is performing it or under what circumstances it occur. Methods to increase reliability often involves different types of standardisation procedures that aims at securing that the measurement is implemented as identical as possible each time.
(Lundahl, Skärvad, 1997)

2.5. Source of errors

During the work process of a report there are many different potential sources of errors. These sources can have great impact of the quality of the report. If the source of errors is notified in the beginning of the work, actions can be taken to prevent errors from arising and give misleading results. Being aware of the source of errors and trying to prevent them implies a more correct and reliable result. (Lekvall & Wahlbin, 2001)

2.5.1. Objective error

If the purpose of the thesis is incomplete or wrongly defined the thesis can, even if it fulfils its purpose, be useless. The result of the thesis may not be relevant to the problem. It is of importance that the purpose of the thesis is carefully worked through and correctly formulated to obtain a useful result to the problem. In some cases our thesis are discussing situations that were not mentioned directly in the given specification. To avoid any misunderstanding the purpose of this thesis has several times been discussed with the supervisor at Alfa Laval. Therefore the final formulated purpose of this thesis corresponds well to the underlying problem and the results will be relevant.

2.5.2. Direction and content error

This error depends on the problem specification and arises if the problem has not been specified minute enough or specified in the wrong way. The delimitations might be inappropriate and give the thesis an incorrect direction. If the specification of the problem is incorrect the thesis might not fulfil the purpose. To ensure that this error did not arise, the objective of the thesis has been formulated in consultation with the supervisors at Alfa Laval.

2.5.3. Frame of reference error

Errors can arise in the search for references. All theories about the problem and the subjects might not be found. In this case important theories and references might not be used and evaluated. The theories and models found about the problem and subjects can be misunderstood. The theories found might e.g. be meant for another situation than the classification of spare part inventory. To prevent these errors from arising several different references have been used. We also analysed the suitability of each specific theory.

2.5.4. Data error

Different data has been used in the analyses. In these data several errors might be found. The data can be incorrect because of input errors as e.g. quantity, standard price and lead time. The data such as lead time can be out of date since the data in the enterprise systems only are updated now and then. The data used in the analysis might also be incomplete because of mistakes and misunderstandings during the transfer of data. The data might also be incomplete because some data such as lead time are missing for some components. In our thesis we have found many of those problems described above. These will be further explained in chapter 5.2 together with the data analyse.

2.5.5. Interview and benchmarking error

There can be different errors in the written and oral interviews with personnel at Alfa Laval and at the participating companies in the benchmarking. The respondent might not be able, or want to give us the correct information. This kind of problems likely occurs in this thesis but can not be fully prevented. These errors can not be prevented but has to be considered when the outcome is analysed. The questions in the interviews and benchmarking might be formulated in an inappropriate way. Because of this the questions might be misunderstood and the wrong answers given. The answers from the respondent might also be misunderstood or wrongly interpretive by the interviewer. The answers from the respondents have been considered as reliable and have not always been validated.

2.5.6. Analysis error

Errors in the thesis can occur that are related from data that has been incorrect processed or analysed. This can lead to that the wrong conclusions have been made. To avoid those errors the data and calculations has been independently checked by both authors.

2.5.7. Interpretation error

From the analyses it is possible that the wrong conclusions could have been drawn. The error can be related to lack of competence when converting the results into theoretical conceptions. To avoid this error the conclusions drawn from the analyses have been discussed with the supervisors at Alfa Laval.

2.6. Objectivity and confirmation

The personal reference frame of the investigator has an influence on the result of the examination. It is disputed among scientist if it is possible or even desirable to achieve objectivity in social scientific research. According to Knutsson (1998), qualitative investigation work, is the term *confirmation* often used instead of objectivity. That means if the investigators interpretations are logically consistent against the research material or not. In practical research situations it is however often a demand that the result should be purpose. According to Lundahl, Skärvad (1999), it is important to realize that the word objectivity could have different meanings for different persons and situations, e.g. impartial, separation between facts and evaluations, multifaceted, complete. The investigator should be aware of his choice of perspective and evaluations that controls among others the formulation of the problem, method and conclusion and thereby report this in his description of the investigation process.

In this thesis we have tried to build our knowledge from as many sources as possible to keep up our objectivity. We have read and heard many different opinions of how things should be done during our time at Alfa Laval but we have tried not to adapt them in our analyse without carefully consideration.

It is always hard to find an outside reviewer whose competence is sufficient in the problem sphere, but we hope that the group of opponents of this thesis will secure our objectivity and confirmation in a satisfying way.

3 Theory

The purpose of this chapter is to give the reader knowledge about theories within inventory management which are of importance to this report.

3.1. Forecasting

There are two main reasons why an inventory control system needs to order items before the customer demands them. First, customers often require delivery in less then the replenishment lead time. Second, sometimes orders have to be made in batches instead of unit for unit due to e.g. high ordering cost. Once the forecast is established it is used to establish; order triggers, order quantities and SS levels. Other uses of forecast are to determine excess, surplus and inactive stock levels. All of this means that we need to look ahead and forecast the future demand. But to estimate the demand is not enough. We also need to estimate how uncertain the forecast is. If the forecast is more uncertain, a larger SS is needed. The difference between the forecasted demand and the actual demand is the forecast error. This is another important factor to estimate and is usually represented by the standard deviation or the Mean Absolute Deviation (MAD).

A suitable forecast method for inventory control typically involves a relatively short time horizon. It is seldom necessary to look more then one year ahead. There are several types of forecast techniques but the most common approach is based on extrapolation of historical data. This means that the forecast is based on previous demand data. The forecasting techniques are grounded on different statistical methods for analysis of time series. These forecasts are easy to apply and update in a computerized inventory control system with thousands of items.

Forecasts could also be based on other factors. It is common that the demand for an item depends on the demand on another item, e.g. an item is used as a component within another item. In this case it is suitable to first forecast the demand for the final product. Next a Material Requirements Planning-system (MRP-system) is used to obtain the demand for dependent items within the final product.

Several other activities could be considered when forecasting demand. Different market activities such as sales campaigns, introductions of new products, competing products from different companies, are factors that affects the forecast. In these cases historical data are no longer representative. It is difficult to take such factors in account in a computerized inventory control system. Instead adjustments have to be made manually in case of such events. Another way of forecasting is by looking at other dependencies. E.g. a forecast for the demand of ice cream could be based on the weather forecast. To forecast the demand of a spare part used e.g. in a machine, it is reasonable to assume that the demand for the spare part increase as the machine gets older.
(Axsäter, 1991)

3.1.1. Demand models

Extrapolation of historical data is the most common approach to forecast the demand. In practise this is very seldom done. With thousands of items to take into consideration the initial work does not to seem to be worth the effort. This means there is not enough historical data and instead a demand model is created intuitively. The general assumptions are very simple. (Axsäter, 1991)

Constant model

In this model the demand in different periods are represented by independent random deviations from an average. The average is assumed to be relatively stable over time compared to the random deviation.
(Axsäter, 1991)

$$x_t = a + \varepsilon_t$$

where

x_t = demand in period *t*
a = average demand per period (assumed to vary slowly),
ε_t = independent random (stochastic) deviation with mean zero

Trend model

In this model the demand assumes to decrease or increase systematically. The model is extended by also considering a linear trend. (Axsäter, 1991)

$$x_t = a + bt + \varepsilon_t$$

where

a = average demand in period 0
b = trend, that systematically decrease or increase per period (assumes to vary slowly)

Trend-seasonal model

Here a seasonal index F_t is introduced that decide the demand in period t. E.g. if F_t=1.2, this means that the expected demand in this period is 20% greater due to seasonal variations. If there are *T* periods in one year, we must require that for any *T* consecutive periods $\sum_{k=1}^{T} F_{t+k} = T$. By setting *b* = 0 in this model we obtain a constant-seasonal model.

$$x_t = (a + bt)F_t + \varepsilon_t$$

where

F_t = seasonal index in period *t* (assumed to vary slowly)

When forecasting it is important to understand that the independent deviation ε_t cannot be taken in account. This means that ε_t always has to be zero to do an accurate forecast. Consequently, if the independent deviations are large it is impossible to avoid large forecast errors. (Axsäter, 1991)

Moving average

The moving average demand method is based on the same principles as the constant method. Assume the same underlying demand structure. The independent deviation ε_t cannot be predicted so all we need to estimate is the average demand *a*. If *a* were completely constant, the best estimate would be to take the average of all observations of x_t. If we assume that *a* varies over time, the problem is solved by looking at the most recent values of x_t. The moving average is calculated by taking the average over the *N* most recent values of x_t. (Axsäter, 1991)

$$\hat{x}_{t,\tau} = \hat{a}_t = (x_t + x_{t-1} + x_{t-2} + ... + x_{t-N+1}) / N$$

Where

$\hat{a}_t$ = estimate of a after observing the demand in period *t*

$\hat{x}_{t,\tau}$ = forecast for period > *t* after observing the demand in period *t*.

Exponential smoothing

The result of this method is similar to the moving average method, but in this method the demand levels from past periods are weighted and affect the forecast differently. We assume a constant demand model and we estimate the parameter *a*. To update the forecast in period *t* the previous forecast and the most recent demand x_t is used.

$$\hat{x}_{t,\tau} = \hat{a}_t = (1 - \alpha)\hat{a}_{t-1} + \alpha x_t$$

where $\tau > t$ and

α = smoothing constant (0< α <1).

The value of parameter α is adjusted to historical data to obtain the best suitability.

The exponential smoothing method could also be extended to include both trends and seasonal variations. If the smoothing method includes trends we now have to estimate both the average demand *a* and the trend factor *b* just as in the trend model previously explained. If the method also includes seasonal variations the Winters trend-seasonal method, which is a generalisation of exponential smoothing with trend, could be used. In this case the seasonal index F_t has to be estimated as well. (Axsäter, 1991)

Correlated stochastic deviations

In the methods previously used the stochastic variations where assumed to be independent. This is a major simplification and it is easy to think of situations where this is not true. E.g. if there are only a few large customers we can sometime expect demand in consecutive periods to be correlated. If there is a high demand in one period it is reasonable to expect that the demand in the next periods will decrease. The opposite could also be true, if there is a high demand in one period this may lead to high demand in the following period. Forecasting techniques that can handle correlated stochastic demand variations and other more general demand processes has been developed by Box and Jenkins. (Axsäter, 1991)

3.1.2. Low-frequent items

The forecasting methods we have discussed so far can sometimes be inappropriate for low-frequent items. Assume e.g. that a demand normally arises twice a year but then concerns large quantities. If we use an exponential smoothing method the forecast will increase just after the demand occurs and then gradually decrease until next demand arises. This unwanted effect could be reduced by using a small smoothing constant, but then the forecast will react very slowly to demand changes.

A different and more attractive method is to only update the forecast in periods with positive demand. Two averages are then updated by exponential smoothing: the size of the positive demand and the time between to periods with positive demand. This gives a more stable forecast and also shows the demand structure in a better way. (Axsäter, 1991)

Another opinion is expressed by Sussams (1988). Many companies have a problem with excessive stock, which can be defined as stock which provides a considerable higher service level than what is desired. This problem is especially common for the slow-moving items. To forecast the demand for a very slow moving item is not an easy task. For fast moving products, the exponential smoothing method or regression analysis is used. These two methods will not give a good result when handling slow moving products because there is too few data to base the forecast on. Also it is very hard, or impossible, to see a trend in the demand. A better method in this case is the moving average (see chapter 3.1.1). This method is not as sensitive if the sales rate doubles or halves, which give a stabilising affect on the stock level control.

One way to keep the inventory levels down is to have a centralized stockholding. Then the amount of stock to cover the service-level is much less than having stocks dispersed in regional depots. Another advantage with keeping stockholding centralized is that there is more data to base the forecasting on. This is especially useful in the controlling of slow moving items. (Sussams, 1988)

3.1.3. A comparison between moving average and exponential smoothing method

The two most common methods to calculate a forecast today are the moving average method and the exponential smoothing method.

Stig-Arne Mattson (2004) has made a report where he makes a comparison between these two. The analyses and calculations have been made in Excel and are based on randomly generated periods of demand with and without influence of trends and season variability. The quality has been measured with MAD, systematic forecast deviation and degree of instability between periods.

There is a simple relation between the number of periods in the moving average and the α-value in exponential smoothing method if both methods have the same average age on the included demand data. This relation can be described as:

$\alpha = 2/(n+1)$

n= number of periods

The number of periods in moving average corresponds to the α-values in table 3.1.

α-value	**Number of periods**
0,05	39
0,1	19
0,2	9
0,3	6
0,4	4
0,5	3

Table 3.1. Number of periods and corresponding moving average values

With exponential smoothing, at a random demand without any trends or season variability's, a significant better forecast quality is maintained measured with MAD while using a α-value about 0,05. Regarding the systematic forecast deviation, the quality of the forecast is equivalent for different α-values. Also considering the degree of instability a α-value around 0,05 shows better result than higher α-values.

In demand-cases with a trend and a moderate varying demands around this trend, α-values around 0,2-0,4 gives the best quality of the forecast. If the demand varies a lot around the trend, α-values around 0,05-0,1 delivers a better result. The systematic forecast deviation diminishes with higher α-values, while the instability in the forecast increases with a higher α-value. When having season variability's in the demand, a very small α-value gives the best results.

When having a random demand without any trends or season variability's, a significant better quality of forecast measured in MAD with a moving average is maintained when a number about 18 periods is used. The authors of this thesis have also had a conversation with Stig-Arne about this and the 18 periods was the maximum number of periods that was investigated during his report. Stig-Arne thought that larger number of periods would give an even better result.

When having a low and very variable demand, a common spare part situation, a exponential smoothing with an α-value of 0,05 always seems to be preferable instead of a moving average irrespective of the number of periods. Regarding the systematic forecast deviation, the quality is similar for different number periods. Also concerning the forecast stability index, the quality of the forecast becomes better when more periods are included in the calculations.

3.2. Manual Forecasts

The forecasting methods we have discussed so far are all based on extrapolation of historical data. There are situations when these forecasting methods are not suitable. Sometimes we know that there is factors that affect future demand, but which have no affect on the previous demand. These types of factors are very difficult to take into consideration in a computerized forecasting system. Usually it is much simpler to let manual forecasts replace forecasts based on historical data in such situations. Examples of situations when manual forecasts could be considered includes the following: price changes, sales campaigns, conflicts that affects demand, new products without historical data and new competitive products on the market. (Axsäter, 1991)

3.3. Forecast errors and forecast control

Measurements of forecast errors are fundamental for all forecast control. Continuous measuring of forecast errors should therefore be a natural part of all forecast system. The purpose is partly to identify individual stochastic errors and also to identify systematically errors, i.e. that the forecast is systematically too high or too low. If the forecast is too low it might lead to stock outs and if it is too high it might lead to overproduction and increasing stock levels. The size off the forecast error also decides the size of the SS. (Mattson & Jonsson, 2003)

To determine the size of a SS it is not enough to know the mean of the future demand. You also need to know how uncertain the forecast is, e.g. how large are the forecast errors in general? In statistics the most common way of describing variations around the mean is trough the *standard deviation*:

$$\sigma = \sqrt{E(X-m)^2}$$

where X is the stochastic variable, m its mean and E refers to the expected value. Standard deviation is equal to the square root of the *variance*, σ^2. In connection with forecast errors another definition is used. By old tradition the *Mean Absolute Deviation* (MAD) is estimated. MAD is the mean value of the absolute deviation from the mean.

$$MAD = E|X-m|$$

The reason why MAD was estimated instead of σ was originally because of the simplified calculations. However this is not a problem today but the MAD-value is still used in most forecasting systems.

It is obvious that MAD and σ in most cases measures the same thing. If we assume that the forecast errors are normally distributed it is possible to show this simple relationship:

$$\sigma = \sqrt{\pi/2}\,MAD \approx 1.25\,MAD$$

This relationship is used in most forecasting systems, also in situations when the assumption that forecasts errors are normally distributed is not valid.

A low MAD-value is not itself a good enough measurement on high forecasting quality. A good forecasting method should also give small average forecast errors in the long run, i.e. the forecast should give a low value just as often as a high value compared with the real demand. If the forecast method works ideally the average forecast error should equal zero. (Axsäter, 1991)

3.4. Lead time

The time that passes from that a customer places an order until the order is delivered to the customer is called the lead time. If the lead time is tolerable or not is decided by the market and the characteristics of the product. (Aronsson, Ekdahl & Oskarsson, 2003)

3.5. Make to Order vs. Make to stock

3.5.1. Strategic logistics decision making

Logisticians must make strategic level decision in order to manage uncertainty, customer service and cost. Wanke & Zinn (2004) explores the relationship between three strategic level decisions and selected product, operational and demand variables.

- Make to order vs. make to stock.
- Push vs. pull inventory deployment.
- Inventory centralization vs. decentralization.

Strategic decisions are a function of product, operational and demand related variables such as delivery time, obsolescence, variation of sales and inventory turnover. E.g. Dell Computer uses a make to order system and pulls demand through by only manufacturing and distributing computers in response to a customer order. In this way the company maintains a minimal level of inventory. On the other hand Hewlett-Packard, a competitor of Dell, elects to manufacture products to stock based on a forecast. In this study Wanke & Zinn brings up earlier studies and compares them with result of their own analysis. The results shows that their analysis support earlier theories, which will be presented her.

There are six variables with reported relationship with the make to order vs. make to stock decision. *Process technologies* are either continuous or discrete. Make to order are more frequent in discrete process industries than in continuous process industries. This is because they are more flexible from a manufacturing point of view. If the risk of *obsolescence* for a product is large, the propensity towards make to order increases. This is because the risk of holding inventory is high and firms manage it by only producing sold items.

The *coefficient of variations of sales* is analogous to obsolescence. The *lead time ratio* is the quotient of the *delivery time* over the supplied lead time, which means how much time that is available to manufacture a product once it is sold. The smaller the time available, the more likely products will be made to stock. The greater the *perish ability* of the final product; the more likely that products are made to order to avoid loss of inventory. The study suggests that managers should focus on delivery time and coefficient of variation of sales as indicators of the make to order vs. make to stock decision.

The push decision moves products on the basis planning or forecasting, while the pull decision moves products based on demand. Since lower inventory levels are more likely to be achieved under pull rather then push decision, variables that affect the inventory risks and carrying costs may influence the pull decision.

Obsolescence and *delivery time* are linked to the pull decision, delivery time because firms may not need to forecast if delivery time is long.

Demand information visibility is the extent that actual demand information penetrates a supply change towards the initial supplier, also known as order penetration point. The idea is that companies rely on planning inventories in the absence of actual demand information.

A *high cost of good sold* equals a high amount of working capital required. This may lead to a pull decision because the expensive inventory is an incentive to react to demand rather than to plan and keep products in inventory.

Cost density, coefficient of variation of sales, inventory turnover and delivery time are variables that may affect inventory decentralization. The lower the cost density, the higher the pressure to keep transportation unit costs down. Freight consolidation, which spreads transport fixed costs, can be achieved with inventory decentralisation. Freight consolidation also impacts the time between two replenishments and because of this the inventory turnover falls. Short delivery times could also lead to inventory decentralization.

3.5.2. Simple and combined inventory policies, production to stock or to order?

In an inventory model three strategies can be applied. Either you decide between production to stock (s.S.), production to order (direct delivery), or production partly to stock and partly to order. Popp refers to this as *simple* or *combined inventory policies.* His study shows that the policy of direct delivery will be applied instead of the (s, S) when the holding costs are very high in relation to the setup costs. Then it is advantageous to hold no stock at all and to order each time when a demand occurs. This is true under some simplified conditions that, e.g. lead time for replenishments of stocks equals zero. The two simple policies can be combined so that larger demand values with lower probabilities are subjected to the policy of direct delivery and the smaller demand values. The conclusion is that in practise the combinations of two policies often occur when extreme demand values exist. (Popp, 1965)

3.6. Reordering systems

One of the questions to answer when managing inventories are: when is the right time to order? In the following text the most common strategies of reordering systems are described. From these strategies numerous of variants could be found but this thesis only describes the main strategies. Some of the terms often used in this part are expressed by Axsäter (1991) as:

Inventory position = stock on hand + outstanding orders – backorders

Inventory level = stock on hand – backorders

SS = SS, explained further in chapter 3.8.

3.6.1. (R,Q)-system

One of the most common reordering point systems (ROP-system) are the (R,Q)-system. It implies that an order of size Q is placed every time the inventory position reaches, or drops below, the reorder point level R. The system is often used with either a continuous or a periodic review approach. If the inventory position has reached far below the R-level it might be necessary to order a larger quantity then Q to raise the inventory level above R. The size of the order can then be multiplied with n to reach above R. This variant of an (R,Q)-system is called a (R,nQ)-system. The reorder point is expressed as:

$$R = \hat{x}_x + \text{SS}$$

Where $\hat{x}_x$ = Expected average demand during lead time.
(Axsäter, 1991)

If R is recalculated continuously when changes occur in demand or lead time, the system is called a floating reordering point system. Most common is to calculate R periodically e.g. one or a few times per year. (Mattson, 2004)

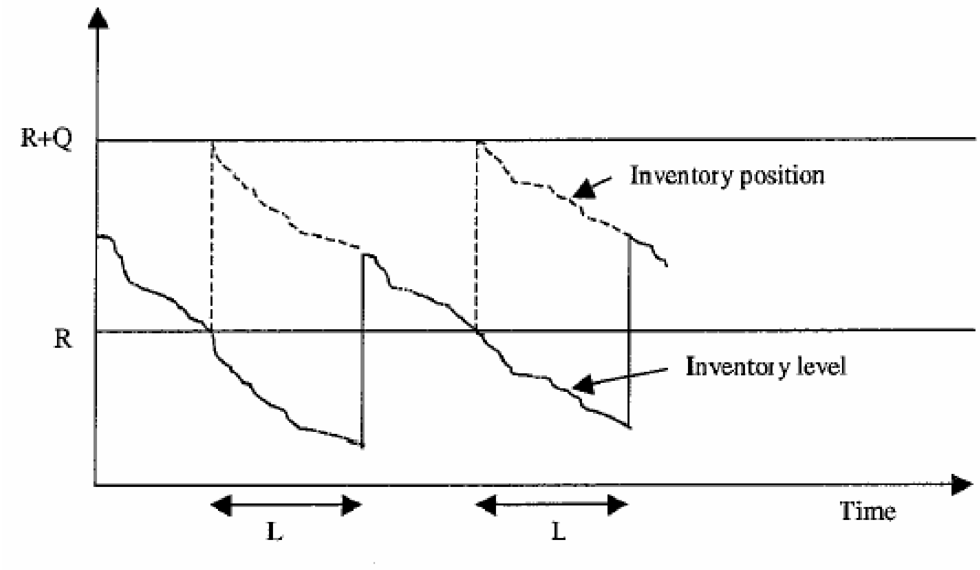

Figure 3.1. (R,Q) policy with continuous review continuous demand. (Axsäter ,1991)

3.6.2. (*s,S*)-system

The (*s,S*)-system is a form of a ROP-system where *s* and *S* is equivalent to a reordering point and to a pre-specified order-up-to level. When the inventory position level reaches, or falls below, the level *s* an order is placed for the quantity that is needed to reach the inventory position *S*. This quantity is thereby variable and not fixed. Similar to the (R,Q)-system, this system can be used with a continuous review approach or a periodic review approach. If a continuous review approach is used and the demand always is one item the (*s,S*)-system is equivalent to a (R,Q)-system.(Axsäter,1991)

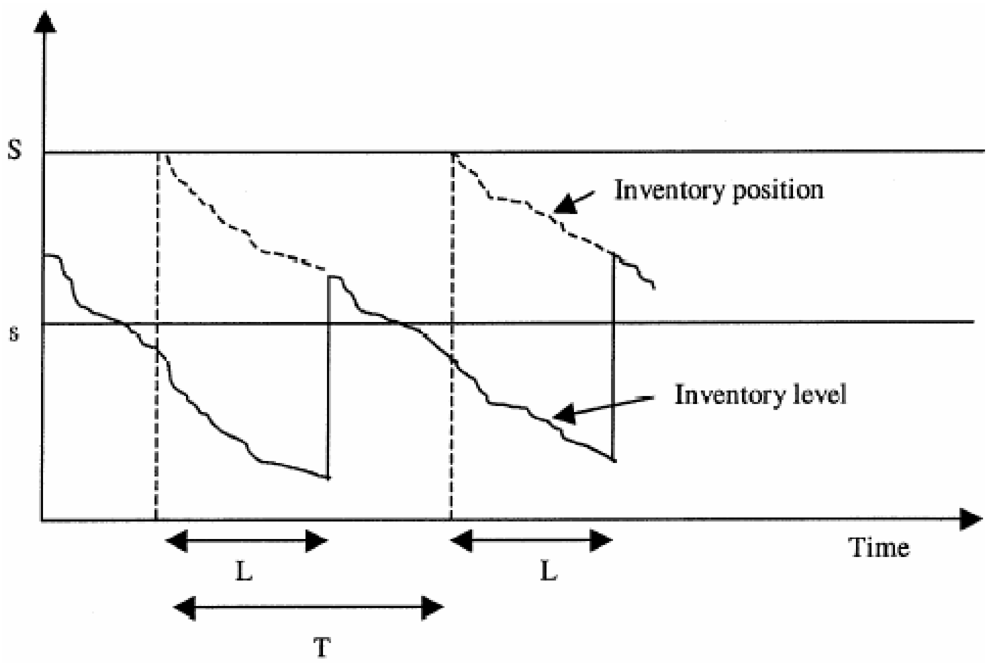

Figure 3.2. (*s,S*) policy, periodic review. (Axsäter, 1991)

3.6.3. S-system

To use a periodic review approach and have a fixed order period but a variable order quantity is called using an S-system. When working with an S-system the inventory position is at each inspection replenished up to the order-up-to level *S* regardless of if the inventory position has reached the reorder level *s* or not. (Axsäter, 1991)

3.6.4. MRP-system

A material requirements planning system (MRP-system) differs from ROP-systems and considers that items demands can be dependent of one another. The technique is especially useful for items with occasional big demands. When an item is used to produce another item the dependency is called to be vertical. When an item instead is attached to another product, e.g. a remote control for a stereo, the dependency is called horizontal.

MRP-planning makes following assumptions:

- A production program for the end-product has to be updated continuously. The program has to include all the needs that can affect the present purchase planning of components and raw material. The time horizon should therefore reach over the total lead time from purchase to finished item.

- External needs for items that are not end-products e.g. spare parts.

- A structure register, that is specifying the connections between different items, is required.

- Statistics of stock on hand, outstanding orders and backorders has to be available.

- Lead time for all the items has to be known.

(Axsäter, 1991)

3.7. Order Quantities

The ordered quantity should cover the need that exists or expects to exist. An obvious way of deciding the right ordering quantity is therefore to let the order correspond to every single need, which means that a new order is created for every need and the order quantity correspond to the size of the need. For a lot of reasons it is not always suitable or possible to manufacture or procure the quantity that is needed at every single occasion. The reasons could be of both technical and economical natures. Needs from several sources has to be collected to larger order quantities. (Mattson & Jonsson, 2003)

When we have decided to use larger order quantities, next question to answer will be how large order quantity (Q) should be ordered? In this chapter we describe the most relevant methods for deciding the right order quantity.

3.7.1. Fixed Order Quantity (FOQ)

This method is based on a fixed order quantity that is decided intuitive or from previous judgements. These judgments could be based on estimated annual consumption, price, order cost and obsolescence. The order quantity is judged at every re-order point and varies from time to time. The conditions under which the FOQ technique may be considered includes (Bernard, 1999), (Mattson & Jonsson, 2003):

- Quantity may be fixed at a standard container, unit load or shipping load.
- Limited shelf space.
- There may be a requirement to purchase a supplier’s standard production lot size.
- The company may elect to take advantage of a particular supplier price break.

3.7.2. Period Order Quantity (POQ)

A period order quantity covers the total demand for a specified number of periods. The time period remains constant while the order quantity varies since demand varies from period to period. This system is the opposite of the fixed order quantity system. Periods may be selected as shifts, days, weeks, etc. All demand during a period are added and ordered together. If there is no demand there is no order. A situation where periodic ordering is used could be when deliveries require a time period equal to the delivery or pickup cycle, e.g. a shipment that arrives in port once a month. (Bernard, 1999)

3.7.3. Economic Order Quantity (EOQ)

The most commonly used method to decide the right order quantity by mathematical calculations is the economic order quantity formula. It is also known as the square root formula or the Wilson formula after one of its creators. The calculations are based on a minimization of the total cost, which is a combination of the inventory holding cost and the ordering cost. The model is based on the following assumptions:
(Mattson & Jonsson, 2003)

- The demand per time unit (d) is constant and known.
- The lead time for inventory replenishment is constant and known.
- The ordering cost (A) or the setup cost is known and independent of the order quantity.
- The inventory holding cost (h) per unit and time unit is constant, known and independent of order quantity.
- The order quantity (Q) does not need to be an integer.
- The replenishment of inventory is instantaneous, i.e. the whole order quantity is delivered at the same time.
- No shortages are allowed.
- The price and cost for each unit is constant, known and independent of order quantity and place of purchase/manufacturing, i.e. no discount are allowed.

Since no SS is needed in this model the inventory level will vary over time as in Figure 3.3.

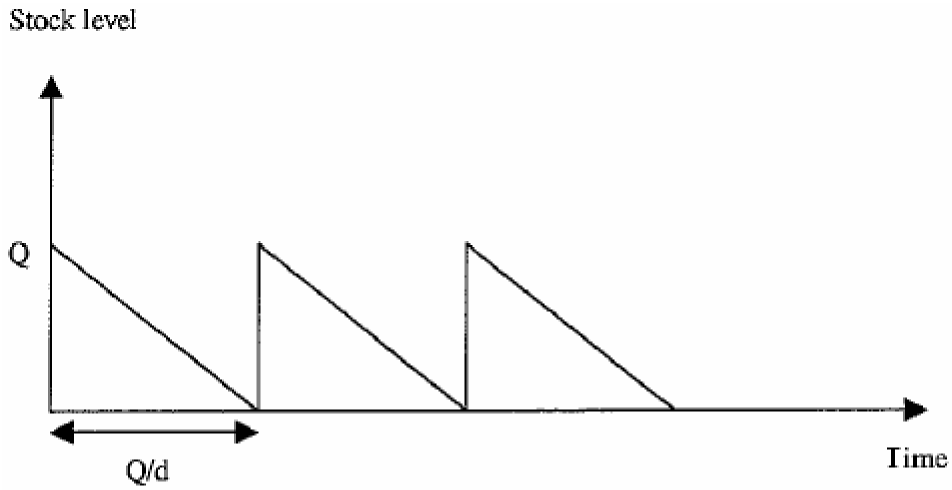

Figure 3.3. Development of inventory level over time. (Axsäter, 1991)

The total cost per time unit equals the holding cost and ordering cost. We Obtain. (Axsäter, 1991)

$$\text{Total Cost}\,(C) = \frac{Q}{2}h + \frac{d}{Q}A$$

The cost function can be minimized with respect to *Q*. The first order condition gives us

$$\frac{dC}{dQ} = \frac{h}{2} - \frac{d}{Q^2}A = 0$$

Solving for *Q* we obtain the economic order quantity:

$$Q^* = \sqrt{\frac{2Ad}{h}}$$

If we insert Q^* in the cost function we get:

$$C^* = \sqrt{\frac{Adh}{2}} + \sqrt{\frac{Adh}{2}} = \sqrt{2Adh}$$

This equations state that the economic order quantity is the point where the holding cost equals the ordering cost. This relation is illustrated in fig. 3.4.

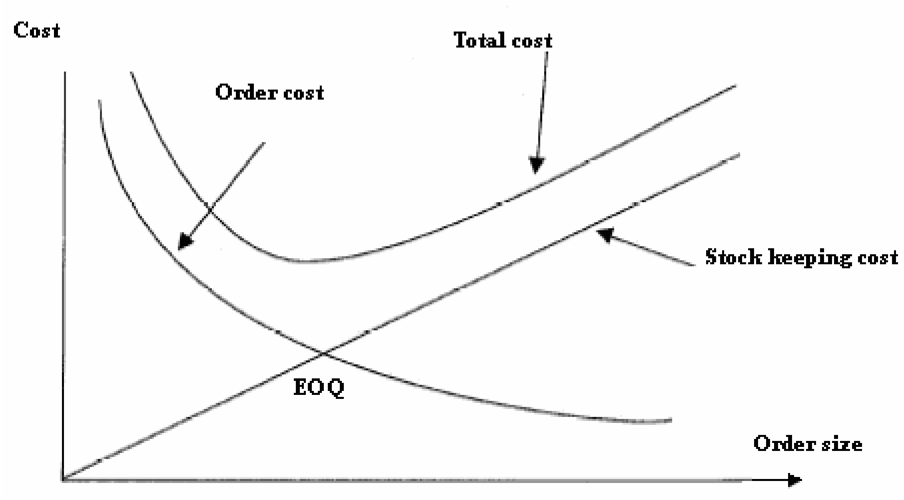

Figure 3.4. Connections between order quantity and ordering cost.
(Mattson & Jonsson ,2003)

As figure 3.4 shows, the total cost curve is very flat near its optimum. This means that total cost would not changes much if the order quantity differs from the optimal value. Thereby the economic order quantity is relatively insensitive for errors in the other parameters as well, e.g. demand or holding cost.

It exist a large amount of variations of the economic order quantity formula. Most of these variants are characterized by that some of the assumptions in the original formula has been modified or eliminated. This makes it possible to develop models that take other factors in considerations. E.g. finite production rate, quantity discounts and shortages. These variants will not be covered in this thesis.
(Mattson & Jonsson, 2003), (Axsäter, 1991)

3.7.4. Lot-for-Lot (L4L)

This method is the simplest and one of the most commonly used ways to determine the order quantity. The method means that the order quantity equals a unique demand. This method results in lower holding costs, since there is no inventory, but also higher ordering costs.

The L4L method may be considered in the following situations:

- Materials are purchased for a specific customer order, which cannot be applied to other orders.
- Parts may regularly undergo engineering revision changes over time. Using the L4L ensures that only sufficient quantities of each revision are ordered.
- The ability to bypass MRP and generate orders directly from the bill of material explosion process.
- When a part is being phased-out. This limits the risk of generating excess, surplus, inactive and obsolete inventory. (Bernard, 1999)

3.7.5. The Wagner-Whitin algorithm and the Silver-Meal heuristic

The EOQ model assumes constant demand. If demand varies over time there are different methods for calculating the right order quantity. The object is, like before to choose the order quantity that minimizes the sum of the ordering and the handling cost. The difference is that we can no longer expect the order quantity to be constant. These problems are solved by using Dynamic Programming. The total costs are calculated each period. For each period there are two alternatives, either to order the demand needed for the current or future periods, or already having it in stock from preceding periods. An optimal method for solving this problem is the Wagner-Whitin algorithm. Since the method comprises of extensive calculation it is seldom used in practice. Instead a simplified calculation that gives a solution close to optimum is used: The Silver- Meal heuristic. (Axsäter, 1991)

3.8. Safety Stock (SS)

When a suitable order quantity and reordering point is chosen it is time to find a proper SS level. The demand is often looked upon as normally distributed and deterministic, even though the actual demand is known to be stochastic. There is a risk that a stock out situation will occur during lead time if the deterministic demand becomes below the actual demand. On the other hand there is a risk of an ascending deterministic demand inventory if the actual demand is lower. The SS (SS) is used to cover those random variability's for the demand during lead time. How big the SS should be depends on how big the insecurity is in the deciding of the demand and how the service level (chapter 3.9) is set. There is also a possibility to base the SS on a shortage model instead of service level, but it is not the most commonly used method. (Axsäter, 1991)

3.9. Service level

The concept service level is an expression for ability to deliver to customer. (Mattsson, 1997)

There are a number of different pieces in the puzzle to make a customer satisfied. To make the whole service package work it is important to be aware of all of these pieces. Aronsson, Ekdahl & Oskarsson define seven pieces that could have different importance depending on the business-situation.

- Lead time- The time from reception of the order to delivery to the customer. This is often especially important when handling spare parts.

- Delivery reliability – To be able to deliver at the right time. The "lean-production" of today has often high set demands on this point.

- Delivery dependability – To be able to deliver the product in the right amount with the right quality.

- Information – When lead time is becoming more and more important it helps to exchange information to secure an ideal delivery.

- Customization – To be able to carry out the customer's particular demands. Perhaps have the product delivered in a specific way or with a faster transportation.

- Flexibility - Be able to adjust to suddenly changed conditions.

- Order fill ratio – The part of the orders, or order lines, which can be delivered direct from stock.

In addition to the enumerated factors above, Aronson, Ekdahl and Oskarsson (2003) present the cycle service level and the fill rate as factors that also are related the service level. These are connected to the stock outs in a company and together with the other seven they are evaluated by the customer. To make the customer satisfied it is important to keep a satisfactory level on all the factors. What satisfactory levels are, is up to the customer to define, though it is also equally important to estimate them from the companies point of view.

3.9.1. Different measures

Most of the service level factors are quite uncomplicated to monitor and evaluate, but the information, customization and flexibility factors are different. These three are so called soft factors and are rather hard to measure in numbers. Nevertheless, they are not of less significance than the other factors that affect the service level. (Aronsson, Ekdahl & Oskarsson, 2003)

The joint factor for the service level definitions are that they measure how well the company are satisfying different demands from the customer. For each definition it is possible to define a number of different targets. Each target must have a timeframe and it is easier to reach the wanted level with a longer time period. The timeframe must be carefully decided to suite the different situations. Using different timeframes can generate valuable information for the company about how things work in altered time perspectives. The company must set desirable target levels for the different factors to achieve and uphold. The target levels should be set so that they are attractive for new customers and satisfying for the old customers. (Hadley, 2004)

Delivery reliability
To measure the delivery reliability, the number of deliveries on time is divided with the total numbers of deliveries.

$$\textit{Delivery dependability (\%)} = \frac{\textit{Number of deliveries on time}}{\textit{Total number of deliveries}} * 100$$

How to define "on time" changes for different companies and depends on the type of product and the importance of the time factor in the market. In some cases an "on time"-delivery can differ with several days, while in some situations only an exact time is acceptable. (Aronsson, Ekdahl & Oskarsson, 2003)

Delivery dependability
It is important that the delivery contains the right product in the right quantity and quality. To measure this, the number of complete deliveries is divided by the total number of deliveries.

$$\textit{Delivery dependability (\%)} = \frac{\textit{Number of complete deliveries}}{\textit{Total number of deliveries}} * 100$$

Sometimes dependability and reliability are measured together. Just as in the reliability case, the way to define the dependability factor changes from different companies and products. Some companies accept certain differences in a quantity while some wants the exact amount. (Aronsson, Ekdahl & Oskarsson, 2003)

Order fill ratio (SERV2)
This factor describes the part of the orders that is on hand in stock at the time for ordering. There are two ways to measure the order fill ratio. Which one to chose depends on the customer. If the customer's production can start without a complete delivery the order fill ratio at order line level is suitable. It is measured as:

$$\textit{Order fill ratio (\%)} = \frac{\textit{Number of delivered order lines}}{\textit{Total number of order lines}} * 100$$

If the customer needs a complete order to start the production the order level is a better approach. It is measured as:

$$\textit{Order fill ratio (\%)} = \frac{\textit{Number of delivered orders}}{\textit{Total number of orders}} * 100$$

(Aronsson, Ekdahl & Oskarsson, 2003)

Cycle service level (SERV 1)
The cycle service level is also called $SERV_1$ and is defined by Axsäter (1991) as:

$$SERV_1\,(\%) = \left(\frac{Number\ ordercycles\ without\ shortage}{Total\ number\ of\ ordercycles}\right) * 100$$

This measure is used to examine the performance of an inventory. It is the most common and frequently used measure of service level of stocked items and is also often used when deciding the SS level in an inventory. A desirable service level is set by the company and then they can dimension the SS level with respect to demand characteristics. (Mattson, Jonsson, 2003)

3.9.2. SS calculated for a given SERV1.

$$SERV_1\,(\%) = \Phi\left[\frac{SS}{\sigma_x}\right]$$

Where

Φ = Normal Distribution
SS = Safety Stock
σ_x = standard deviation of demand during lead time. σ , the standard deviation, can be replaced with the MAD-value which is defined by:

$$\sigma = \sqrt{\frac{\pi}{2}} * MAD \approx 1{,}25MAD$$

The function *Φ* can not be systematically calculated but is easily accessible in tables. A cycle service level always corresponds to a safety factor *k*, see table 3.2, which is used when dimensioning the SS.

Service level	Security factor	Service level	Security factor
50%	0	90%	1,28
75%	0,67	95%	1,65
80%	0,84	98%	2,05
85%	1,04	99%	2,33

Table 3.2. SERV1 with corresponding safety factor. (Axsäter, 1991)

After determining the safety factor we obtain the safety stock as

$$SS = k\sigma_x$$

k = service factor based on SERV1

The standard deviation for demand during the lead time depends on both the uncertainties in demand and lead time.

$$\sigma_x = \sqrt{E(L)\sigma_d^2 + (E(d))^2\sigma_L^2}$$

σ_L = Standard deviation of lead time

This equation is often simplified with the assumption of a constant lead time, i.e. E(L)=L and σ_L=0

$$\sigma_x = \sigma_d L^{1/2}$$

(Axsäter, 1991)

3.9.3. SS calculated for a given SERV2.

$$SERV_2 = \left(G\left(\frac{(SS+Q)}{\sigma_x}\right) - G\left(\frac{SS}{\sigma_x}\right) + \frac{Q}{\sigma_x}\right)\frac{\sigma_x}{Q}$$

Where

$$G(v) = \int_v^\infty (x-v)\varphi(x)dx = \varphi(v) - v(1-\Phi(v))$$

(Axsäter, 1991)

3.9.4. Comparison between SERV1 and SERV2

The SERV1 and SERV2 are both service measures for stocked items. When dimensioning the SS, SERV1 is an easy tool to use though it has some significant disadvantages. It only considers the number of order cycles with stock out occasions and does not consider the stock out quantity. For a better understanding about the actual service level the customer fill rate (SERV2) can be used. SERV2 considers the stock out quantity that in most cases gives a more accurate view of the service to the customer. The problem with SERV2 is that it does not take the frequency into concern and that the actual demand often is hard to determine. Data on sales are often the only thing the companies have and are not the same as the actual demand. (Axsäter, 1991)

3.9.5. Shortage cost

When an item is not in stock for immediate delivery, it generates costs that are hard to define. How big the cost will be depends on the customer's ability to wait. If there is no hurry, then the delivery can be made at a later occasion without any actual costs. When the customer goes to another supplier because of the stock out the cost is the coverage margin for the affair. Often a stock out situation also generates a loss of goodwill amongst the customers.

When an item is used as a component in production a stock out can have very complex consequences. The lack of one item can stop the whole production chain and generate many extra costs that could be very hard to evaluate.

Shortage cost should be defined so that the real cost that arises is shown. If a lack of a spare part stops the production of a machine, the cost is proportional to the time that the machine stands still. The shortage cost could then be defined as: cost per unit and time unit. If the shortage is covered with overtime production it could be suitable to put the cost as an extra unit cost.

One of the benefits to know how high the shortages costs are, that there is a possibility to balance the shortage cost towards the capital holding costs. With that balance it is possible to optimize the customer service.
(Axsäter, 1991)

3.10. Differentiated control of deliveries into stock

Stig-Arne Mattsson (2005) has made some experiments concerning the adaptation and application of the classic stock control theories. The affects of differentiation when dimensioning the items order quantity and SS was especially studied with both theoretical analyse and simulation. The results can be summarized in following points:

- If an appropriate classification model is chosen, the differentiation of order quantities results in that the turnover stock can be reduced without increasing the ordering cost. This combined with the differentiation of the SS leads to overall reduced handling costs.

- To differentiate the SS with more than one dimension, e.g. combine two each one separately effective classification methods, resulted in most of the cases in a marginal or no improvement compared to using only one.

- The affect of differentiation of SS grows with increasing shortage costs, e.g. the value of differentiate the steering parameters is dependable of the size of the shortage costs. When the shortage cost is very small a differentiation can even lead to increased costs.

- The choice of the most suitable way to classify depends not on the size of the shortage cost but only of how big the decrease in the stock handling cost can be.

When differentiating of incoming delivery frequencies and thereby of order quantities, the most efficient way to classify for reducing the capital binding in the turnover stock is using the turnover value. The bigger the difference was in the amount of incoming deliveries between the different classes, the bigger the decrease in capital binding.

Based on the results from the different methods, the following guidelines can be set to be used for choosing the most suitable way to classify the differentiations:

Dimensioning method and shortage situation	**Best classification method**
% increase on lead time consumption and need for number of days. Shortage leads to lost sales with the shortage cost proportional to the value of each item.	Item value or turnover value
% increase on lead time consumption and need for number of days. Shortage leads to backorders with a constant shortage cost per incomplete order.	Picking frequency
Calculated from SERV1. Shortage leads to lost sales with the shortage cost proportional to the value of each item.	Incoming delivery frequency or turnover value
Calculated from SERV1. Shortage leads to backorders with a constant shortage cost per incomplete order.	Incoming delivery frequency or picking frequency
Calculated from SERV2. Shortage leads to lost sales with the shortage cost proportional to the value of each item.	Turnover value
Calculated from SERV2. Shortage leads to backorders with a constant shortage cost per incomplete order.	Picking frequency

Table 3.3. The best classification method depending on situation.

Olhager (2000) point out that if different items have very dissimilar demand patterns and picking frequency. This should also be considered when reclassifying, not only the turnover value of the items. He suggests a classification matrix which contains of turnover value in one of the dimensions and picking frequency in the other.

3.11. What impact does delivery time have in comparison with delivery time variations on the size of the SS?

The necessary SS level to reach a suitable service level is not only depending on the length of the delivery time but it also depends on how much the delivery time varies between orders. Which one of these two to reduce to lower the bonded capital in the SS depends among other things on how large the demand is and how much it varies. To what extent it pays off to lower the delivery time also depends on how much it varies. To be able to reduce the SS in an efficient way, it is essential that these connections are known and thereby could be taken in consideration.

Stig-Arne Mattson (2003) has written an item about how different circumstances should affect the choice of focus when deciding if lead time variations or lead time should be used to reach the best level for a SS. Concerning under which circumstances it is suitable trying to reduce the delivery time compared to diminishing the delivery time variations, following guidelines can be formulated.

- The use of a shorter delivery time for lowering the SS is most effective when reducing the delivery time for items with a small demand and a large demand variation, especially when the delivery time varies a lot. The smallest effect when shortening the delivery time is received with items that have a large demand and small demand variations, especially when the delivery time varies a lot.

- The use of a reduced delivery time variation for lowering the SS is most effective for items with a large demand and a small demand variation, especially if the delivery time is short. The smallest effect when reducing the delivery time variation is received with items that have a small demand and large demand variations, especially when the delivery time is short.

From these guidelines it can be concluded that if a reduction of the SS is wanted for an item with a very variable demand and with a high variation coefficient, i.e. a large ratio between the standard deviation and the medium demand, the primary measure should be to reduce the delivery time. These circumstances are common for items with a small turnover, e.g. spare parts. On the other hand, if the demand is fairly even with a low variation coefficient, the variations in delivery time should be the primary thing to reduce rather than the medium delivery time. These circumstances are common for items with a repetitive production.

Both of the guidelines also conducts to that if it is hard to reduce the lead time variations, but a safeguard is needed, then an intentional longer lead time can be set when dimensioning the SS to get this effect.

3.12. Postponement

The idea behind postponement is that risk and uncertainty costs are attached to the differentiation (form, place and time) of supplies that occurs during manufacturing and logistics operations. To the extent that parts of the manufacturing and logistics operations can be postponed until final customer assurance have been obtained, the risk and uncertainty of those operations can be reduced or fully eliminated.

The concept of logistic postponement is to uphold a full-line foreseeing inventory at one or a few strategic locations. This means to postpone changes in inventory location downward in the supply chain to the latest possible point.

The concept of manufacturing postponement is to keep the product in a neutral and non committed status as long as possible in the manufacturing process. This means to postpone differentiation of form and identity to the latest possible point.
(Pagh, Cooper, 1998)

3.13. Activity-Based Costing

The easiest way to account for fixed material cost is to calculate it as a percentage of the variable cost. Some companies still use this method today for calculating order costs. In the simplest case a single percentage factor is applied to all variable manufacturing costs, or two different percentages may be used for material cost and labour costs. (Schönsleben, 2000)

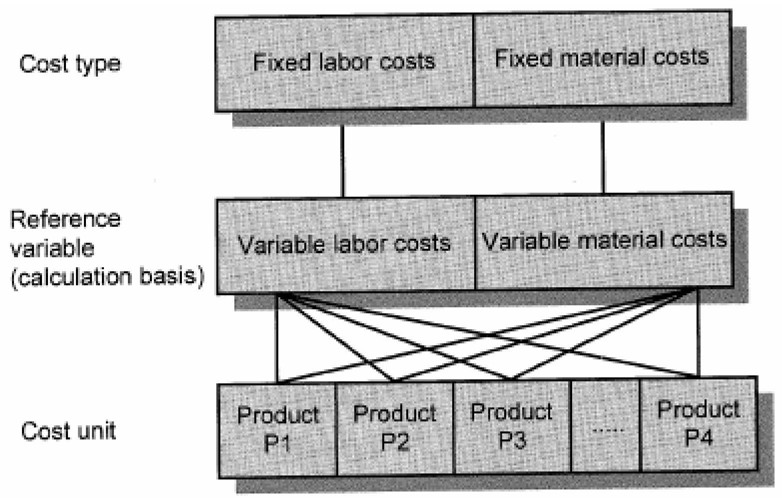

Figure 3.5. Apportioning fixed costs with traditional costing for two fixed cost types. (Schönsleben, 2000)

In contemporary companies, especially in manufacturing companies, the fixed cost is often considerably large in relation to the variable costs. This is particularly the case within the manufacturing function, where the fixed costs are extensive due to mechanisation, automation, robots and computerisation. (Olsson, Skärvad, 1995)

Other various fixed cost are: (Schönsleben, 2000)
- Material procurement and storage cost
- The cost of managing subcontracted operations
- Machinery, tool, production facility and infrastructure costs
- The cost of research, development, licensing, construction, process design, planning & control, etc.

When the fixed costs share of the total cost gets bigger, the difficulty of making a fair judgment of how to distribute the fixed cost increase, at the same time as the need for this increase. To find a solution to this problem is one of the main drivers of developing activity-based costing. The activity-based costing model aims at:

- Fixed cost should be linked to activities instead of cost carriers.
- Identifying the activity variables (cost drivers) for each activity.
- Achieving a costing model that distributes costs more correctly and fairly then possible in traditional accounting systems.

Instead of summing up the fixed cost the traditional way, using material-, production- and other general overhead costs, the fixed costs are summarised in different activities. Examples of activities could be construction, development, procurement, marketing, service, etc. In this way the precision in the accounting system increases. The cost carrier is replaced with an activity, which means that instead of looking at “where something is done”, you look at “what is done”. An activity could be a part of or the same thing as a cost carrier but could also range over several cost carriers.

For every activity a cost driver has to be defined. A cost driver is the reason why the costs of carrying out an activity falls or raises. Examples of cost drivers are, number of orders, number of order lines, number of items, number of new items, time, weight, etc.

Different products have different needs of the different activities. By using this model for cost-distribution you avoid the problem of over-debiting (the product carries a too large share of the fixed cost) or under-debiting (the product carries a too large share of the fixed costs) certain products. The summarized advantages of using an activity-based costing model are(Olsson, Skärvad, 1995):

- It creates better precision in the costing calculations and thereby also a better basis for pricing
- Increase the possibility to estimate what activities that are contributing to customer values and which is not.

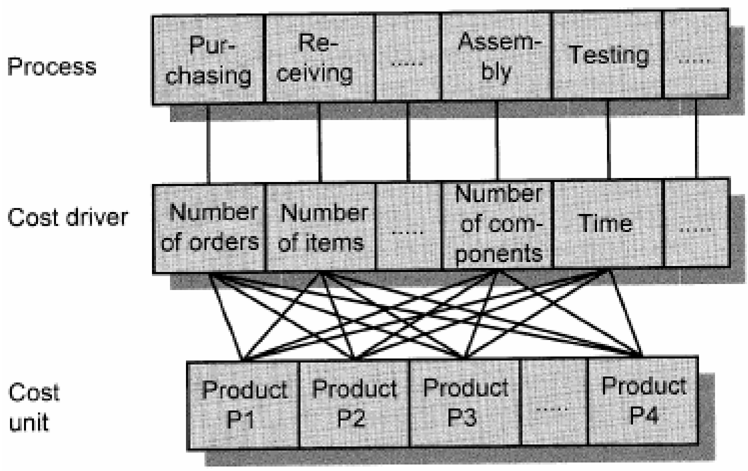

Figure 3.6. Apportioning fixed costs using the activity based costing principle. (Schönsleben, 2000).

An example of activity based costing could be found in appendix 2.

3.13.1 At what overhead level does Activity-based costing pay off?

Many accounting experts agree that activity-based costing can generate more accurate cost information then traditional costing. Companies with a large share of overhead costs in proportion to the total cost usually benefits from adopting ABC while companies with low overhead cost or a simple product line do not, because of the costs of implementation. In a company with negligible overhead cost compared with the total cost, misapplication of overhead would not be a concern. This leads to the question: At what point is it worthwhile for a company to make the switch from traditional to ABC costing?

In a study made by Vokurka and Lummus (2001) they suggest that if the overhead cost is 15% or more of total cost it appears that the more accurate costing with ABC would be beneficial. At overhead cost less then 15% a cost-benefit analysis would be appropriate to further investigate the situation. At lower levels companies with a wide range of products and identifiable activities would benefit from ABC. Companies with low manufacturing overhead costs and a static product mix may find that the cost to implement ABC exceeds the benefits.

3.14. Item classification

In most companies the number of items is very large. To manage perhaps 10000 items or more, supplied by several hundred of different suppliers and with thousands of customers is not an easy task. To achieve an acceptable control over each item in such a complex situation, a classification must be made. A classification of the items can be based on the volume, value of usage, time period coverage, usage rate or some other interesting or critical factor. To use several criterions often results in a better system than a classification based one just one criterion. (Aronsson, Ekdahl & Oskarsson, 2003)

3.14.1. Different classification methods

It is a common situation for companies today that the number of stock keeping units (SKU) is so large that it is practically impossible to set stock and service control guidelines for each and every item. This leads to that different items are grouped together and that control policies are set to include the whole group of items. (Cohen, Ernst, 1988)

There are today several ways and suggestions how to classify items. These methods are meant to classify primarily stocked items, but we claim that they also can include non-stocked items and thereby be used to decide what items that should and should not be kept in stock. Some of the methods will be described below.

The ABC method

It has been observed that for all types and sizes of companies a small number of products make up the largest portion of the turnover. (Schönsleben, 2000)

The most commonly used method for classifying inventory items are the Pareto, or the ABC-method. This method regards only the annual use value, which is the product of annual demand and average unit price and divides the items into three groups, A, B and C. Class A contains of 5 to 20 % of the stocked items which account for about 60 to 80 % of the total inventory value. Class B consist of 10 to 30 % of the stocked items that account for 15 to 30 % of the total inventory value. The low-value items are found in class C and represent 50 to 85 % of the stocked items. The most common way is to use these three classes but there is not a rule that says that there can't be more or less. As an example a D class can be used to represent the items that haven't been sold for the last year. (Aronsson, Ekdahl & Oskarsson, 2003)

The methods of materials management are different for each category. It is much more important to reduce the inventory stocks and goods in process for the A items than for the C items. Also, since A items are more limited in number it is much easier to have a close follow-up on them. Management orders A items in frequent small batches and places purchase orders only after intensive evaluation. Naturally leads all these measures to increased ordering and administrative costs.

It is important that C-items are always are available. It can under no circumstances be that items that are really cheap can postpone the delivery of a machine that may have a value of perhaps hundreds of thousands of dollars. Management releases the procurement orders very early, with plenty of margin as to quantity and time. This increases storage cost only slightly, since the items are inexpensive ones. The ordering costs for C items are low, since large quantities are ordered at one time. It may sometimes be possible to trigger orders automatically, without the intervention of a planner, by using a computer-controlled system.

The B items are generally handled with medium priority, between the above two extremes.

Since goods have different importance, depending on which type, most companies have separate ABC calculations for each type of item. This is especially important when the value added is great. In this case an ABC calculation for the entire product range would tend to put all the final products in the A-class and all the purchased items in the C-class. However, this is not the goal with the ABC approach. (Schönsleben, 2000)

ABC inventory classification with multiple-criteria weighted linear optimization.

ABC analysis can, according to Ramanathan (2004), only be effective when the inventory being classified is fairly homogeneous and the main difference between the items is the annual use value. But in practice it is not very common when even smaller companies often have thousands of items in stock and these needs not to be very homogeneous. Because of this there are many situations when other criteria than the annual use value should be taken into consideration when deciding the significance of an inventory item. Ramanathan calls this problem a multi-criteria inventory classification (MCIC) and suggest several criteria's that could be interesting to include. Some of those are: inventory cost, part criticality, lead time, commonality, obsolescence, substitutability, number of requests for the item in a year, scarcity, durability, reparability, order size requirement, stock ability, demand distribution and stock-out penalty cost.

Ramanathan (2004) propose a simple weighted linear optimization ABC-model to find a solution to the MCIC problem. It suggests that each criterion for every product is positively related to the importance level of the item. This means that the larger the score of an item in terms of the criterion, the bigger is the chance that the item will be classified as an A-class item. The score of each criterion will then be added together in a weighted function to the so called, optimal inventory score of the item. This indicates the importance level of the item and the weights are chosen so that the optimal inventories score for all the items are less or equal to one. A big advantage of this method is that it is very simple and is easily understood by inventory managers.

The model can be described as:

$$\text{Max } \sum_{j=1}^{J} v_{mj} y_{mj} = 1$$

This means that the weights are chosen so that the best item get an optimal inventory score that equals 1.

The other items therefore get an optimal inventory score that is less than, or maximum equals 1.

$$\sum_{j=1}^{J} v_{mj} y_{mj} \quad \leq 1 \text{, n = 1,2,…..,N}$$

$$v_{mj} \quad \geq 0 \text{, j = 1,2,….,J}$$

m = number of the item
J = number of criteria's
N = number of items
v_{mj} = Weight of the criteria
y_{mj} = the performance of each criteria of the item

These scores can then be used to classify the items. It is very unlikely that several items get the same optimal inventory score and if so, it does not cause any problems unless it happens two items that are right on the limit between two classes. E.g. the limit between A and B items.

The analytic hierarchy process (AHP)

A widely used and highly regarded decision-making technique is the AHP method. The AHP method is a powerful and flexible multi-criteria decision making tool for complex problems. The method makes it easier for the analysts to organise the important aspects of a problem into a hierarchical structure similar to a family tree. This means that every part of a problem is divided in sub-problems so that a complex problem is transformed to several simple ones. In the model inventory items are ranked based on several criteria, with weights assigned to each criterion. By reducing complex decisions to a series of simple comparisons and rankings, then synthesising the results, the AHP not only helps the analysts to make the best decision, but also presents a clear motivation for the choices made. The AHP procedure is available in decision making software packages from several software sellers. The method is described in the following four basic steps:

1) The criteria's that will be the base of the decisions are decided and placed in a hieratic order. Each criteria are built up by sub-criteria's which are also based on their different sub-criteria's and so on to the lowest level is reached.
2) The criteria's are weighted as a function of its importance to the higher level, starting at the bottom of the ladder. To simplify it, the AHP uses a pair wise comparison so that the analysts can concentrate easier. The verbal judgements are then translated into a score.

3) When the judgement matrix ($n \times n$) has been developed the normalized eigenvector of the matrix is calculated.
4) To evaluate the quality of the judgement, an inconsistency ratio I_R is calculated as:

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

$$I_R = \frac{CI}{RI}$$

CI = the consistency index of the matrix $n \times n$
$\lambda_{\max}$ = maximum eigenvalue of the matrix
RI = the corresponding average random value of CI for a random ($n \times n$) matrix

If $I_R \leq 0.1$, the judgement can be considered tolerable.

(Braglia, Grassi, Montanari, 2004)

Other methods

There are several other methods for classifying inventory. This thesis will only describe them shortly though.

Cohen and Ernst (1988), presents a classification method called the ORG method, that is a mix of statistical clustering procedures and operational restrictions that can use any relevant item attributes.

Genetic algorithm for multi criteria inventory classification (GAMIC) uses a genetic algorithm to learn the weights of criteria. Then these weights are applied in an ordinary AHP model. (Guvenenir, Erel, 1998)

The reliability centred maintenance (RCM) is a method to define a decision diagram that guides the analyst towards the best classification for each spare part taking several criteria's into consideration. (Braglia, Grassi, Montanari, 2004)

A multi-attribute decision making (MADM) technique is presented by Braglia, Grassi and Montanari (2004). They are applying an AHP method to solve a RCM decision diagram in an effective and accurate way.

The XYZ classification distinguishes items with regular or even constant demand (X items) from those with completely asymmetrical or unique demand (Z items). Y items lie between the two extremes. It can be used to establish whether essential materials management parameters should be calculated automatically (e.g. using forecast data) or set manually. (Schönsleben, 2000)

4 Empirics

This chapter contains all the information that we gathered from interviews and research at Alfa Laval and other companies during our preparatory work. The main purpose is to give the reader knowledge about the Alfa Laval organisation.

4.1. Presentation Alfa Laval

4.1.1 The Alfa Laval group

Alfa Laval's operations are based on leading global positions within the three key technologies, heat transfer, separation and fluid handling. Continuous development of products is required to strengthen competitiveness. Annually, about 2.5 % of sales are invested in research and development, which results in 25-30 new products each year.

Figure 4.1. Gustav de Laval (Annual report, 2004)

Alfa Laval's growth strategy is based on its growing faster than the competitors. The company intends to grow while at least maintaining its profitability. The aim is to achieve an annual average growth rate of 5 percent over a business cycle.

In 2004, Alfa Laval generated sales of SEK 15.0 billion (13.9). In five years, Alfa Laval's operating margin rose from 7.7 % (2000) to 11.3 % (2004). The target is a margin of 10–13 %. During 2004, Alfa Laval generated an operating cash flow of 1,118 million SEK, corresponding to 7.5 % of consolidate sales.

Alfa Laval's products are sold in approximately 100 countries, of which 55 through its own sales organizations. About 50 % of sales are in Europe, 30 percent in Asia and 20 % in North and South America. The company has 20 large production units (12 in Europe, six in Asia and two in the US), and 70 service centres. Alfa Laval has about 9,400 employees and the largest numbers of employees are in Sweden (1,899), Denmark (1,126), India (1,045), the US (826) and France (583). The president and CEO of Alfa Laval is Lars Renström.
(Annual report, 2004)

4.1.2. Product range

- Heat exchangers (44 % of sales). Their purpose is to heat, cool, freeze, ventilate, evaporate, and consolidate fluids. There are a wide range of products and the customers are found in many different types of industries such as chemical, food processing, oil and gas production, power generation and marine industries and for heating and ventilation of buildings.
- Valves-, pumps- and tank-products (19 % of sales). They are intended for clean and efficient transportation of fluids.
- Separation products such as centrifuges and filtration (30 % of sales). Their function is to separate either different liquids from each other or particles from liquids. They are for example used in the food industry or on the oil platforms to separate oil from water.

In Lund is Alfa Laval producing plate heat exchangers. There are several other different types of exchangers but they are not relevant for this thesis. For the same reason will not the other products be described further.

4.1.3. Plate heat exchanger (PHE)

A piece of equipment that continually transfers heat from one medium to another is called a heat exchanger. It is the natural laws of physics always allowing the transfer of heat from one media to another, or from one fluid to another, until equilibrium is reached. There are several basic rules for heat transfer between media:

- Heat will always be transferred from a hot medium to a cold medium.
- There must always be a temperature difference between the media.
- The heat lost by the hot medium is equal to the amount of heat gained by the cold medium, except for losses to the surroundings.

A plate heat exchanger is mainly build together by plates and gaskets in a stiff frame. Each plate has an elastomer gasket arrangement which provides two separate channel systems that separates the two media. The plates are made of thin sheets of metal, to give it a good heat transfer properties, and are corrugated which creates turbulence in the fluids as they flow through the unit. This turbulence in association with the ratio of the volume of the media to the size of heat exchanger, gives an effective heat transfer coefficient. The turbulence also gives a self-cleaning effect inside the heat exchanger. Gasketed plate heat exchangers are available in standard sizes or can be individually prepared. They can also be taken apart for service. There is a wide range of different materials for both the plates and the gaskets to be used in different applications. (The theory behind heat transfer)

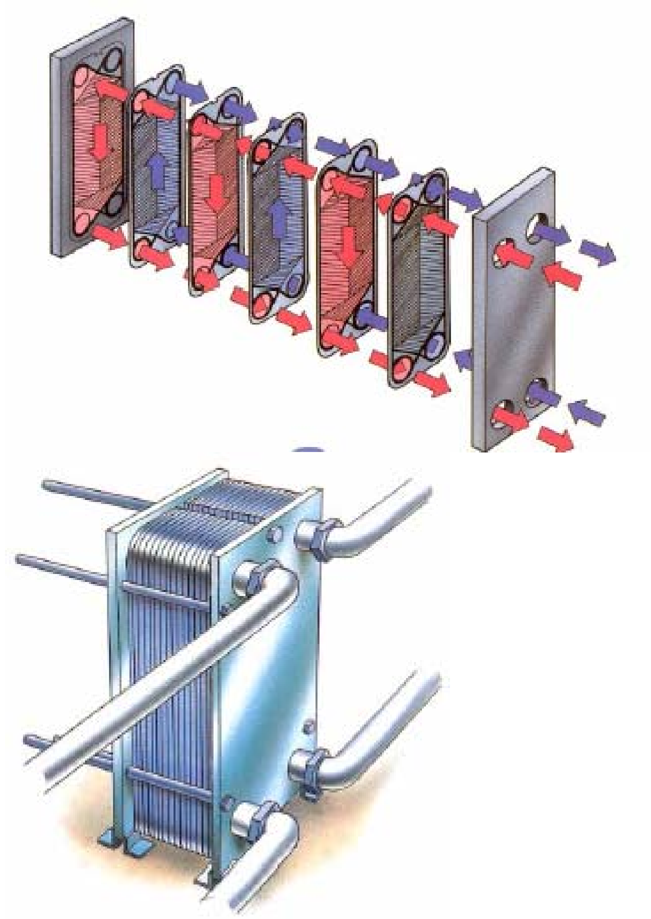

Figure 4.2. Plate heat exchanger (The theory behind heat transfer)

There is a similar principle employed in the brazed construction heat exchanger types (BHE). Instead of the elastomer gasket, special brazing techniques are used to give the same result. They have a strong, compact and light construction but can not be taken apart. (The theory behind heat transfer)

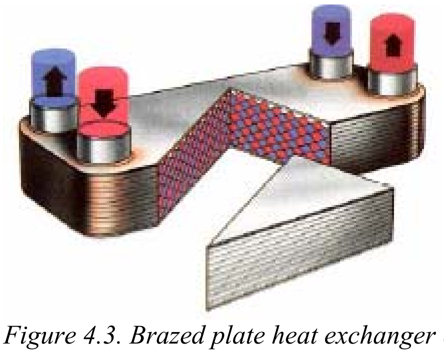

Figure 4.3. Brazed plate heat exchanger (The theory behind heat transfer)

4.2. The Alfa Laval Organisation

The organization of the company was previously based on the three key technologies, Separation, Heat Transfer and Fluid Handling, which continue to form the stable base for the business. Alfa Laval's new organization is based on both centralization and decentralization. All activities with critical mass, excluding sales and marketing, have been centralized. (OneForAll/Organisation)

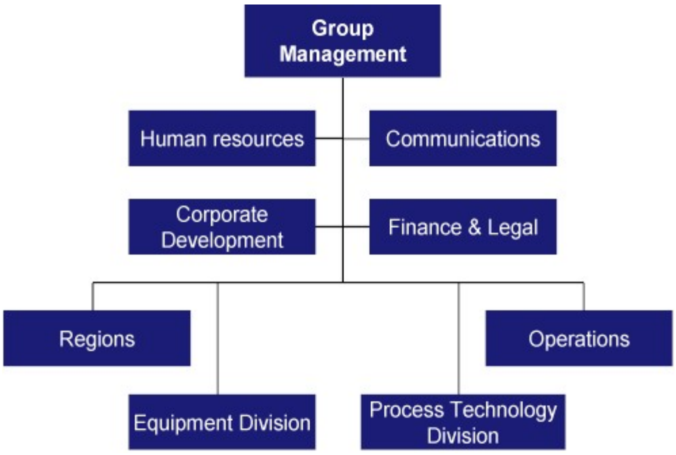

Figure 4.4 Alfa Laval organisation map (OneForAll /Organisation)

Sales and Marketing

The Sales and Marketing have been and will continue to be decentralized, however, in a different way than in the past. Alfa Laval has transformed into a market-driven organization targeted at a number of specific customer segments such as Energy, Marine, Environmental, Food and Beverages, Comfort & Refrigeration, Water, Biotech & Pharmaceuticals and Chemical & other Process Industries. With this approach all salesmen offer their group of customers everything Alfa Laval has to offer, as stand alone products, product packages or systems. The customer segments are grouped into two Divisions, *Equipment Division* and *Process Technology Division*. *Parts & Service* are an integrated part of Alfa Laval's divisions. (OneForAll/Organisation)

Regions

An important factor behind Alfa Laval's successes is its strong and wide sales and marketing network. Alfa Laval is a truly global company with local presence and sales in more than 100 countries and own Sales Companies in 50 countries. A Sales Company is focusing on a number of specific customer segments relevant for the local market and is divided into three divisions; Equipment Division, Process Technology Division and Parts & Service. (OneForAll/Organisation)

Operations

Purchasing, Logistics and Manufacturing are today organized in one division – Operations, which is divided into three main functions:

- *Purchasing* – responsible for all Alfa Laval production purchasing including activities as strategy, supplier development, frame agreements and outsourcing.
- *Logistics* - responsible for global distribution including shipping in the supply chain from producer to the Alfa Laval customer and/or distributor.
- *Manufacturing* - Responsible for the global manufacturing. It consists of 20 manufacturing units, which produce components and complete products/systems for supply to the customers.

(OneForAll/Organisation)

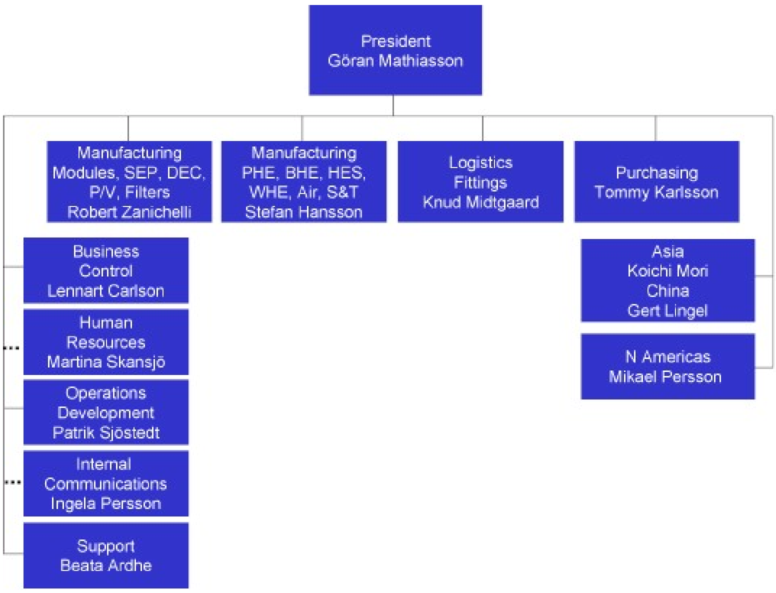

Figure 4.5 Alfa Laval organisation map (OneForAll/Organisation)

4.2.1 Operation Development

The mission for Operations Development is to pro-actively develop Alfa Laval's supply chain processes and technologies, in partnership with the business divisions and sales companies.

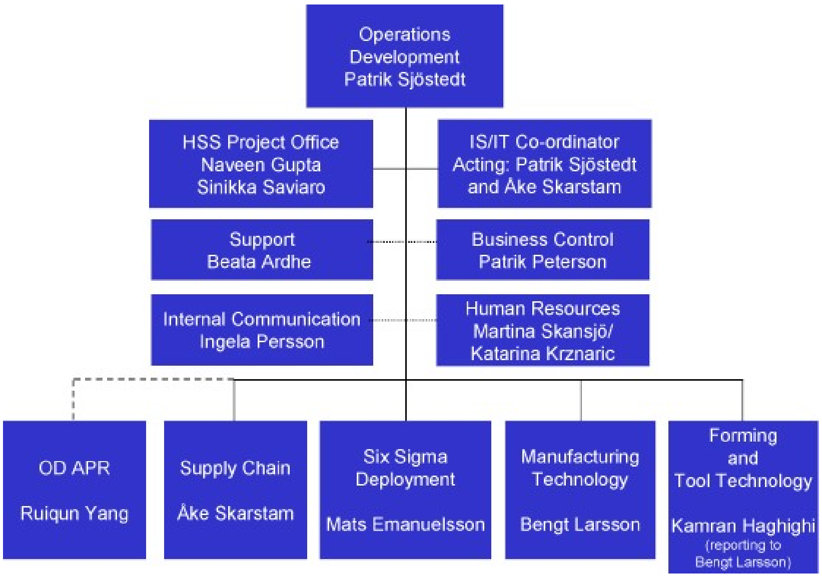

Figure 4.6 Operations development organisation map (OneForAll/Organisation)

The department of Supply Chain is a part of the Operations Development Management Team. Their main purpose is to secure critical mass on projects aiming at reconfiguring Alfa Laval's Supply Chain Networks. Two focus areas are Information Technology and Inventory Management since these are key drivers for Supply Chain success. Another crucial area is Supplier Development. Making sure that the sourcing processes are geared to handle a dramatic increase of supply from low cost countries is of utmost importance. Accurate forecasting and efficient order processing is extremely important for success in this area. (OneForAll/Organisation)

4.2.2. Logistics

To optimize the supply chain of part numbered products is a matter of balancing costs, capital and lead time. Alfa Laval has a global Logistics organization, divided into three regions - Americas, Europe and Asia/ Pacific. DC's (DC) are located in Lund and Tumba in Sweden, Kolding, in Denmark, Indianapolis in the United States, Singapore and Shonan in Japan. Global Logistics employs around 300 people.

OL-EU-L is the European supplier of spare parts for PHE and standard stocked BHE. Around 45 people work at DC Lund. Of them, 30 people are located at the DC in Staffanstorp and 15 at the Shipping department at the Gunnesbo site in Lund. (OneForAll/Organisation)

4.2.3. Supply Change

Alfa Laval has a general supply change structure from supplier to end customer for all products. The chain starts with a supplier that delivers components either to a

Component Unit (CU) or directly to a DC (DC). The Supply Unit (SU) receives the components from one or several CU and thereafter they refine and/or assemble the components into a final product. After the products are assembled they are delivered to a DC or directly to a distributor, contractor, or the end customer. As shown in the picture the DC receives components from all parts of the supply change, directly from the supplier, the CU or the SU. All spare parts that are sold to the end customer are delivered through the DC while assembled products usually are delivered from the SU to the end customer. (Skarstam, 2005)

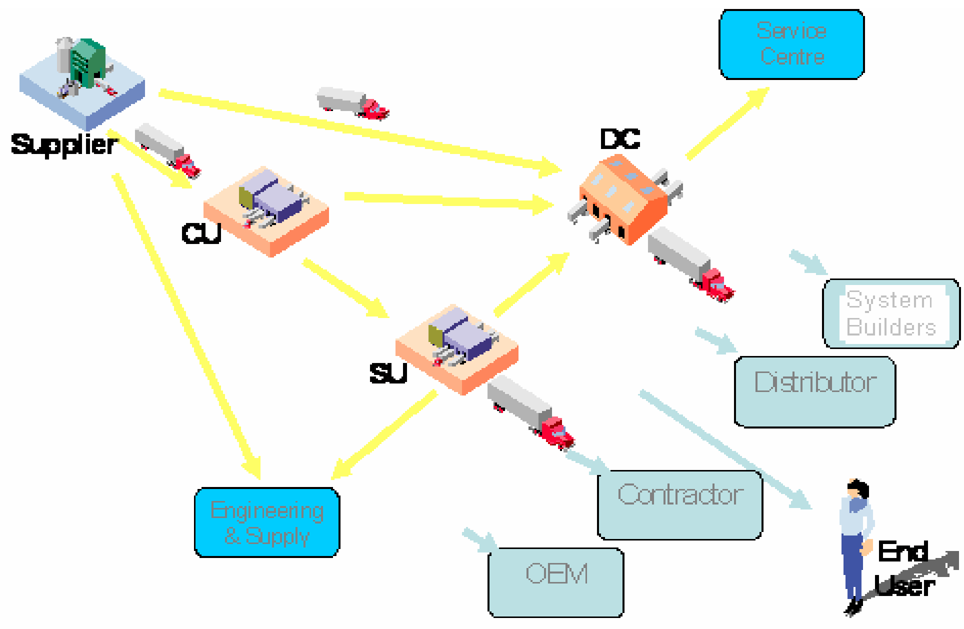

Figure 4.7 Standard Process sales- Operations (Skarstam, 2005)

4.3. Enterprise Resource Planning System within Alfa Laval

The ERP (Enterprise Resource Planning) concept is to have a totally integrated enterprises including efficient production and materials planning, integrated capabilities such as finance, forecasting, sales order processing, sales analysis and local and global distribution, quality control and powerful reporting and monitoring tools. Currently the DC in Staffanstorp uses an ERP system called Jeeves. (OneForAll/Organisation)

Today there is a clear ambition to remove all old ERP Systems for DC's. The only new accepted new ERP System for DC's is Movex, supplied by Intentia. (Persson, R)

4.4. Order Quantity

For non stocked items the order quantity for spare parts, as within the rest of Alfa Laval, corresponds to the quantity requested by the customer. This means that the order quantity is based on the Lot-for-Lot (L4L) method. For stocked, SI products DC´s uses three approaches, EOQ, FOQ, or a calculated minimum order quantity to decide how much to order. The minimum needed order quantity is the minimum order quantity to raise the expected inventory position above the SS level. If the expected inventory position has dropped to such a low level that the order quantity of EOQ or FOQ is not enough to raise the expected inventory position above the SS level the minimum order quantity is ordered. The FOQ is based on the EOQ but modified with regards to multiples and minimum quantities. This means that e.g. if EOQ is 78 units and the FOQ is 100 units the ordered quantity would be 100 units. If the FOQ is a multiple of 30 the ordered quantity in this case would be 3x30=90 units. The EOQ, FOQ and minimum order quantity is calculated in Jeeves each month. (Skarstam, 2005)

Economic Order Quantity

To optimise cost between Carrying cost and Ordering cost.

$$EOQ = \sqrt{\frac{2 * Forecast * Ordering\ Cost}{Unit\ Cost * Carrying\ Cost}}$$

(Skarstam, 2005)

Standard Parameters

Purchase Orders	Manufacturing Orders	
Carrying cost:	40 %	40 %
Ordering cost:	€ 35	*)
Working days:	250	250
Availability stocked, SI:	*)	*)

*) Have to be decided locally at every DC

Table 4.1 Standard parameters EOQ (Skarstam, 2005)

4.5. Reorder Point Principles

The DC´s within Alfa Laval today uses an reorder principle based on fixed order quantities and variable order frequencies, as so called (R,Q) –system. In this system the reorder point R is calculated as the SS level plus the demand during the lead time. The order quantity Q is either EOQ, FOQ, or the calculated minimum need quantity. (Skarstam, 2005)

Minimum needed order quantity= SS + MAX(DDLT or Reserved during lead time) – Refill by PO – Refill by MO

Demand During Lead Time = DDLT = (Forecast / No. of working days) x Lead Time

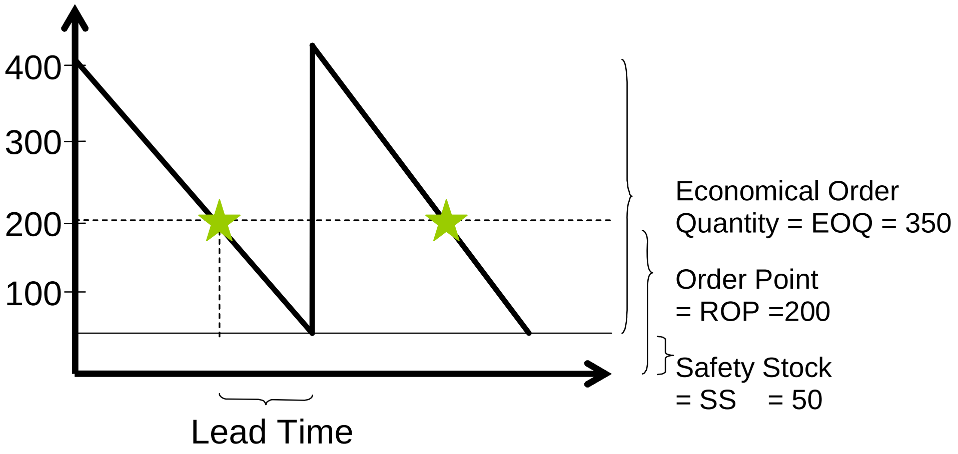

Figure 4.8 (R,Q)-system (Skarstam, 2005)

4.6. SS principles

Alfa Laval uses a SS to protect against fluctuations during the lead time. These fluctuations could arise from forecast errors, quality errors, lead time errors or on hand balance errors. The theoretical formula used to calculate the SS is the same simplified formula (with the assumption of a constant lead time) as mentioned earlier in chapter 3.9. The SS is closely linked to the desired theoretical availability of the item. SI items are today divided into three classes A, B, C, all with different safety factors.

$$SS = k * \sqrt{L + RT} * \sigma$$

$$SS \approx k * \sqrt{L + RT} * MAD$$

k = Safety factor
L = Lead time (in month)
RT = Review time (in month)
σ = Standard deviation (month buckets)
MAD = Mean Absolute Deviation

The lead time and review time are simplifications of several others added lead times. These lead times are; administrational-, supplier-, transport-, control- and manufacturing lead time. (Persson R, 2005)

Restriction on SS

If lead time (from manufacturing or purchase) is shorter then requested delivery time to customer, then there is no reason for keeping SS.

Limitations are also made for lumpy items with to high MAD. Sometimes the MAD-value can be extremely high and as a result of this the SS grows prominently, which is not desirable. In these cases the MAD value is changed manually. The MAD-value should be limited to a maximum of 10% of yearly forecast. (Skarstam, 2005)

4.7. Service Level

To measure and evaluate the performance of the customer service offered by the DC´s different service measurements are used.

Delivery Reliability

The most commonly used measurement for delivery reliability is often mentioned as *availability* (SERV1) and at Alfa Laval it is based on order lines. The availability is measured in % and it is the probability that a customer could receive an order line directly from the DC without a delay. This means that if a customer orders 100 identical items and the DC only delivers 95 of these without a delay the availability is 0 %. If a customer order 10 different items in different quantities (10 order lines) and only 9 of them could be delivered without a delay, the availability is 90%. This measure is only used for SI items and is not valid for NI and RI items. The delivery reliability on customer orders is measured on a one week basis and on ten week basis. The measures are followed up continuously each year during the year.

The real, measured availability is closely linked to the theoretical availability but is very seldom the same. This depends on a lot of reasons e.g. the size and amount of orders received. This fact will not be covered in this thesis. Further on when we talk about availability we refer to the theoretical availability.
(Persson P, Persson R)

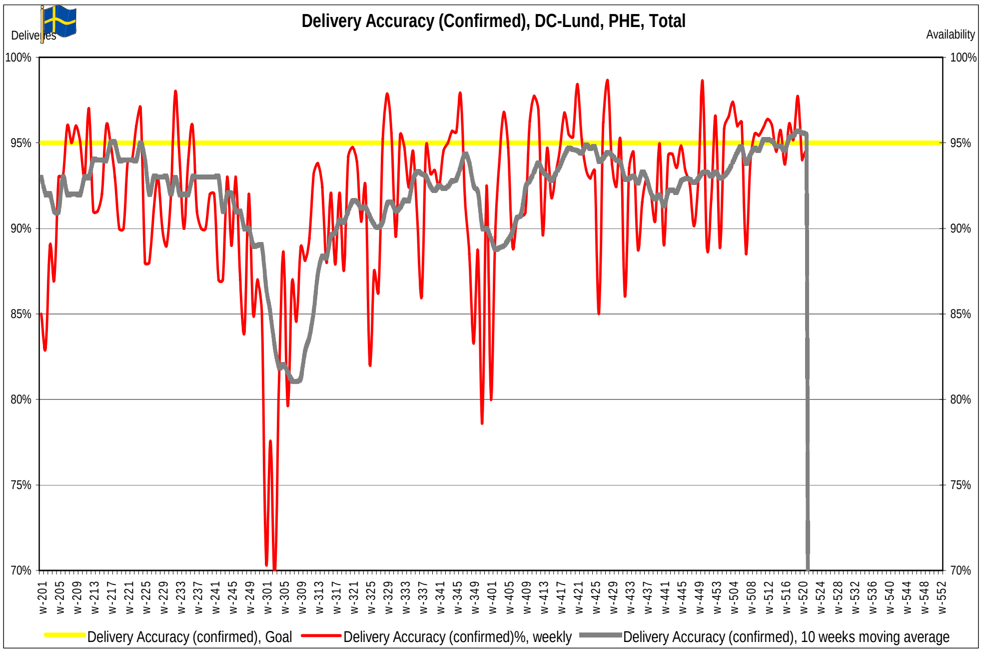

Figure 4.9. Delivery accuracy (availability). The goal line equals the theoretical availability, while the one week and ten week lines shows the real measured availability (OneForAll/Organisation)

For non-stocked items one of the most important service factors according to the customers is the lead time of the item. The customers demand shorter and shorter lead time and for non-stocked items it is therefore important for DC´s within Alfa Laval to meet the lead time requested by the customer. Because of this the service measurement *delivery accuracy requested* is used. This measures the amount of orders lines that Alfa Laval can deliver within the time requested by the customer. (Persson P, Persson R)

Number of picks / year	Item Classification	Availability
0	**R**equest **I**tem (RI)	N/A
1 - 3)	**N**on stocked standard **I**tem (NI)	N/A
4) - ∞	**S**tocked standard **I**tem (SI) - A = 80% - B = 15% - C = 5%	*) 97% *) 89% *) 81%

*) The overall theoretical availability on SI items are 95% (80%*97%+20%*89%+5%*81%).

Table 4.2 Availability for different classes (Skarstam, 2005)

4.8. Forecast Principles, SI & NI

To forecast the demand for spare parts Alfa Laval uses the moving average method, see chapter 3.1.1. It is based on last 12 months history, has a 12 month horizon and is calculated every month.

The forecast is not only based on previous demand data. Several other factors have to be taken into consideration and in these cases adjustments of the forecast are made manually.

+/- Adjust for new products
+/- Adjust for terminated products
+/- Adjust for market activities
+/- Input from tactical forecast
+/- Make reasonability assessment

(Skarstam, 2005)

4.9. Product costing according to MISAL

General Principles

In order to enable analysis, judgements and comparisons between products and between production units it is important to have a well defined and uniform costing system. The system must show production costs, measured as accurate as possible on product level. Alfa Laval Operations works with the full cost concept.

Within Alfa Laval the term “Factory” is often used, which refers to both manufacturing and logistics. Some of the contents are only applicable to manufacturing and in some situations there is a difference between manufacturing and logistics in the way cost should be absorbed.

Each individual company within the group might find some rules and recommendations that are not fully optimal for their situation. This inconvenience must be put against the large benefit of having a group uniform system.

The following general principles apply to the Factory Cost (FC) concept:

- The calculated cost is valid for one year
- The cost level is to be an average for that year
- FC is to reflect the full cost of the factory
- FC should not include any margins

The use of the FC is valid within the following areas:

- Accounting within a Factory

- A component in pricing decisions
- Efficiency judgements about a factory
- Valuation of inventory

4.10. Purpose and benefit of product costing

The main purpose of cost calculation is to:

As purposely as possible show a true and fair cost for each item.

The demand for as accurate manufacturing cost as possible is vital, since this is the base for judging products profitability, affecting marketing strategies, product development and rationalisation in production. A general principle in costing is that it should provide full cost coverage. This means that both direct and indirect cost relating to the manufacturing process should be included.

The more of the cost that are attributed directly to the product the better the accuracy will be. However, at a certain level the cost for increased accuracy is not compensated by further improved decision information. (MISAL)

One thing that has been revealed when looking at the standard price setting is that the NI prices are set according to an arbitrarily medium batch size. E.g. a L4L batch size of 40 does not get a standard cost based on 40, but around 200. Also if a batch size is 300 the standard cost can also be based on a batch size of 200. The explanation to this is that small batches would be very expensive if they are to carry the whole setup cost themselves. By this it follows that small batches are cheaper than they should be and also that larger batch sizes gets more expensive because of having to carry some of the cost for the small batches. This results in that the overall costs are covered, but not by the "right" batches. One explanation for this is that the production often gathers small batches of one type of plates to a large batch and thereby saves a number of setups. If so, the standard cost is more correct but does not follow the NI definition to manufacture NI items L4L.

4.11. Factory Cost according to MISAL

The responsibility for the manufacturing units is to provide specified and developed products to the marketing organisations; hence FC should only cover:

Cost for resources utilised in order to deliver specified current products from Operations during the year at forecasted volumes.

Factory cost consists of direct costs as material and wages and indirect cost, attributed to the product via one or several cost carriers. Cost carriers used within

Operations are the traditional material-, process- and general overhead burden. Material overhead should cover all cost associated with acquiring, receiving and handling the material, until issued for production. Process overhead is to cover the cost in production until final operation is performed. General overhead should cover cost incurred after the last operation and some general costs. It could be presented as a step-by-step calculation model:

Step-by-step calculation model for manufacturing

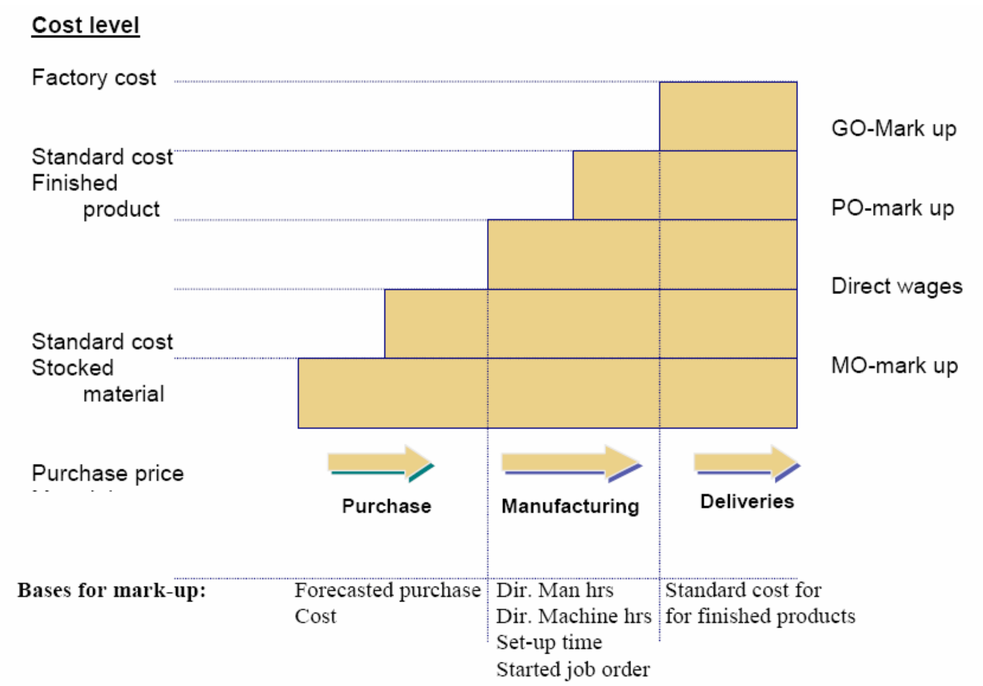

Figure 4.10. Step by step calculation model for manufacturing (MISAL)

Within Logistics, a DC has no or very limited manufacturing, why a simpler model apply for their calculation method:

Step-by-step calculation model for logistics.

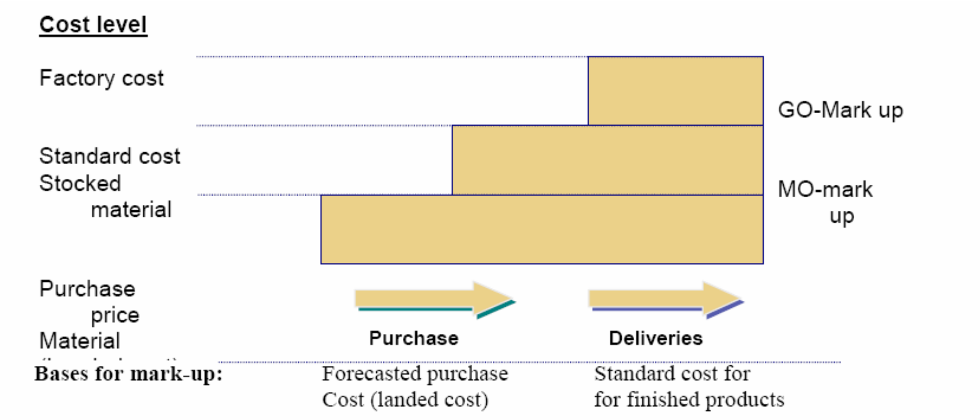

Figure 4.11. Step-by-step calculation models for logistics *(MISAL)*

GO - General overhead within logistics

Within logistics, general overhead is generally the only mark up used at most DC's and should then cover all overhead cost (not covered by Material overhead if used). GO should be used to absorb all the cost associated with purchasing and material handling. Preferably all cost that should be attributed via GO are registered on one or several dedicated cost centres to enable and enhance focus and follow-up.

Costs to be included in GO:

- Purchasing (central and local)
- Stock adjustments on purchased items
- Goods reception and inspection
- Inventory handling
- Rent for inventory space
- Calculated interest on inventory
- Calculated interest on accounts payable (income)
- Cost for supplier's tool
- Finance (invoice handling for purchased items)
- Obsolescence & slow moving on purchased items
- Income from sale of scrap

4.12. Activity Based Value Added Within Logistics

An Alfa Laval Pre-study project aims at evaluating an activity-based concept to calculating the GO mark up and to define principles and cost drivers for an activity-based model. The pilot project is based at the Alfa Laval DC in Kolding. In accordance with MISAL the object of this study is to: “As purposely as possible show a true and fair cost for each item”. The Pre-study was supplied to us by Sören Krarup and then Mikael Larsson helped us to apply the model to Staffanstorp’s figures.

The GO mark up is today arbitrary and is only based on the standard price of each item. This system does not take into account what kind of item we are dealing with or how the structure of the order looks like. To solve this problem an Activity Based Costing Model is used to show the real mark up for each item in a simple and logic way.

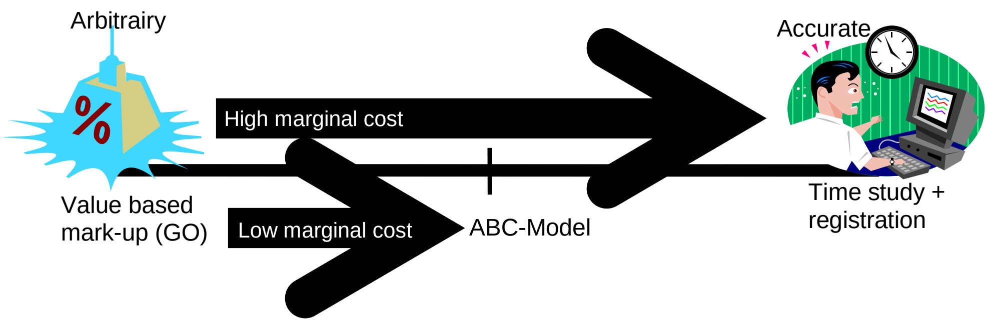

Figure 4.12. Comparison between GO and accurate mark up (Krarup,2005)

The ABC model used in Kolding is based on order lines. The mark up in this model consists of a differentiated order line fee for items within each class (SI, NI, RI and DS) plus a charge based on the value of the product.

In this model cost for different activities of the warehouse are separated and the costs are allocated through a resource-driver. The resource driver for inventory management and order reception; time, has to be estimated by the warehouse manager while the others are easy to measure more accurately.

Activities	Cost (KDKK)	Resource Driver: Description	SI	NI	RI	DS	Cost Objects: SI	NI	RI	DS
1. COMMON MAIN PROCESSES										
1.1 Inventory Management/Purch.	5.547	*Time*	*43%*	*15%*	*26%*	*16%*	11	15	38	278
1.2 Order Reception	7.479	*Time*	*25%*	*25%*	*43%*	*7%*	8	34	83	166
1.3 Warehouse handling cost										
1.3.1 Inbound	3.809	*PO orderlines*	*42%*	*27%*	*31%*		7	18	31	
1.3.2 Facility	2.128	*Squaremeters*	*70%*	*15%*	*15%*		7	6	8	
1.3.3 Pick & Pack (outbound)	15.710	*Location. & effic.*	*65%*	*21%*	*14%*		45	60	58	
2. DC SPECIFIC PROCESSES										
2.1	-	-	*0%*	*0%*	*0%*	*0%*	0	0	0	0
2.2 To be defined if any	-						0	0	0	0
2.3 To be defined if any	-						0	0	0	0
3. INVENTORY HOLDING										
3.1 Calculated Interest on inventory	4.936	*Inventory alloc.*	*87%*	*5%*	*8%*		1,4%	0,2%	0,1%	
3.2 Provision to inventory reserve	1.500	*Provision alloc.*	*90%*	*5%*	*5%*		0,4%	0,0%	0,0%	
4. MANAGEMENT										
4.1 DC Management	5.539	*Cost of mat*	*39%*	*20%*	*39%*	*3%*	0,7%	0,7%	0,7%	0,7%
4.2 Centrally allocated cost	6.705	*Cost of mat*	*39%*	*20%*	*39%*	*3%*	0,9%	0,9%	0,9%	0,9%
4.3 Corporate Management Fee	4.953	*Cost of mat*	*62%*	*26%*	*8%*	*4%*	1,0%	0,9%	0,1%	1,0%

Input to factory cost calculation

Customer order line fee (sections 1–2)

SI	NI	RI	DS
78	133	218	444

% value fee (sections 3–4)

SI	NI	RI	DS
4,5%	2,7%	1,9%	2,6%

Table 4.3 The Kolding pre-study (Krarup, 2005)

DC specific processes must be significant to be taken into account. It can be handling of certificates, labelling, handling of large/heavy items, returns, etc. (Krarup, Larsson)

4.13. Theoretical Inventory Value

In accordance with the file Inventory Calculations, the theoretical average inventory value for each item calculated at DC´s within Alfa Laval is equal to:

$$Theoretical\ Inventory\ Value = (SS + \frac{EOQ}{2}) * Std.\cos t$$

This formula is based on several assumptions; some of them are not completely true in reality at Alfa Laval. A previous thesis made by Fälth & Trygg (2005) at another warehouse within Alfa Laval, shows that there is a difference between the actual- and the theoretical average inventory value. In this case the actual average inventory was larger then the theoretical inventory.

The assumptions made in this formula is that all order quantities used in the equation are equal to the EOQ, inventory is replenished when the inventory position has dropped to the SS level, the consumption is assumed to be continuous and deliveries is supposed to be instantaneous. (Skarstam, 2005)

4.14. Classification of spare parts at Alfa Laval according to Re-classification guide

Alfa Laval divides their spare parts into four main groups: SI (Stocked item), NI (None stocked Item), RI (Request Item) and UI (Unidentified Items, stocked and none stocked). The UI group will not be further described in this thesis since it is items that are used for different kits and are not for sale as single items. Also, Alfa Laval has pointed out that the UI-class is going to be removed and should not be given much thought.

The grouping of items are based on the picking frequency so that it gives a good result according to the Pareto rule i.e. 20 % of the items replies to 80 % of the total number of picks. The different classes is currently defined as:

≥ 4 picks/year = SI,
2-3 picks/year = NI and
≤ 1 picks/year = RI

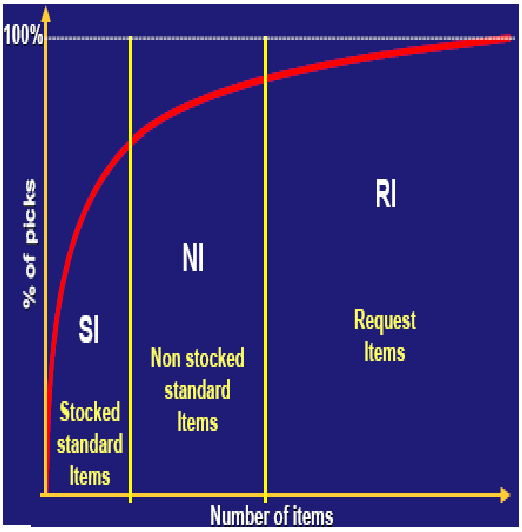

Figure 4.13. Part of picks (Skarstam,2005)

There are rules set by Alfa Laval about what information that should be available for the items in the different classes (see table 4.4).

SI	Forecast
	A,B,C frequency class
	Safety stock & EOQ
	Stock availability = 95%
	Standard cost
NI	Forecast
	Buy L4L
	Delivery time
	Standard cost
RI	No forecast
	Buy L4L
	On request delivery time
	On request standard cost
UI Stocked	Not for sale, but used e.g. in a KIT. see SI
UI Non Stocked	Not for sale

Table 4.4. SI,NI,RI-rules (Skarstam,2005)

To decide which class a spare parts should be in, Alfa Laval has a system that is updated every year. The classification has influence on a variety of important factors, such as: inventory management, delivery time, standard cost, physical location and costing update. The re-classification process is carried out between the 15: th of September and the 7: th of November and is needed so the inventory management can prepare itself before the new classification takes affect in the 1 January the coming year. When the new classification is set, it remains unchanged until the next update; although mistakes and absurdities are corrected as they are discovered. The reason why the update frequency is once per year is to avoid a "nervous" system. A system can be called nervous when it is too sensible and therefore creates unnecessary disturbances in the inventory management. E.g. if the demand of an item vary over the year and the classification is made every month. The item could then be shifting classes several times per year which would create a lot of unnecessary work.

As can be seen in figure 4.14, the reclassification is made in several steps. First the items are listed with historical data and current classification. Then the new classification is set according to the standard limits of pick frequency. After that a comparison is made between the first two, the DC's makes their own special adjustments (will be discussed further in chapter 4.14.1). The adjusted setup is then discussed between the different customer segments and the product managers and a final decision is made. The differences from the standard setup are compared and documented.

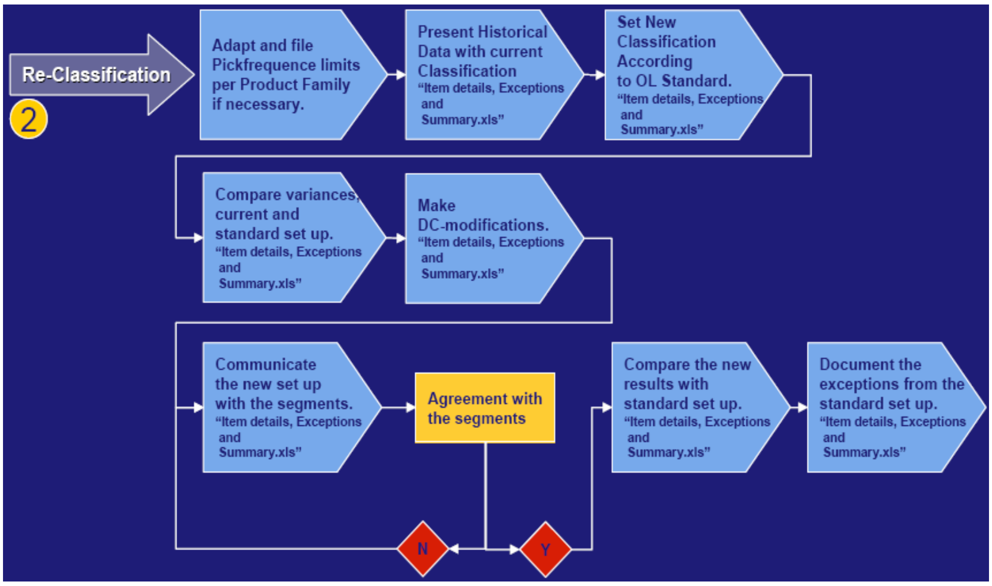

Figure 4.14 Reclassification structure (Skarstam, 2005)

4.14.1. Different reasons to change the standard classification

The DC: s can make different changes in the standard setup. Some of them are:

If an item is stocked in a different part of the organisation it is not always necessary for the DC to keep it.

In Staffanstorp there are a large amount of different NI-items that are assembled varieties of a small number of SI-plates and SI-gaskets in different combinations for different applications. Even if some of these NI-items are picked more than 4 times per year, it still remains as a NI-item. This means that e.g. five plates and five gaskets can be combined together to 25 different combinations. Instead of having a large number of different combinations in stock that is origin from a small number of elements, the DC just keeps the elements in stock and combines them when an order comes in. This is a kind of postponement so even if such an combined item is picked ≥ 4 times, the item is still classified as an NI, but with a short lead time. This is helping Alfa Laval to keep the stock levels down and still be able to deliver to the customer within short notice. Another advantage of this postponement is that the relatively cheap gaskets can not be kept in store for much longer than a year, but the expensive plate can be kept for much longer. In this way there is always a fresh gasket put on the plate.
(Persson R)

4.15. ABC classification of Stocked Items

At DC´s within Alfa Laval stocked items (SI) are divided into three different classes: A, B and C. The classification is based on the number of customer order lines and is upgraded every month. It follows the Pareto (80/20) principle. Items within the A-class stands for 80% of all order lines (picks), while the B-class stands for 15% of all order lines and the C-class 5% of all order lines. (Persson R)

4.16. Product Life Cycle

The product life cycle curve is a very useful tool to discuss the market dynamics for a certain product and/or market. Every product develops along this curve. It is just the time scale that differs. Some products have hade a rapid development (less then 10 years) along this curve and for other products it will take decades. Each product will go through an Introduction phase, Growth phase and finally become a Mature product on the market. (Alfa Laval Distributor Guide)

According to Lars Warlin, General Product Manager Parts and service at Process Technology Division it is not unusual that a products life cycle is as long as 25 years.

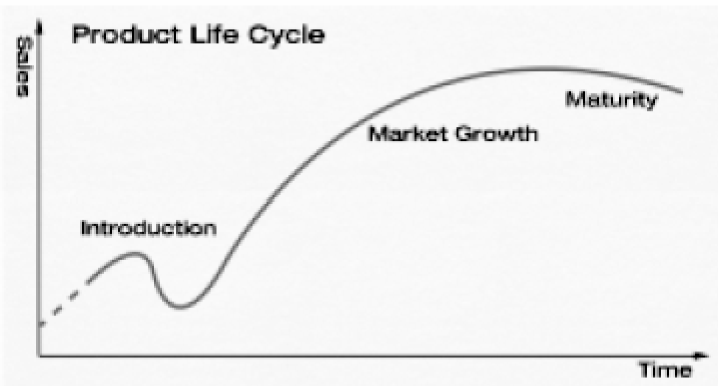

Figure 4.15 Product life cycle (MISAL)

4.17. Obsolescence

There are several reasons and different definitions of obsolescence at Alfa Laval. The obsolescence according to accounting principles in MISAL (Management Information System Alfa Laval) differs from the physical obsolescence used at DC´s. In the later case an obsolete item is scrap, i.e. the item is thrown away. This resent year the obsolescence at DC Staffanstorp according to MISAL definitions is five times larger then the physical obsolescence at the DC.

According to Peter Persson, Inventory manager at DC Staffanstorp, common reasons for scraping are:

- Terminated Products. Spare part could be replaced because newer versions are available or if segments decide not to provide the item due to low demand.
- Durability. Several items, including most gaskets, only have durability up to one year. After this time the item has no value and is therefore scrapped.
- Manually changed forecasts. In cases where items do not have complete or valid historical demand data, forecasts are made manually on assumptions, based on "know how" by people within the organisation. This often leads to a too large inventory that finally becomes obsolete and scraped.

The main reasons for obsolescence are when the demand for an item with a former high and continuous demand suddenly falls. In these cases large volumes are held in inventory which will take years to spend.

When demand usually is low and constant and a single large order is received, this single order increase the forecast very much, which leads to too high inventory levels.

Peter P. states that low frequent items do not stand for a large share of the obsolescence costs. By their nature they are ordered in small quantities and hence the cost of scrapping is cheaper for a few items then for a high volume item.

Obsolescence according to MISAL

The inventories should be accounted for at their *gross* value. The gross value is equal to the manufacturing or purchase cost. The net value is obtained by subtracting the provision for obsolescence and slow-moving parts from the gross value. During the year, a calculated charge should be made monthly to the provision for scrapping of and obsolescence in inventory. The annual provision should correspond to the average actual cost of scrapping.

Provision for obsolescence according to MISAL

Items, which have seen no demand at all during the last two years, are written down by 100%.

An additional provision should be calculated to take care of the obsolescence risk from items with low demand. The forecast (e.g. the next 12 months) should preferably be used as a demand figure. Items with such a low demand that the inventory quantity will last more than one year are written down by the following percentages:

- 0 % for the part of the inventory to be consumed during year 1
- 50 % for the part of the inventory to be consumed during year 2
- 75 % for the part of the inventory to be consumed during year 3- 4
- 100 % for the part of the inventory to be consumed during year 5 and later

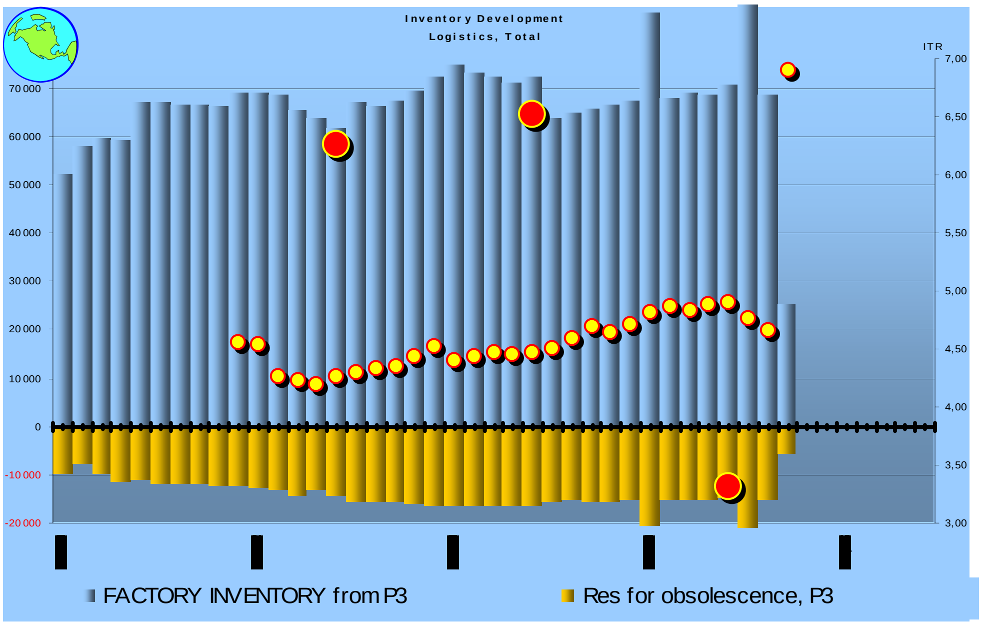

Figure 4.16 Inventory development, logistics and total. The yellow part of the staples represents the reserve for obsolescence according to MISAL (OneForAll/Organisation)

4.18. Aspects on the spare part logistics from the sale segment

In a discussion with Lars Warlin and Ulf Grevillius, a number of different aspects on the spare part logistics and how he and the sales segments experience the situation of today were brought up. They were overall satisfied with the handling of SI. It was the NI and RI that caused them trouble.

4.18.1. The long replenishment time on SI

If a large order empties the warehouse stock, the replenishment time in many cases are several months. This is hard to justify to the customers.

4.18.2. The present SI-limit leads to different service levels

Warlin says that the frequency classification model that are used today are clearly better compared to the one before, but that the SI-limit of 4 picks results in different service levels depending on the size of the warehouse.

4.18.3. Production and spare parts are not synchronized

The lead time of Alfa Laval's spare part distribution is often very long. One of the reasons for this is that the production of spare parts and the ordinary production are not synchronized with each other to a satisfactory level. When NI items are needed they are manufactured L4L in an own batch in the factory with a long lead time. This can in many cases be avoided when the part perhaps is available in stock somewhere else in the organisation or when the same part is manufactured in the ordinary production, sometimes as often as several times per month. In theory, a large number of an item can be thrown away in Staffanstorp when the warehouse in Indianapolis still has got a demand for it.

4.18.4. Competitive pirates in the market

The market of today demands more and more of Alfa Laval and its competitors. A high price, long lead time and products that are easy to copy, opens up opportunities for competitors and also for pirates that often can offer the customers a lower price with a lead time no longer than two weeks. To compete with this, Alfa Laval offers the customers a high standard technical support and service. Most of the customers want to buy original Alfa Laval spare parts because they do not want to take the chance with having pirate parts. Normally the service is well planned and then there is no problem to offer the spare parts at the right time. The problem arises when an unforeseen breakdown occurs and an extremely high amount of an item or a non stocked item is needed. With a high downtime cost, the competitors and pirates offer a tempting alternative for the customers. This can also result in loosing the customer in the future because of lack of trust.

4.18.5. One Four Eight

Warlin presented the *One Four Eight* target. If this target would be reached it would, according to Lars, generate a very good starting point for the sales segments to provide a satisfactory service for the customers. One Four Eight stands for:

One - The lead time from DC for all SI-items are one day.
Four - The maximum lead time from DC for all NI-items are four weeks.
Eight - The maximum lead time from DC for all RI-items are eight weeks.

4.18.6. New type of classes

To achieve a better classification model for the items, Lars suggests two new classes:

- **CI** – To guarantee having the item in stock for the customer. The customer has to pay the holding costs.
- **EI** – Emergency Items. Items so critical that they always have to be in stock.

4.18.7. Clear the forecasts from abnormal values

The forecast are often being disturbed by low frequent abnormally large values. These extreme values are often so high that they can not be satisfied directly from stock. If these abnormally large values are taken out of the forecast calculations, the results should be more correct.

4.18.8. Differentiated GO mark up

Ulf Grevillius thinks that the GO mark up is not suitable for all items. E.g. some of the tools (NI) that Alfa Laval is selling could be found in any hardware store but with the GO it is suddenly 25% more expensive for the customer. This could be very irritating for the customers and Alfa Laval looses goodwill. Ulf suggested a differentiated GO, but knew that this would meet an opposition from other segments.

4.18.9. After sales service

Ulf Grevillius means that it is important to implement more service thinking in the selling of new products at Alfa Laval. There are large possibilities in selling service packages that are not being used at the moment.

4.19. Benchmarking toward other companies

The main purpose of this benchmarking is to collect different approaches in spare part logistic management and compare them with Alfa Laval's present setup. The participant companies represent a wide variety of different production industries, with in some cases totally different business environments. Because of this, it is not always possible to compare the different participants to draw any conclusions, but they can be a valuable source of ideas. Here follows a short presentation of the participating companies gathered from the company's homepages:

Kalmar Industries AB
Kalmar is manufacturing heavy mobile material handling applications, such as fork lifts etc. They are not only selling the machine, but also a whole function which the machine is a part of. Some of their main objectives are a high technical quality, to build long term customer relationships and to maintain a high availability to prevent expensive down time for the customers.

Atlas Copco Compressor AB
This business area develops, manufactures, markets and distributes many different types of industrial compressors. They are world leading within their area and their main objective is to be and remain "first in mind and first in choice". This should be achieved through customer interaction and commitment and with innovative

products for the sake of the customer's productivity. This position is maintained and driven by continuous research and development in compressor technology.

ITT Flygt AB

Flygt is the world leader of submersible pumps, mixers and accessories. Their company policy is to do business in a manner that meets the needs of the present without compromising the ability of future generations to meet their needs i.e. ensure sustainable development. They are focusing of having innovative high quality products.

AB Ph Nederman & Co

Nederman manufactures products that improve industrial working environments such as mist collectors, fume extractors, personal safety equipment and vacuum systems. Nederman aims to develop, manufacture and market products capable of solving, customer's problems as easily as possible for all concerned, i.e., the end-user, the distributor, Nederman and its suppliers. For this purpose, products are developed in a modular design that easily combines to suit the single workplace installation as well as larger more complex systems. The supply unit in Sweden does the end assembly while the suppliers produce the components.

Volvo Cars

Volvo cars mission is to create the safest and most exciting car experience for modern families. The production of vital components, such as engines and body components is mainly based in Sweden. Volvo cars try to be one of the strongest and most respected brands in the car industry and put a lot of effort to maintain a high level customer service regarding spare parts.

Volvo Group/Parts

Volvo group has a broad range of trucks, construction equipment, boat engines and buses. Consistently providing high quality products and services requires a tremendous commitment from the organization - and therefore it is assigned very high priority by Volvo Groups management. Any spare part should be available for the customer within 24 hours.

Scania Parts

Scania develops, manufactures and sells trucks, buses and industrial or marine engines. Scania claims that their dealer network and Scania Parts logistics network is one of the most advanced in the world. They offer high availability for all Scania Parts, not just a selected few. Each and every single Scania Part can be delivered to just about any point in the world – within 24 hours at the most. Three core values; customers first, respect for the individual and quality form the basis of both Scania’s corporate culture and its business behaviour.

Sandvik Tooling

Sandvik Tooling is the largest of Sandvik's three business areas and has grown rapidly. They are manufacturing tools and tooling systems for metal cutting, as well as components and high-volume blanks in cemented carbide. The products produced within Sandvik Tooling are primarily industrial consumption goods. They have a strict focus on the needs of their customers and next-day delivery is offered to customers in most parts of the world.

Sapa Profiler AB

Sapa develops and markets high value added profiles, building systems and heat transfer strip in aluminium. Their business concept is built on close co-operation with customers all over the world. The needs of the customer are always in focus. What differentiate Sapa and the other companies in this benchmarking is that Sapa has a short setup time and very low setup costs for their products.

ABB automation technologies AB

The Automation Technologies division supplies a complete range of hardware and software products for automation and control, measuring instruments and sensors, drives, semiconductors, motors and machines, power electronics, switchgears and auxiliaries as well as low voltage products and systems. Good relations with customers, partners and government circles at home and abroad are a prerequisite for the corporate success of ABB.

4.19.1. Answer summary

The full answers from the companies are posted in Swedish in the appendix 1. Here follows the questions and a summary of the answers.

1. The company name/segment/respondent

2. How many items do you have in your assortment?

Kalmar	**Atlas Copco**	**Flygt**	**Nederman**	**Volvo cars**	**Volvo Group/parts**
220000	25000	35000	8600	97000	250.000
Scania parts	**Sandvik tooling**	**Sapa**	**ABB**	**Alfa Laval**	
65.000	42000	70 000	13000	54500	

Table 4.5. Number of items in assortment.

3. How many of these items are stocked items?

Kalmar	**Atlas Copco**	**Flygt**	**Nederman**	**Volvo cars**	**Volvo Group/parts**
30000	5000	7000	1650	99%	100.000
Scania parts	**Sandvik tooling**	**Sapa**	**ABB**	**Alfa Laval**	
65.000	42000	2000	3500	1200	

Table 4.6. Stocked items.

4. How much of the demand do these items represent?

Kalmar	**Atlas Copco**	**Flygt**	**Nederman**	**Volvo cars**	**Volvo Group/parts**	**Scania parts**
50%, 80-90%	40-50 %	80%	65,00%	99,5%	99.9%	99,9 %
Sandvik tooling	**Sapa**	**ABB**	**Alfa Laval**			
Ca 85 %	30%	100,00%	52%			

Table 4.7. %age of demand.

5. How do you measure the demand in this case?

Kalmar	Atlas Copco	Flygt	Nederman
Sold art. number, turnover value	Turnover value	Volume	Turnover value
Volvo cars	**Volvo Group/parts**	**Scania parts**	**Sandvik tooling**
Number of picks	Mainly turnover value + picks and volume	Volume	Turnover value
Sapa	**ABB**	**Alfa Laval**	
Turnover value	Turnover value	Number of picks	

Table 4.8. Parameter for measuring the demand.

6. How do you decide if an item should be a stocked item or not?

Kalmar	Atlas Copco	Flygt
Picks + criticality	Turnover value	Picks + turnover value
Volvo cars	**Volvo Group/ parts**	**Scania parts**
Almost everything is kept in stock	Picks+ item value	Almost everything is kept in stock
Sapa	**ABB**	**Alfa Laval**
Manual + picks and volume. Lead time also.	Manual judgement	Picks + manual
Nederman	**Sandvik tooling**	
Picks + turnover value	Criticality. Appraisal by the logistic and market side.	

Table 4.9. Parameters for keeping in stock or not.

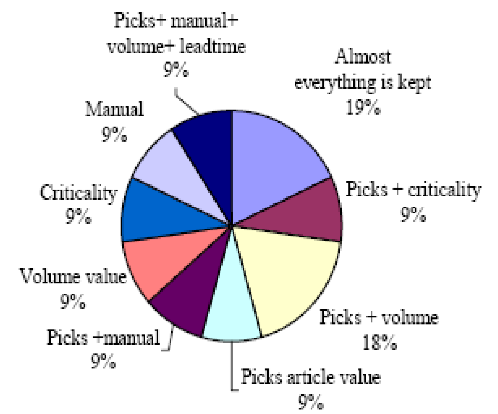

Figure 4.17. Pie diagram of table 4.9

7. How often do you investigate if your items should be kept in stock or not?

Kalmar	**Atlas Copco**	**Flygt**
Week	Continuously	6 months
Volvo cars	**Volvo Group**	**Scania parts**
Continuously	Continuously	3 months
Sapa	**ABB**	**Alfa Laval**
3 months	Year	Year
Nederman	**Sandvik**	
6 months	6 months	

Table 4.10 Classification frequency

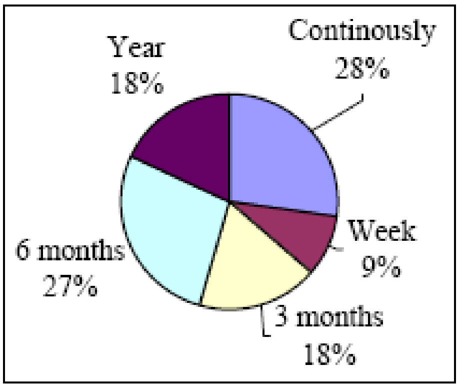

Figure 4.18 Pie diagram of table 4.10

8. In question 6 and 7, how long time period of historical data are you using?

Kalmar	**Atlas Copco**	**ITT Flygt**
Two years	Two years	Year, but switching to 6 months
Volvo cars	**Volvo Group/parts**	**Scania parts**
Not appliable	6 months	5-10 years
Sapa	**ABB**	**Alfa Laval**
Year	Two years, but longer if possible	Year
Nederman	**Sandvik tooling**	
6 months	Not appliable	

Table 4.11 Historical data

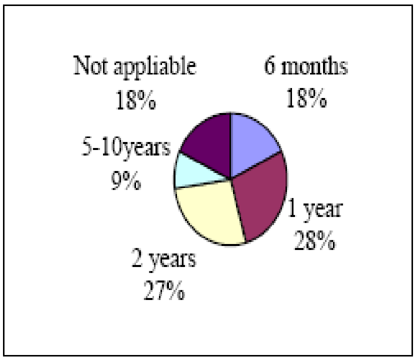

Figure 4.19 Pie diagram of table 4.11

Why did you choose this period?

For information why, see the appendix 1.

9. If you have changed the time period in question 8, have you seen any affect of this?

Kalmar replies that one year is to short when the lifetime of the products is >10 years.

Flygt has got one year now but are going to use six months in the future to achieve a faster system.

Volvo has got a policy to have the spare parts available for 15 years after the model has gone out of production. After that it is the money that controls whether or not they keep it in stock.

Sapa has tested different time periods but has not come to any conclusions.

ABB uses at least two years and more when it is possible.

The rest of the companies has either said no or didn't want to answer.

10. Do you use an ABC classification for your stocked items? If so, what is this classification based on (e.g. Turnover value, picking frequency, volume, etc)?

Kalmar	**Atlas Copco**	**ITT Flygt**
Yes, value, picking frequency and availability	No	Yes, turnover value
Volvo cars	**Volvo Group/parts**	**Scania parts**
No, but have other classifications	Yes, picks and item value	Yes, turnover value
Sapa	**ABB**	**Alfa Laval**
Yes, turnover value	Picking frequency	Yes, turnover value
Nederman	**Sandvik tooling**	
Yes, turnover value	Yes, picks and item value	

Table 4.12 Using ABC

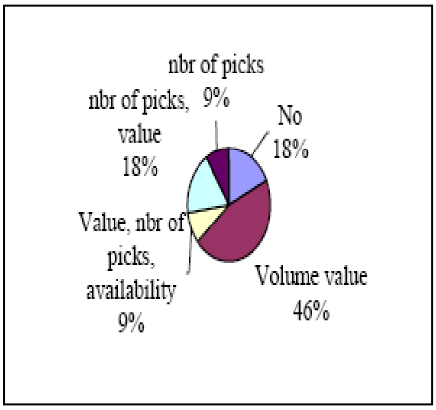

Figure 4.20 Pie diagram of table 4.12

11. How often do you update your ABC classification?

Kalmar	**Atlas Copco**	**ITT Flygt**
Month	Not appliable	Year (+week)
Volvo cars	**Volvo Group/parts**	**Scania parts**
Not appliable	Continuously	Month
Sapa	**ABB**	**Alfa Laval**
3 Months	Year+ when needed	Month
Nederman	**Sandvik tooling**	
6 months	Month	

Table 4.13 ABC update

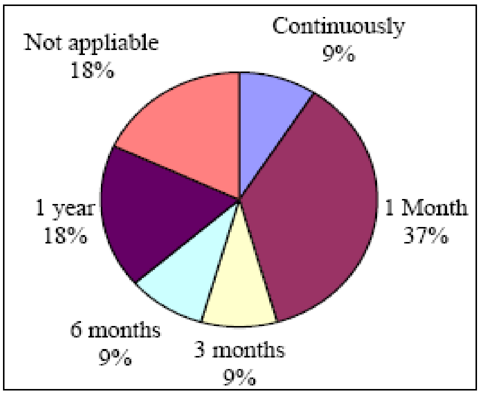

Figure 4.21. Pie diagram of table 4.13

What made you chose this time period instead of the others?
For information why, see appendix 1.

12. Do you use larger DC's or small warehouses closer to the customer?

All of the companies had DC's of some sort but their function varies. In some cases the companies has also additional regional warehouses and some also kept a stock at the retailers. See appendix 1 for more information.

13. Is your assortment divided up into families? E.g. Alfa Laval has divided theirs into three families: thermal, separation and fluid.

Seven out of eleven has divided up their assortment into families, but they are not always used in the controlling of the stock.

14. Do you have the whole assortment on all the warehouses or does each warehouse have their special assortment or family? What made you make that decision?

The general approach is to base the assortment in a DC depending on which marked it is intended to serve. Other is to let the lead time or the volume decide where the items should be kept.

15. Did you investigate the changing of cost when putting an item into stock compared to having it as made to order?

There where several companies that had made this analyse but it gave different results depending on their business environment. Some of those who had not done it had made the conclusion that it was not possible because of lead time demands or the complexity of shortage costs.

16. Do you have the same mark up for handling costs on all the items? E.g. does the made to order items carry a part of the stock keeping costs for the items made to stock. Is it a % or a fixed sum mark up?

Kalmar	**Atlas Copco**	**ITT Flygt**
One %mark up	Two %mark ups	One %mark up
Volvo cars	**Volvo Group/parts**	**Scania parts**
One %mark up	Depending on the business area	No reply
Sapa	**ABB**	**Alfa Laval**
No, individually mark ups	One %mark up	One %mark up
Nederman	**Sandvik tooling**	
One %mark up	No, individually mark ups	

Table 4.14 Mark up for handling costs

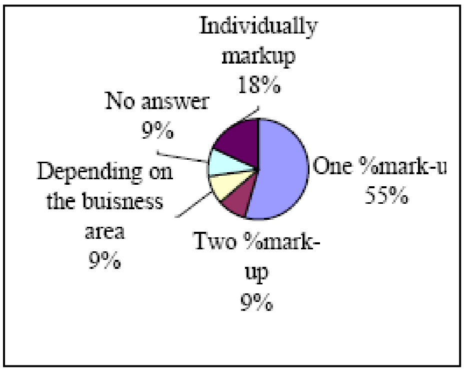

Figure 4.22. Pie diagram of table 4.14

17. How is the stock keeping cost divided on your items? Which resource drivers do you use (e.g. per time unit, order line, etc)?

Five of the companies used a general mark up based on the item value. Two used the order line as a resource driver. The rest uses a number of different resource drivers in combination with each other.

18. The service level in stock is an expression for the ability to deliver directly from stock. The term can be generally defined as the probability that a customers order can be delivered from stock in accordance to the customers wishes or that a material can be picked from stock for a production order according to plan.

Probability for ability to deliver directly from stock during an order cycle (SERV1).

Share of demand that can be delivered directly from stock (SERV2).

Which kind of measure/measures do you use?
The most commonly used was to deliver according to agreement with the customer. SERV 1, SERV 2 and delivery in accordance to current lead times were also used.

19. What is your service level based on?

A. Based on shortage costs
B. Based on maximum allowed inventory costs.
C. Policy for suitable service level established by i.e. the company management
D. Other

Policy for suitable service level established by, i.e. the company management were used in almost all the companies. There are also combinations of all the different alternatives to resolve the most appropriate service level. The car industry uses benchmarking towards their competitors. Sapa based their service level on customer priority because it does not provide any value for Sapa to keep their products in stock.

20. In question 19, why have you chosen this method?
The most common answer is that the competition influence the service levels and that almost all companies are focused on the customers needs.

21. Do you have a service level where you also include the made to order items (i.e. non stocked items)?
Everyone but Sandvik had this service level. Volvo cars answered that this was not appliable because almost all items are kept in stock.

22. Have you made any lead time analysis? E.g. some of the items perhaps do not need to be kept in stock when the lead time is short enough to satisfy the customer anyway. If yes, what was the result and how did you come up with that result?
All of the companies had made a lead time analysis, apart from Scania that answered that this was not appliable.

23. Have you made any life cycle analysis, e.g. if the item is in its introduction, mature or end faze. If so, did you use this analysis in your inventory management?
Four of the companies used a life cycle analyse in the control of the spare part stock. Three of the others used it, but not in the stock control. Volvo cars had done some analysis but did not come to any conclusions. Alfa Laval and Kalmar had not made any analysis and Scania did not answer.

5. Analysis

This chapter discusses and analyses empirics in chapter 4 and makes comparisons to theories in chapter 3.

5.1. Benchmarking of other companies

Alfa Laval in Staffanstorp has 2% (1200 of 54500) of their assortment as SI. There is a grey zone regarding this number because of the "special" NI that is assembled from SI items with a short lead time(<5 days). If these are included the share increases to around 20%. When analyzing the demand data from Staffanstorp including the past 4 years, it shows that only 23% of the 54500 items have had a demand. This can be explained by Alfa Laval's policy to offer the customers spare parts for products during almost their whole lifecycle. These lifecycles are often several decades. Compared to the other companies in the benchmarking, Staffanstorp has a very small share of the assortment in stock. Sapa that has a very customer order based production has about 3% of their assortment in stock. The other companies have 14-20% except from Sandvik, Volvo and Scania that have almost 100%. A important figure in this matter is that Alfa Laval's 2% stands for 40% of the total turnover value. The other companies, except for Sapa are all having a larger share of the turnover value in stock. When comparing these numbers it is easy to se that Alfa Laval has a very large % turnover value in stock/ % SI items ratio. This ratio is perhaps not a measure that includes all aspects, but good enough concerning the statistics which have been available for the writing of this thesis.

Kalmar	**Atlas Copco**	**ITT Flygt**	**Nederman**	**Volvo cars**	**Volvo Group**
6,23	2,50	4,00	3,39	1,01	2,50
Scania parts	**Sandvik tooling**	**Sapa**	**ABB**	**Alfa Laval**	
1,00	0,85	10,50	3,71	18,17	

Table 5.1.The companies % turnover value in stock/ % SI items ratio

The large ratio could be interpreted as that Alfa Laval has a better Pareto situation than the other companies. Or in other words, Alfa Laval has a relatively small number of items that represents a large share of the turnover value. When also regarding the low share of turnover value in stock we make the assumption that Alfa Laval is spending lesser resources on their stock keeping than the other companies. This supports the complaints from the sales department about bad service concerning spare parts. One thing that should be added here is that when including the "special" NI, the share of the Alfa Laval turnover value in stock increases to 81%. This is an interesting aspect but we can not take that into concern when comparing with the other companies because they might have a similar situation which we do not know about.

When looking at the question about how to estimate if an item should be kept in stock or not, it is only Alfa Laval that exclusively looks at the picking frequency. Several of the other companies use the picking frequency as one of the parameters, but in combination with something else. Which method that is most effective in Alfa Laval's case is analysed in chapter 5.2.1.

When looking at the question about how often the classification is done regarding what should be kept in stock or not, Alfa Laval and ABB has the longest period. What is troubling with this is that like in so many other cases in the organisation this principle is not followed by the Alfa Laval personnel in charge of the practical management in the warehouse. They are reclassifying continuous during the year. In some extreme cases it is necessary to make these reclassifications, but not to the extent of today. This behaviour is not making things easier when trying to evaluate if the current setup is working or not.

Regarding what time period which is used when reclassifying, Flygt is going to decrease the period length from one year to six months. This leads to a faster reacting system but also to a more nervous one. The question is if Alfa Laval can get reliable data on especially the slow moving part if such a short period is used. There are already hard as it is today when looking at one year. One approach is to use a shorter period in the introduction and end phase of the life cycle to receive the faster reaction in the system and a longer time period in the mature phase when the demand is more stable. Scania and several others use longer time periods with the motivation that their products have such a long lifecycles. This description is also applicable on Alfa Laval's items. This would have an affect especially when looking at the slow moving parts when a longer time period gives larger values to work with.

Alfa Laval is the only company that are doing their ABC classification based on the picking frequency. A analyse of this is made in chapter 5.3. When updating their ABC Alfa Laval is using the time period of one month, which most of the other companies also does. This is not something that is closer analysed in this thesis.

Many of the companies are using DC's as a part of their distribution chain. The approach in this case is mostly depending on which level the companies have on their service. Those who has got the toughest demand on the delivery time has the most frequent items close to the customer. It also depends on how valuable the items are and in what volumes.

Many of the companies have got their items divided into families but there is hard to make any conclusions about the spare part handling out of that.

The general approach among the companies are to gather the assortment on the DC's depending on what market they are intended to serve. Alfa Laval's layout is probably suitable for their needs. Their items are generally expensive, so the distribution cost are not such a big issue for them as it is for many of the other companies. This makes it easier to fulfil a short lead time on the items in stock. Once again, the sales department are satisfied with the SI items at Alfa Laval, it is the NI and RI they are complaining about. And in that case it is not the transportation so much as the manufacturing time that is the problem.

Sandvik's investigation showed on increasing cost and a lower service when having more items as NI. Atlas Copco has made the opposite judgement and has increased the NI items. How to interpret this is hard, but the lead time demands from the customers is an important factor in this case. The basics for this question is described in chapter 3.5.1. When looking at Alfa Laval's lead times in general, a larger amount of NI can not be a very popular decision amongst the customers and the sales department. As we se it, well motivated criticism from the sales department and the conclusions from the beginning of this chapter concerning the amount of resources spent on stock keeping of spare parts, a higher share of today's NI items should be classified as SI.

The most common way to divide the handling costs is a general mark up. By this follows that high volume items carries a greater share of the handling costs then they should. The Kolding model with differentiated mark ups seems to be a better approach if Alfa Laval thinks it is worth the effort to implement. The approach with separate mark ups seems to be working for Sapa and Sandvik.

The participating companies were generally using SERV1 and SERV2 for measuring their service levels. There are downsides with both these measures. SERV1 does not take the volume into concern and SERV2 excludes the frequency. The theory describes the SERV2 to be the better one of these two describing the experienced service by the customer. Alfa Laval is mainly looking at the SERV1 based on picking lines. If they were to look more at the SERV1 based on the complete orders that are delivered as many other companies, they would get a better picture of how their service really works. We cannot find any reason not to measure both SERV1 and SERV2. Even if only one of them is used to control the stock, the other one can be a valuable helping tool.

Alfa Laval has made some kind of lead time analyse when deciding to assemble the items that consists of other SI items in Staffanstorp with a relatively short lead time. This kind of postponement saves a great deal, when not having to stock a lot of combinations that can be assembled easily. Despite from this postponement, no other analyse has been made and we do not see the relevance in making it either. This is because of the overall long lead times of the items which makes it impossible to reclassify SI to NI because of this reason.

Regarding a life cycle analysis, there should be interesting to study a graphical illustration of an items demand to conclude some kind of general trend. Even though the demand in some cases can be extremely variable, it can still be a valuable source of information when looking at the high volume products which stands for most of the obsolescence risk.

5.2. Overhaul of the present classification system

In this chapter we try to answer the questions of which part and how much of Alfa Laval's range of products should be kept in stock. We will answer this question mainly by examine how inventory costs and service levels are affected by different inventory set ups.

Alfa Laval's way to divide items in SI, NI and RI is both logical and simple. The present limit between NI and RI (>1 pick) seems to be logic. Our work concerning the classification has almost solely been about where to draw the limit between the classes NI and SI and the rules concerning them. The reason for this is that it is these two classes that gives the results when looking at the customer service and inventory cost.

To analyse this question, data have been collected from all items that has been a part of the product range at DC Staffanstorp within the last four years. The collection of data has been made by sending queries to the Enterprise Resource Planning system/Warehouse Management System used at Alfa Laval, which is *Jeeves©* in the DC Staffanstorp case.

In order to analyse the collected data in an appropriate way, a number of requirements have been established. Each item must have all required data to be valid in the analysis. These requirements will be listed below.

- Standard Cost.
- Lead Time
- MAD value or Standard Deviation
- Forecast for the next 12th months
- Delivered number of order lines.
- Delivered Quantity

If these data is collected it is eventually possible to calculate the value of the theoretical average inventory, inventory turnover rate and the service level which are the premier measurements used to evaluate the impact of what is kept in stock.

$$Theoretical\ Average\ Inventory Value = (SS + \frac{EOQ}{2}) * Std.\cos t$$

This formula is an approximation used under the condition that replenishments are generally made when the SS level is reached.

$$Iventory\,Turnover\,Rate = \frac{Turnover\,Value}{Theoretical\,Average\,Inventory\,Value}$$

As showed before the SS could be based on either SERV1 or SERV2 and is affected by the lead time, the standard deviation and the desired service level. The SS based on SERV2 is also affected by the order quantity. Due to simplicity and lack of data the equation of the standard deviation is simplified with the assumption of a constant lead time.

The collection of data visualised many shortcomings. Several data is missing which complicates the analysis. The biggest shortcoming seems to be the lack of forecasts and lead times. A large number of items lack data even if they are classified as NI and SI according to the definition of number of picks. According to the stocking policy used at Alfa Laval NI and SI items should always have a forecast, a standard price and a lead time.

Another shortcoming is that several lead times are inaccurate which leads to unnecessary large SS. The worst case scenarios are the lead time for titanium plates that are set to 998 days. The rationale of this is to show to the customer that there is a shortage of titanium and therefore a long lead time. These shortages should be illustrated in another way so they do not affect the size of the SS in a drastic manner.

Demand data last 48 months	**Total**	**UI**	**RI**	**SI**	**NI**
Number of items in database	**54090**				
Items without demand last 48 months	41661				
Items with demand	**12429**				
No standard price, forecast or lead time	10951				
These 10951 items consist of:					
No standard price	*113*	*112*	*1*		
No forecast	*10914*	*1162*	*149*	*20*	*9583*
No forecast despite minimum 2 picks during last year	*2956*	*195*	*22*	*19*	*2720*
No lead time	*462*	*419*	*12*	*1*	*30*
Number of items with complete data	**1478**	**39**	**2**	**866**	**571**
Number of items with complete data(Last 12 months)	**1446**	**24**	**1**	**866**	**555**
Removal of UI items and one invalid NI item	25	24			1
Number of items with complete and valid data	**1421**	**0**	**1**	**866**	**554**
Invalid Lead time(titanium)	*57*				

Table 5.2. Assortment to receive items with valid data to be used in the analysis.

Table 5.2. clearly shows the shortcomings mentioned earlier. The most obvious example is that there are 2761 items (RI, SI and NI) picked more then two times during last year that lacks a forecast. This means that out of all products that is supposed to have a forecast it is missing in 66% of the cases. The items with invalid lead time have been arbitrary changed from 999 days to 200 to make them more appropriate in the ongoing part of the analysis.

A major issue in our thesis is how to handle slow moving parts. Out of the 2761 items that has no forecast almost every single one is low frequent. This makes the analysis somehow inaccurate since the used data mostly derives from items with high demand.

To simplify the analysis even more, the large amount of "special" NI-items that are assembled varieties of SI-plates and SI-gaskets has now been classified as SI if they meet the right classification requirements. E.g., if one of those NI item are picked 6 times during a year it will now be classified as a SI item. We made this choice since the "special" NI-setup of these items is a local phenomenon at DC Staffanstorp. The second reason is that with the former setup the measurement of the share of the total demand that is kept in stock would be to low.

We will try to illustrate by an example. If we have 8 SI items and 2 "special" NI items each picked 6 times a year the former system would say that 80% of the items was kept in stock. In our analysis we state the 100% of the items are kept in stock, which we believe reflects the reality in a better way. In the former system it would be impossible to reach 100% even if all items where kept in stock.

All articles with complete and valid data (1421)	**Number of picks**	% of valid data	% of all	**Turnover Value**	% of valid data	% of all	**Number of Items**	% of valid data	% of all
All Articles with valid Data	64394	100,0%	76,5%	108508720	100,00%	52,1%	1421	100,0%	20,0%
Minimum of 4 order lines	64016	99,4%	76,0%	107960781	99,50%	51,8%	1244	87,5%	17,5%
Minimum of 10 order lines	61873	96,1%	73,5%	97331944	89,70%	46,7%	900	63,3%	12,7%
Minimum of 15 order lines	59709	92,7%	70,9%	90022016	82,96%	43,2%	719	50,6%	10,1%
Minimum of 20 order lines	57436	89,2%	68,2%	83145191	76,63%	39,9%	586	41,2%	8,3%
Minimum of 25 order lines	55625	86,4%	66,1%	73315559	67,57%	35,2%	504	35,5%	7,1%
All Articles	84215			208463588			7093		

Table 5.3. %age of valid data compared with all available data.

One of the purposes of this study is to answer the question:

What will happen if we classify from the opposite way, e.g. 96% of all picks will define items as SI's, 97% - 99% as NI's and the rest as RI's.

Today the classification method is based on picking frequency, where a SI should be picked four times or more. The used measurement is:

$$\%\,of\ total\ demand\ \ keept\ \ in\,stock = \frac{Number\ of\ delivered\ orderlines\ classified\ as\ stocked\ (SI)}{Total\ number\ of\ delivered\ orderlines}$$

As we can see clearly in table 5.3, 4 picks or more is equal to 99,4% of picks and 99,5% of the turnover value out of the items with valid data but only 76% of all picks and 51,8% of the total turnover. This leads us to the problem that it will be impossible to reach the desired limit of 96% of all picks classified as SI.

In order to get most benefits out of our valid data we have decided to use an artificial rule that states that 90% of all picks with valid data should be kept in stock. After several discussions we have made the conclusion that this is a suitable limit. Secondly we believe that it is not the limit itself that is important but the method of calculating what should be kept in stock or not. The availability has been set to 95% (SERV1) measured in order lines and the fill rate has been set to 95% (SERV2)

5.2.1. Different Inventory Classification Methods

In this analysis the object has been to minimize the total theoretical inventory value, to maximize inventory turnover value and to maintain a desired service level of 95% (SERV1 and SERV2) while having 90% of the total number of picks in stock.

In the rest of this chapter we are going to analyse different classification methods by the measures made above. The methods are compared with each other and with the cost of having all items in stock.

Basic Principles

We began the analysis by using simple single criterion methods. The advantages with those methods are that they are easy to implement and to understand. In our ongoing analysis we primarily use multiple-criteria weighted linear optimization mainly influenced by the theory of Ramanathan, see chapter 3.14.1. Several criterions are used and the score of each criterion will then be multiplied together in a weighted function, we call this the “Inventory Score”. This weighted function indicates if the item should be kept in stock or not. The basic principle is that an item with a high inventory score should be kept in stock prior to an item with a low inventory score. Originally this method was supposed to be used as a method to classify items already kept in stock, but our analysis shows that it is also possible to apply this method to answer the question if an item should be kept in stock or not.

The AHP method, is another powerful and flexible multi-criteria decision making method, see chapter 3.14.1. This method is based on different criteria’s placed in a hieratic order. In our analysis we have been able to identify these criteria’s, but it has been hard to decide the mutual hieratic order between them, therefore we will not present an analysis of this method.

1. Present Classification: Number of Picks

In this classification all items are listed by their total number of picks in a descending order. To separate two items with the same amount of picks we have decided to keep the item with the highest volume. The advantage with this method is that it keeps a small number of items in stock and has a low inventory value. It keeps the risk of obsolescence low. It is also very simple and easy to understand. According to theory many picks also usually lowers the standard deviation, which lowers the SS. There are also some disadvantages.

- An item with a low but steady demand does not get stocked. E.g. with the present classification limit with four picks, several items that are picked 2-3 times a year during several years are not stocked.
- Items that are picked at low frequencies and in small volumes often have a slow turnover rate. This depends on the large economic order quantities that are calculated.
- Items that are picked at low frequencies and in large volumes often have a slow turnover rate. This depends on the large SS that are calculated.
- Items with a high demand measured in volume but low demand measured in number of picks does not get stocked. These items should be kept in stock under the condition that the demand can be satisfied immediately from stock on hand.

2. Volume

Items are listed in a descending order classified by their total delivered quantity. To separate two items with the same quantity we have decided to keep the item with the highest amount of picks. This method shows better results if we measure the availability in share of total volume kept in stock. As it is now the average inventory value is to large compared to the %ages of order lines that are kept in stock. The disadvantage with this method is that items with a low but steady demand, i.e. a lot of picks but small total volume does not get stocked while an item with a high but temporary demand get stocked.

3. Turnover value

Items are listed in an ascending order classified by their turnover value. This method shows the best results if the object is to maximize the total number of items in stock while limiting the turnover value in stock. If the object is to minimize the total amount of items in the classification should be made in a descending order. This method is more suitable for classifying different service levels for items that are already decided to be kept in stock, i.e. the classical ABC-calculation model that claims that items with a high turnover value should have a lower service level then items with a low turnover value.

4. Number of Picks / Turnover value

In this classification method our thought was to maximize the number of picks and to minimize the turnover value. In this way we create a factor that indicates that an item with a large factor value should be kept in stock prior to an item with a low value. This first try to differentiate items by creating a factor does not show any good result. This depends on the large correlation between turnover value and number of picks.

5. Number of Picks / Standard Deviation during Lead time

Our thought in this method is that items with a low number of picks and a large σ_{LT} should not be kept in stock. Here we can see obvious results in terms of a lower inventory value. Items that are sorted out generally have few picks and a long lead time. One problem is that some items with a high a continuous demand (many picks) are sorted out because of their long lead time. In general a high standard deviation depends on variations in demand patterns.

6. Volume*picks/Standard Cost

Items with large volumes, many picks and low standard cost should be kept in stock. This method results in the same average inventory value as the classification based on picks. It is more complicated then the present method and does not show any better results; hence it will not be more evaluated.

7. EOQ

This method classifies items in a descending order after the size of the economic order quantity. There are no significant advantages using this method.

8. Number of picks/((EOQ+SS)*Standard Cost)

Here the object was to maximize the number of picks and to minimize the cost of the EOQ and the SS. This method shows the best results so far. The inventory value is cut by half while maintaining the same amount of order lines in stock.

9. Number of picks/Average Inventory Value

The method is similar to the one above except that we divided the EOQ into half. This is equal to the average inventory value. This is the best method we have developed in our thesis and shows the best results. It manages to sort out the items that are most expensive to keep in stock. A typical product that is sorted out has a long lead time, a high standard cost and few picks and large volumes. This method has some problems which we will discuss further on in chapter 5.2.2.

10. Number of picks^x/Average Inventory Value

The object in this method is the same as in method nbr. 9, but have increased the impact of the total number of picks. The result shows that the positive effects are that the number of items decreases and the inventory turnover rate increases. The negative effect is that the average inventory value increases slightly.

11. Number of picks/Average Inventory Value[x]

The object in this method is the same as in method nr. 9 but to increase the impact of the total average inventory value. This results in more stocked items and a lower turnover value.

12. Number of picks/Standard Cost

Items with a large number of picks and low standard cost should be kept in stock. This is a very simple and understandable method that shows good results. This method has an advantage of being very similar to the original setup.

13. Number of picks^2/Standard Cost

Same as in method nr. 12, but with an increased weight on number of picks.

14. Volume/ Average Inventory Value

This method is the same as in method nr. 9 but here the volume is divided with the average inventory level. As mentioned before this method as well as all other methods based on volume is much more suitable if we measure the demand in the total share of the volume kept in inventory.

Classification Method	Total	picks	volume	Turnover value	Picks/ (Std.Dev.LT)
Number of different articles	1421	614	787	1398	1092
% of orderlines that is kept in inventory	100,00%	90,02%	90,05%	90,01%	90,00%
% of volume that is kept in inventory	100,00%	91,48%	99,04%	84,13%	71,63%
% of turnover value that is kept in inventory	100,00%	77,66%	96,06%	74,85%	55,05%
Theoretical Average Inventory Value (SERV1)	17648639	9936940,41	15419937,7	14134212	6500942,42
Theoretical Average Inventory Value (SERV2)	13141981	7488153,58	11273879,5	10032866	4949832,68
Theoretical ITR(SERV1)	5,90	8,37	6,52	5,40	8,42
Theoretical ITR(SERV2)	7,93	11,11	8,92	7,60	11,06
SERV1	95,0%	95,0%	95,0%	95,0%	95,0%
SERV2	95,0%	95,2%	95,0%	95,0%	95,6%
Total number of Picks	64394	57968	57989	57963	57954
Total delivered Quantity	2019388	1847388	1999973	1698954	1446543
Total Quantity Forecast 12 Months	2066542	1911562	2048629	1747545	1452962
Total Delivered 12 Months std.cost	108508720	84268591	104228458	81219300	59731578,1
Forecast 12 Months Std.Cost	104206264	83177750,6	100513434	76257669	54745106,6

Table 5.4. Shows the result for different classification methods

Classification Method	Picks/ (Std.Dev.LT *std.cost)	Picks/((EO Q/+SS)*Std. Cost)	picks/(Av.In v.Val)	picks/Stc.c ost	volume/(Av. Inv.Val.)
Number of different articles	1012	949	967	715	808
% of orderlines that is kept in inventory	90,01%	90,02%	90,00%	90,02%	90,00%
% of volume that is kept in inventory	80,20%	79,98%	79,77%	93,58%	95,98%
% of turnover value that is kept in inventory	45,72%	46,84%	46,40%	64,92%	71,46%
Theoretical Average Inventory Value (SERV1)	4973150,75	4929705	4910343	7479885	8004019
Theoretical Average Inventory Value (SERV2)	3579755,92	3579957	3553710	5364750	5925938
Theoretical ITR(SERV1)	9,48	9,59	9,60	9,39	9,32
Theoretical ITR(SERV2)	13,17	13,21	13,27	13,09	12,59
SERV1	95,0%	95,0%	95,0%	95,0%	95,0%
SERV2	95,4%	95,5%	95,5%	95,2%	95,3%
Total number of Picks	57964	57965	57953	57966	57954
Total delivered Quantity	1619555	1615117	1610920	1889691	1938136
Total Quantity Forecast 12 Months	1659872	1635952	1646520	1951581	1984584
Total Delivered 12 Months std.cost	49613641,6	50830619,8	50344582,9	70443806	77536708,7
Forecast 12 Months Std.Cost	47144677,7	47287221,7	47162398,1	70215692	74602952,5

Table 5.5. Shows the result for different classification methods

Our calculations show that there are several types of classifications that lower the total inventory cost. The easiest way to classify is by using one criterion. If we classify by two criterions as in the examples with number of picks divided with the standard cost this results in a lower inventory cost then using one category. The best classification but also the most complicated is the one using a combination of several different criterions. This is the case when we classify by using average inventory value.

5.2.2. +/- using classification methods with several criterions

The advantages of using several criterions when classifying is obvious: It is easier to identify which items that is least suitable to keep in stock.

Item No.	Std. Cost	Lead Time Days	Forecast Quantity	No. Of Order Lines	Delivered Quantity	Turnover Value	EOQ	SS	Theoretical Average Inventory Value
1	656	57	3366	7	2281	1495492	91	1183	805619
2	591	72	194	3	32	18908	23	237	146665
3	2071	83	1776	21	1891	3916564	37	393	852483
4	492	200	634	7	247	121591	46	350	183409
5	755	32	33	6	33	24909	8	194	149282
6	204	198	2	5	334	68143	4	575	117622
7	2113	72	6	1	10	21131	2	10	22892
8	167	26	1634	5	1705	284769	126	532	99419
9	64234	37	1	6	6	385404	0,2	2	117453
10	203	26	43	3	129	26142	19	276	57739
% of all				**0,10%**	**0,34%**	**5,94%**			**14,50%**

Table 5.6. The most expensive products to keep in inventory according to the picks/Average inventory value method.

The table shows the most expensive products to keep in inventory. Here 0.1% of all picks equals 14.5% of the expected inventory value. As seen in the table items in general have a high standard cost, a long lead time, few picks and an extremely large SS. Also it is worth noticing that seven out of these ten items would be kept in stock in the present classification system. A problem with this method is that some items with a high demand are classified as non stocked items just because they are expensive to keep in stock, e.g. item number 3. To solve this, our thought is to use certain limitations in our classification. This will be more discussed further on in chapter 5.2.4.

5.2.3. Other factors that affects the classification

The factors mentioned in this chapter could be important factors for the classification, but have not been analysed by numerical methods. This depends on the absence of data for those factors. It would be possible to make good estimations of those factors, but we have chosen not to investigate this area further due to our timeframe for this thesis.

Durability
According to *Wanke and Zinn*, see chapter 3.5.1, the greater the durability of the final product, the more likely the product is made to order or purchased to order to avoid loss of inventory. In the Alfa Laval case gaskets has a much shorter durability then plates and other components. In order to prevent gaskets with low turnover to be kept in stock a factor could be multiplied to the inventory score. E.g. If a factor of 0.5 is multiplied to the inventory score the requirements for a gasket to be kept in stock is much higher then for a plate, which have longer durability.

Obsolescence
The obsolescence or the coefficient of variations of sales should also be taken into consideration when classifying. The risk of holding such inventory is higher if an item has a short life time. The first thing that could be said is that the large values of obsolescence that are presented in financial reports, e.g. table 4.13. are much greater then the physical obsolescence. There are several opinions within Alfa Laval why obsolescence occurs and what levels of obsolescence that is acceptable. For instance manually changed forecasts, sudden drop of demand, low durability and demand peaks have been mentioned. Other possible reasons are the inventory that was ordered in to large volumes before Alfa Laval introduced their current classification system. We believe that the largest cost for obsolescence is former high volume items with large quantities on hand where demand suddenly has dropped. In order to minimize the impact of these items we believe that it is important to be cautious when calculating forecasts and SS for stocked items. When deciding if an item should be kept in stock or not the demand is a crucial factor. The classification system used today is mainly based on the fact that items with many picks is less inclined to become obsolete then items with few picks. However we believe that items with few picks do not stand for a large share of the obsolescence cost and should therefore be stocked in many cases. In chapter 5.5.2

we will describe more precisely which low frequent items that should be stocked and in chapter 5.2.4 how to settle an appropriate stocking policy for these items.

Part criticality

Some critical items should be stocked even if the demand is low. This could be solved in mainly two ways. Either you set a policy that decides what parts that have to be stored at all times, or you use factor that is multiplied to the inventory score. This factor could be set within a wide range, stretching from anywhere between 1 and 100 depending of the part criticality. The reason to store this type of critical emergency items is that some customers have an extremely high downtime cost compared to the value of the stored item. If Alfa Laval offers these products to customer directly from stock, it creates a great goodwill and customer value.

Lead time ratio

The lead time ratio is the quotient of the delivery time over the supplied lead time, which means how much time that is available to manufacture a product once it is sold. If the lead time is shorter then the delivery time there is no need to stock items. This fact is used at DC in Staffanstorp for different NI-items that are assembled varieties of SI-plates and SI-gaskets in different combinations. These items have a short lead time ranging between one and five days, which is acceptable to the customer. Most NI items sold at DC's within Alfa Laval have a much longer lead time then customer accept. Therefore it is not possible to make these items on a make to order basis. The key question for the DC's to lower their inventory level is to shorten the lead time from their suppliers.

5.2.4. Introduction of certain limitations

We have introduced several different classification methods, some more complicated then others. All methods has its advantages and disadvantages and because of this some items that should be kept in stock are classified as a non stocked item and the other way around. In other cases items that are kept in stock are ordered in to large quantities or with to large SS. Because of this these items accounts for an unnecessarily large share of the inventory costs and also have a very long turnover rate that increases the risk for obsolescence. In order to minimize these risks we want to recommend some basic limitations.

Limitation of the SS

By limiting the MAD value the SS levels for some items would be lowered considerably. This suggestion has already been tested at Alfa Laval but is not currently in use. In their setup the MAD value of each item was limited to a maximum of 10% of the yearly demand. Our calculations show that this limitation alone would lower the average inventory cost with 17 %.

Limitation of Q

In several cases the ordered quantities are too large. Because of the EOQ formula some cheap items are ordered in quantities that will take several years to turn over.

An option could be to lower the ordering cost used in the economic order quantity formula which will lower the ordered quantities. On the contrary we believe that plates ordered from the production should have higher ordering costs. In many cases the EOQ for expensive plates with high demand is very low compared to the demand and the SS. By ordering does in larger quantities a lot of work could be saved and less set ups need to be made. Another limitation could be to set a maximum order quantity equal to one or two times of the forecast for next year.

Limited service level for low frequent items

Items that are picked few times during a year often require large SS to achieve high service levels. This is due to their large deviations in demand. If Alfa Laval decides to keep these items in stock they could do so by storing them without a SS. In this case the service level measured in SERV1 would drop to 50 % but SERV2 can still be kept relatively high. This is a way of minimizing the risk of having low frequent items in stock. The reason of having those items in stock is that they create extra customer value compared to selling them with a long lead time lot for lot. We believe that the customer value is much greater then the cost for keeping those items in stock.

Maximum order value

Sporadic and extreme demand values disturb the forecast, especially when looking at a short time period. These extreme values should be removed from the forecast because even with large SS Alfa Laval will not be able to deliver such high order quantities directly from stock. They only lead to unnecessarily high stock levels. Another problem is that during the refill time the stock level is down at zero, which means that no other orders could be delivered with a lowered service level as a consequence. To solve this problem a maximum order level should be introduced.

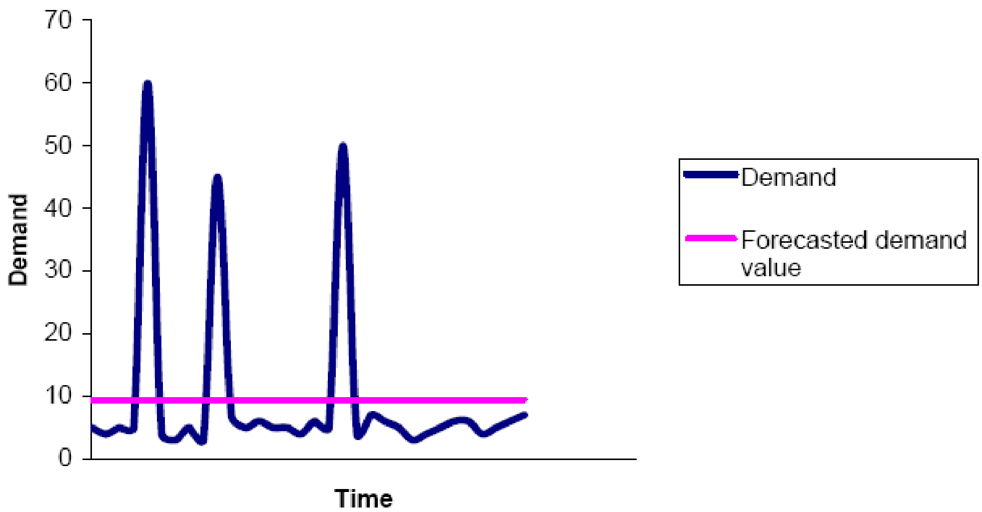

Figure 5.1. Forecasted demand with spikes

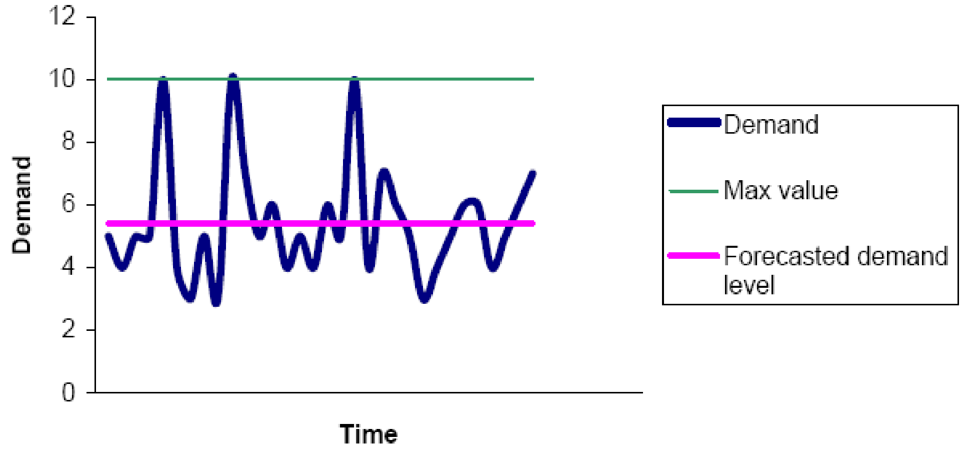

Figure 5.2. Forecasted demand with max. order value

Figure 5.1 and 5.2 are based on an item with 32 picks in one year that has three "spike" values. It is easy to see that the forecasted demand level is drawn up by the spike values and that it will be more correct compared to most of the orders when using a maximum order value.

We have found two approaches with this maximum order level. Either Alfa Laval let the customer know about the maximum order level or they keep it hidden. If they let the customer know, the customer who wants to have a larger amount than the maximum level can directly see that he has to except a certain lead time. This makes it clear for the customer in an early stage what he can expect. It must be further investigated if this fact is experienced as positive or not by the customer. If the level is hidden, the ordering system would work as today towards the customer. Either way, the maximum ordering level does not make any practical difference for the customer because he would have to wait for his large order anyway. The difference is that the forecast could be calculated more correctly.

Another thing is that these "spikes" are often represented by internal orders from other parts of the organisation, e.g. other warehouses. In these cases it is even more unnecessary to disturb the forecast with their high volume orders. Such a high volume orders should be going directly to the production and are not to be included in the warehouse statistics.

Even demand during the year

Another situation with abnormal "spikes" is when most of the orders occur during a short period of time. E.g. if an item is picked 10 times during one year and 100 pieces each time, it makes a lot of difference if these picks occur during one month or is spread over ten. When the picks are gathered during a short period of time a similar situation as the abnormal demand values described above arises. Anders Granelli suggests therefore that there should be restrictions of how the picks should be spread over the year. An item that has a high demand during one or two months every year and nothing during the other months should not be kept in stock even though the number of picks exceeds the SI-limit. These types of demands could not be taken directly from stock anyway when the refill times are long. In other cases when an item has an even demand during many years, this item should be kept in stock even though the number of picks is below the SI-limit.

5.2.5. What will happen if we classify from the other way?

What will happen is that a percentage of the accumulated number of picks will decide were to draw the line between SI, NI and RI. With the present setup, when a certain number of picks decides what class the item should be in, the percentage measure takes rather big jumps. E.g. if the SI-limit is set to be 4 picks it corresponds to 85 % while 3 picks corresponds to 95 % of the accumulated number of picks. To be able to do the classification the opposite way it is necessary to bring another factor into concern when having to separate the items with the same number of picks. Factors that might be useful are examined in chapter 5.2.1.

Another affect when using a percentage of the number of accumulated picks is that different warehouses now get different limits between the SI, NI and RI. E.g. a 95% limit in a large warehouse can be equal to 10 picks while it in a small one can be equal to 4.

5.3. ABC Classification

In order to manage all stocked items and to set appropriate service levels for all of them it is very useful to introduce a classification system. In our analysis our only goal with the classification is to lower the inventory cost while maintaining the desired service level. The analysis has been made with four classification methods and with two different setups of inventory. We used the same data as in chapter 5.1. Just as before the analysis is based on a total service level of (SERV1) of 95%. It could be possible to increase and improve this analysis even more by analysing the optimal size of the ABC classes. We have chosen to use Alfa Laval's currents setup of 5%, 15% and 80%.

5.3.1. ABC Classification methods

ABC based on number of picks.

Class	C	B	A	Total
% of Turnover value	x	x	x	100%
% of Orderlines	5%	15%	80%	100%
ServiceLevel(SERV1)	81%	89%	97%	95%

Table 5.7. ABC based on number of picks

This is Alfa Laval own setup. This method shows good result in the classification system used today at Alfa Laval, where the items in stock are based on picks. If the new classification method based on picks/average inventory value is used this ABC method does not show good results.

ABC based on turnover value.

Class	C	B	A	Total
% of Turnover value	5%	15%	80%	100%
% of Orderlines	x	x	x	100%
ServiceLevel(SERV1)	99%	97%	92%	95%

Table 5.8. ABC based on turnover value

This is the most common method that is suggested in theory. In our analysis this method shows decent results but not as good as the ABC method based on picks.

ABC Matrix based on number of picks/ turnover value

		C		B		A		Tot
		Picks	Turnovervalue	Picks	Turnovervalue	Picks	Turnovervalue	
A	Picks	8,84%	8,9	20,71%	2,9	50,41%	0,7	80,0%
	Turnovervalue		1,00%		7,20%		73,67%	
B	Picks	8,78%	3,9	4,98%	0,7	1,27%	0,2	15,0%
	Turnovervalue		2,27%		6,87%		6,12%	
C	Picks	4,63%	2,7	0,36%	0,4	0,02%	0,1	5,0%
	Turnovervalue		1,73%		0,93%		0,21%	
Tot		22,25%	5,00%	26,04%	15,00%	51,70%	80,00%	100,0%

Table 5.9. ABC matrix based on number of picks/ turnover value

In this method, also suggested by Olhager in chapter 3.10, we use a combination of the two above categories. They create a matrix with a total of nine classes ranging from AA to CC, where e.g. the AC, AB and AA classes is equal to the former A class (80% of all picks) in the method based on picks and AC, BC, CC is equal to the former C class (5% of the total turnover value) in the method based on turnover value. The numbers with the white digits in the black boxes are equal to the quotient of the picks value/turnover value in each class. A class with a high value on this quotient should have a higher service level then a class with a low value on its quotient to create a maximum total service level with a minimum inventory value.

99,9%	98,0%	94,0%	99,0%	99,0%	92,5%	A	A	B
99,0%	94,0%	85,0%	99,0%	92,5%	85,0%	A	B	C
97,0%	92,0%	80,0%	99,0%	85,0%	85,0%	A	C	C
1			2			3		

Table 5.10. Service levels in the ABC-matrix based on number of picks/ turnover value

In square one, nine different service levels (with a total service level of 95%) are set based on the quotient specified above. In square two and three these nine service levels have been simplified into three classes.

This method gives us better result then in the method only using one criterion.

Our analysis also tells us that it is hard to optimize the service levels of these nine classes by hand and that our result is even better if we simplify them into three classes.

It is a lot of work involved in creating a matrix and in most cases it is easier and more effective to create a factor between two criterions instead. However, this is not possible in all cases. E.g. it is possible to create a powerful matrix with the factors volume and turnover value but if we create a factor equal to volume/turnover value this is equal to the standard cost of the item, which is useless in this case.

ABC factor based on number of picks/ average inventory level

Class	C	B	A	Total
% of factor: Picks/Average Inventory Level	5%	15%	80%	100%
ServiceLevel(SERV1)	83%	93%	99%	95%

Table 5.11. ABC factor based on number of picks/ average inventory level

This method was developed from our previous inventory classification method from chapter 5.2.1.9. In similarity with previous analysis this method shows the best results among our tests. In this context the method is even more powerful then under the original setting. Under the ABC classification there is no reason for using the possible limitations discussed in the original method.

Total savings using different ABC methods

	Inventory based on picks	Inventory based on picks/average inventory value
ABC based on Turnover Value	4,37%	0,48%
ABC based on picks	10,73%	-0,60%
ABC based on Picks/Turnover value matrix	13,23%	2,20%
ABC based on Picks/ Average inventory Value factor	21,88%	9,92%

Table 5.12. Total savings using different ABC methods

Table 5.12 shows the results of using the different ABC methods. It is clear that the ABC classification has a greater impact on the inventory based on one criterion (number of picks) then it has on the inventory based on multi criteria's (picks/average inventory value).

	Original inventory Cost	ABC Savings	Total
Current classification method and current ABC method based on Picks	9936940	10,73%	8870307
Current classification method based on Picks and new ABC method based on picks/average inventory value	9936940	21,88%	7762738
New classification method and ABC method based on picks/average inventory value	4910343	9,92%	4423114
Savings Using New Method			50,14%

Table 5.13. Total cost of holding 90% of demand (based on picks) in Stock with a total availability (SERV1) of 95%

If the object is to keep a certain share (90%) of all order-lines (picks) in inventory with a total service level (SERV1) of 95% this table shows that a lot of savings could be done by switching classification and ABC method. The savings by switching methods is up to 50%

It is also possible to look at the problem form a different angel:

Our calculations shows that it is possible to keep approximately 98% of all picks in inventory for the same price as it cost to keep 90% of all picks by switching inventory classification- and ABC Method.

5.4. Handling cost for items within each class

The general overhead cost (GO) used today is a mark up that is based solely on the cost of each item that is ordered. It is a very simple method that is also used by many of Alfa Laval competitors. This method tends to favour small orders with cheap items over large orders with expensive items. In order to show the real cost in a more accurate way an activity based costing model has been developed. The model takes four factors into consideration when calculating the GO mark up for an order; number of order lines, standard cost, volume and type of item. This result in a more fair costing model where simple orders with few order lines of stocked items cost less then a small order with many order lines of non stocked items. By using this new method Alfa Laval is more eligible to set correct prices to the customer. The overhead cost (GO) at Alfa Laval is around 25%. This means that the activity based costing method should be suitable according to the study made by Vokurka and Lummus in chapter 3.13.1.

An opportunity for Alfa Laval is to develop the activity based costing model on step further by introducing more cost drivers. Possible drivers could be weight and size of an item. This way the costing could be even more accurate. The question is if it would be worth all extra work involved in measuring all items just to create a little bit more accuracy.

We believe that the pilot activity based costing project implemented in DC Kolding is suitable at other DC's within Alfa Laval. The method is relatively simple but also adjustable to fit local processes. At DC in Staffanstorp it would be appropriate to take the cost associated with assembling and manufacturing of certain NI items (see chapter 4.14.1) into consideration. An appropriate resource driver would be time and the cost should be based on number of order lines and a % value fee based on the volume and price of the items.

A weakness with the new method is that it requires more time and knowledge from the people working with it. In order for the model to work it is important that the warehouse managers are able to set the right parameters for the resource drivers. Some parameters, like square meters and number of order lines are easy to measure while other like time requires more careful estimations by the managers.

5.4.1. Standard cost in today's setup

When manufacturing an L4L-order with NI-items the standard price does not always reflect the real standard cost. This is described in chapter 4.10. It should be possible to give the smaller batches a higher price with a price based on the real batch size. The customers that order larger quantities should not be punished and pay some of the cost that arises from the orders of small quantities. Certainly there can not be too expensive to order a small quantity, e.g. if a customer order one NI item and to pay a whole setup cost, but some kind of system to reward larger orders should be applied. The online order site can have a table that shows the prices in different order quantities, etc.

Another thing is the difference in standard cost when a item goes from SI to NI or vice versa. The standard cost is changing significant if the value of the L4L batch sizes and the EOQ differs a lot. In general the standard cost is rising when making a SI item to a NI. This should be taken into the equation when reclassifying. This means that a change of class does not only affect the customer service, but also the standard cost.

5.5. Statistics during more then 12 months

In this chapter we try to analyse the affect of looking at statistics during more then 12 months. In order to do so we have collected all demand data for DC in Staffanstorp during the last 4 years. This data has been used in two ways, first to determine witch time period that gives the best forecasts results and secondly to look at demand patterns for low frequent items.

5.5.1. Forecast error

To measure which time period that gives us the best forecast result we have calculated the forecast errors for different time periods. The Forecast error has been calculated by the MAD-value. The MAD-Value has then been divided with the demand for the last period to express the error as a %age. The forecast is based on the moving average method for 1, 2, or 3 years and the exponential smoothing method with a α –value of 0,05 that has been running for 2 and 3 years. Today the forecasts at DC within Alfa Laval are based at a time period of one year.

MAD-Value In % of total demand	**Forecast Based on 3 years**	**Forecast Based on 2 years**	**Forecast Based on 1 year**
All Items with demand during the last year			
Moning Average Method	10,03%	8,42%	9,15%
Exponential Smoothing Metod	14,59%	10,16%	
High Frequent Items (10 picks or more)			
Moning Average Method	8,48%	7,45%	7,93%
Exponential Smoothing Metod	11,69%	9,71%	
High Frequent Items (20 picks or more)			
Moning Average Method	7,88%	6,82%	7,16%
Exponential Smoothing Metod	11,07%	8,63%	
Low Frequent Items (20 picks or less)			
Moning Average Method	15,57%	12,74%	14,38%
Exponential Smoothing Metod	23,17%	14,13%	
Low Frequent Items (10 picks or less)			
Moning Average Method	17,65%	13,25%	15,40%
Exponential Smoothing Metod	28,94%	15,65%	

Table 5.14. Forecast errors for different items and time periods. All items that are marked deleted or phase out in the collected data has been excluded form this analysis.

The forecast errors have been calculated for different types of items to see if the results differ between the groups. The moving average method gives better results then the exponential smoothing method. The result also shows that two years is the best forecast period for all types of items and that the results worsens for longer time periods when using the moving average method. Not surprisingly the forecast error is smaller for high frequent items then it is for low frequent items. These results cohere with the calculations made in Stig Arne Mattson's report that is described in chapter 3.1.3. His report claims that the results are best for a period of 18 periods or more when using the moving average method. It also claims that the exponential smoothing method is preferable when the demand is low and very variable. Another report performed by Jepson, Mårtensson, Rehncrona, Rojecki and Winter (2004) at Alfa Laval achieved the same result. It claims that the best forecast results for items with low demand are received when using the exponential smoothing method with a low α-value. This is however not true in our analysis. We believe that this depends on our demand data that is measured in years. If the data would have been measured in months our forecast would have more values and therefore it would have adjusted more from the original value and our forecast errors would become smaller.

5.5.2. Analysis of demand during four years

Alfa Laval's current classification method suggests that an item should be kept in stock if it is picked four times or more during a year. In this chapter we try to analyse the effects of using demand data for several years in our classification by comparing data from different time periods. The analysis has been made by comparing the total number of items kept in stock and how large share of all order lines they account for. We choose order lines as a factor instead of volume or turnover value because both classification and availability (SERV1) at Alfa Laval is based on this.

Number of items				
Year (Total)	**1**	**1+2**	**1+2+3**	**1+2+3+4**
Total	54090	54090	54090	54090
Minimum 1 Orderline	7093	9439	11041	12429
Minimum 2 Orderlines	4376	6088	7324	8425
Minimum 3 Orderlines	3279	4688	5695	6549
Minimum 4 Orderlines	2701	3927	4834	5575
Minimum 6 Orderlines	1966	3076	3778	4419
Minimum 8 Orderlines	1567	2568	3212	3733

Table 5.15. Number of items kept in stock depending on time period and number of order lines.

Share of all orderlines				
Year (Total)	**1**	**1+2**	**1+2+3**	**1+2+3+4**
Total	100,0%	100,0%	100,0%	100,0%
Minimum 1 Orderline	[redacted]			
Minimum 2 Orderlines	96,8%	98,0%	98,5%	98,8%
Minimum 3 Orderlines	94,2%	96,4%	97,2%	97,6%
Minimum 4 Orderlines	92,1%	95,0%	96,2%	96,7%
Minimum 6 Orderlines	88,3%	92,8%	94,3%	95,2%
Minimum 8 Orderlines	85,2%	90,9%	92,9%	93,8%

Table 5.16. Share of all sold order lines kept in stock depending on time period and number of order lines.

The tables for instance tells us that if the today classification system was followed strictly, 2701 items that stands for 92,1 % of all order lines would be kept in stock. An option that has been discussed is to classify over two years and then double the minimum number of order lines to eight. In this case the number of items and order lines slightly decrease.

There are several items that have a steady but low demand below 4 picks during the last year which are not classified as stocked in the today system. Table 5.17 shows that there are many items that are picked 2-3 times during several years. In our opinion these items should be kept in stock since they show a steady demand and therefore runs a small risk of becoming obsolete. If these items should be kept in stock they should be ordered in small quantities and with reduced SS to minimize risks.

Due to Alfa Laval's simplicity policy some persons within the company seem to favour the old system based on order lines. Instead of calculating how many items that should be kept in stock as a %age of the total demand a certain fixed limit measured in picks is desired. In order to set this limit we have evaluated numerous options and their affect of the inventory size.

Our suggestion is to primarily use data based on last year demand and to complement this with data based on several years for items with low but stable demand. If management wants more items in stock the limit for the minimal number of order lines should be lowered and vice versa. Since our opinion is to keep more items in stock we have mostly evaluated set ups that increase the number of items.

Minimal Number of Orderlines	Number of Items in Stock	Change Compared with today
2 during last year	4376	62%
2 each year during the last 2 years	3554	32%
2 each year during the last 3 years	2645	-2%
2 each year during the last 4 years	2281	-16%
3 during last year	3279	21%
3 each year during the last 2 years	2242	-17%
3 each year during the last 3 years	1981	-27%
3 last year or minimum of 2 each year during the last 4 years	3436	27%
3 last year or minimum of 2 each year during the last 3 years	3498	30%
3 last year or minimum of 2 each year during the last 2 years	3686	36%
4 during last year	2701	0%
4 last year or minimum of 2 each year during the last 4 years	3023	12%
4 last year or minimum of 2 each year during the last 3 years	3147	17%
4 last year or minimum of 2 each year during the last 2 years	3432	27%
4 last year or minimum of 3 each year during the last 4 years	2798	4%
4 last year or minimum of 3 each year during the last 3 years	2841	5%
4 last year or minimum of 3 each year during the last 2 years	2927	8%
5 during 2 years and minimum of 2 during last year	3214	19%
6 during 2 years	3076	14%
6 during 2 years and minimum of 2 during last year	2946	9%
8 during 2 years	2568	-5%
8 during 2 years and minimum of 2 during last year	2516	-7%
8 during 2 years or minimum of 2 each year during the last 3 years	2971	10%
8 during 2 years or minimum of 2 each year during the last 4 years	2833	5%
8 during 2 years or minimum of 3 each year during the last 3 years	2641	-2%
8 during 2 years or minimum of 3 each year during the last 4 years	2609	-3%

Table 5.17. Suggestions for different limits of picking frequency

5.6. Lead Time Analyse

A big problem with Alfa Laval's spare part distribution is that the lead time is often very long. In the theory we mention the *lead time ratio* that is the quotient of the *delivery time* over the supplied lead time, which means how much time that is available to manufacture a product once it is sold. The smaller the time available, the more likely products will be made to stock. One of the ground parameters of the question, make to order or make to stock are that the customers must be able to accept the lead time if the item should be reclassified from SI to NI. In Alfa Laval's case there are just the "special" NI products that have a lead time that can be called acceptable in an urgent spare part situation. The reason behind the short lead time for these items is that they are built together by SI components at the DC. Almost everything else has a lead time of at least seven weeks. It is not very likely that the customers who have an unplanned stop in their production would regard seven weeks as acceptable. The seven week lead time is more of an argument for having more items in stock.

One of the reasons behind the long lead times is that the production of spare parts and the ordinary production are not synchronized with each other. E.g., when NI items are needed they are manufactured L4L in an own batch in the factory with a long lead time. This can in many cases be avoided when the part perhaps is available in stock somewhere else in the organisation or when the same part is manufactured in the ordinary production, sometimes as often as several times per month. If a global spare part register would be implemented, a spare part could be sent from another location and thereby shortening the lead time. Also if a better communication could be established between the ordinary production and the spare parts production, it should not be hard to increase the batch size with a few items in the ordinary production and thereby save a setup cost. The extra time that it takes to produce some extra items are very small compare to the time that is consumed by an additional setup. This may also have a positive effect for the production in general when it does not have to be interrupted by small spare part batches as much as before. If the lead time can be lowered because of this, it affects the SS and thereby lowers the costs in the warehouses. The main problem with this idea is that it demands a lot of work with a setup of a communication system that has to be able to manage the complex situations that arises.

A different approach to achieve shorter lead time is to have a manufacturing unit only for spare parts. This would be more flexible and faster compared with today's setup but would generate a great deal of extra costs.

Another positive effect with shorter lead time is that it gives other competing companies and pirates a tougher situation on the market. Today is the situation that the customers often want to buy original parts but can not afford to wait because of the long lead time. This can also result in loosing the customer in the future because of lack of trust. In those cases when Alfa Laval can not come up with a spare part within reasonable time, they should be able to buy a pirate plate or gasket as a temporary solution. This would perhaps not generate such a good profit but the customer would at least be satisfied and Alfa Laval's goodwill would be kept alive instead of loosing the customer completely.

5.7. Other Ideas

5.7.1. One global DC for low frequent spare parts

As it is now, the limit when a spare part becomes a SI is >3 picks per year. If gathering all the low volume items in one global DC, the accumulated number of picks globally would in many cases rise above the SI level. See chapter 3.1.2. about centralised stockholding. This would lead to that a large number of former NI items all of a sudden becomes SI and can be delivered instantly. The more continuous demand that the accumulated number of picks results in, also brings down the MAD-values and there by also the SS. Another effect is a lower risk for obsolescence. The extra transportation costs the centralisation would generate are small compared to the positive effects according to Lars Warlin. The fact that more of Alfa Laval's spare parts are SI items would also make the situation harder for pirates and competitors.

5.7.2. More focus on service

According to Ulf Grevillius there is a lot of unused space in the after sales area regarding service. If there were more focus on this area it could generate several positive effects for the economy in several parts of the organisation. If more of the PHE were to be sold together with a service program this would help to secure a part of the demand forecast instead of it being based on historical data. Today there are several examples in the industry where small GSM-equipped gauges can measure the condition of a machine and the same method could certainly be used also on a PHE. If this was combined with a computer system that would keep track on the service cycles it could also help the production with their planning. It is hard to find any real disadvantages with implementing such a system. It seems it would bring security and economic advantages for all parties involved. The gauges and a extra computer system would of course add some extra costs but they can be considered as small compared to some of the customers down time costs. This system also brings another dimension to Alfa Laval's customer service and an advantage in the competition with other companies.

5.7.3. Store gaskets in vacuum

One of the problems with storing gaskets is that they have a limited durability. This ageing process could according to Srinivasan Iyengar be slowed down if storing the gaskets in vacuum. When looking at the way gaskets are stored today, it should not be hard to wrap each layer of gasket in a pallet with plastic and thereby achieve a better durability. If having gaskets delivered in vacuum from the suppliers they could postpone the exposure of oxygen until the time of picking or even to the delivery to the end customer. This idea is not directly included in our specification but has been included anyway because of the positive affect it could have on the logistics at Alfa Laval.

5.8. Simplicity

A constant repeated word during the work of this thesis has been ”simplicity”. To be able to reach out to all segments with a change of routines it is vital to keep things as simple as possible so that the implementation really follows thru. The problem is that the present 4 year old classification setup, which is based on the picking frequency, is very simple but anyway it seems not to have been fully applied by all the personnel yet. Now, when some segments want to go one step further in the development there will be an even larger difference between those who follows the directions and those who are still behind. A refinement of the system is necessary but will not give the desirable result if not the proper preparatory work is made. This issue is something that Alfa Laval should spend some serious effort on. An idea can be brilliant on the planning stage but it is finally judged by its performance in practical use.

6. Conclusion

This chapter will give answers to the purpose and the six specific questions of the report. The conclusions are based on the analyses made in chapter 5.

To remind the reader of the purpose of this master thesis it is repeated below.

The main purpose of this master thesis is to make an overhaul of the present classification concept at Alfa Laval's DC's for spare parts. Another purpose is to increase customer satisfaction and to reduce or keep cost.

6.1. Overhaul of the present concept

Our conclusions can be summarized into two specific statements.

- Alfa Laval's classification concept is not optimal and could easily be improved.
- Alfa Laval should have more different items in Stock.

These statements will be verified in a more detailed way in the following sections.

6.1.1. Item Classification

Our analyse shows that inventory holding cost could be lowered considerably when changing classification method.

In the present classification system only one criterion is used; the total number of picks during one year should be greater or equal to four. Since Alfa Laval measure how large share of their demand that is kept in stock in number of order lines, this is the best method of classifying when using only one criterion. A first step of improving this classification method is to make the fixed limit of four picks variable. In this way management can decide more precisely how large share of the total demand that should be kept in stock.

Item classification becomes better when several criteria's are used. When we introduce a second criterion, the cost of each item, the results are much better. If we introduce a factor that is equal to:

the total number of picks divided with the theoretical average inventory value of each item

$$Classification\ factor = \frac{Number\ of\ picks}{\text{Theoretical average inventory value}}$$

we achieve our best results.

By doing this we are able to sort out the items that stand for a small share of the demand but a very large share of the total theoretical inventory cost.

Several ABC models have been tested and in similarity with our analysis of the item classification our result here becomes better when several criteria's are used. We achieve our best results when using a factor equal to number of picks/theoretical average inventory cost. Another option is to create a 3 x 3 ABC matrix consisting of two criteria's and nine classes. This enables us to see more closely what class of items we should give a high service level to recieve the lowest possible cost. From our analysis we can also draw two general conclusions. First of all, the results of the ABC models are better when we introduce more classes but the service level is much harder to optimize. Secondly the result of the ABC model depends on how we measure demand and on what inventory classification method that is used.

In order to measure the performance of our classification method our object has been to remain a large share of the total demand in stock and at the same time minimize the inventory holding costs. In our analyse in chapter 5.3.1 we show that the total theoretical inventory cost when keeping 90% of the demand in stock could be lowered by 50% compared to the setup used today, if Alfa Laval decides to change classification method and ABC method.

Another way of keeping the inventory cost down is to introduce certain limitations in inventory management. One way of doing this is by introducing a maximum order quantity of how much that could be delivered immediately from the DC. This increases the accuracy of the forecast and lowers the size of the SS. It also reduces the risk of shortage which increases service levels. Another way of keeping SS down is by limiting the MAD- value to 10% of the yearly forecast. This removes all extremely large SS. This suggestion has been introduced before at Alfa Laval, but according to the inventory data we received it is not yet implemented.

6.1.2. Number of items in stock

Our benchmarking and our interviews with people from different areas within Alfa Laval convince us that Alfa Laval should keep a larger share of their demand in stock. This could be done without higher cost by changing item classification, introduce certain inventory limitations and with a changed ABC-method.

The general opinion from the sales division at Alfa Laval is that service for stocked items is very satisfying but when it comes to non stocked items the service is not satisfying. This mainly depends on the long lead time for the items manufactured within Alfa Laval. Our benchmarking that was directed towards 10 other large manufacturing companies gives us the same picture. Alfa Laval keeps a lower share of their demand in stock compared to the other companies. We consider it unnecessary for a leading company like Alfa Laval to lose customers and invite other competitors to the market because of their low service on non stocked items. In order to change this situation Alfa Laval needs to keep a larger share of their low frequent items in stock.

There is always a risk of keeping low frequent items in stock. The items have a slow turnover rate and run a risk of becoming obsolete. In order to minimize theses risks there are some measures that can be done. First of all we want to reduce the SS. The large deviations on low frequent items demands very large SS in order to maintain a high service level compared to items with a higher demand. If we skip or reduce the SS the service level measured in SERV1 will drop but the overall service will rise when having these items in stock compared to not having them in stock. Another measure is to limit the order quantity on low frequent items. In this way we assure that the ordered quantity will be consumed within a reasonable amount of time.

We believe that the largest cost for obsolescence derives from former high volume items. Common reasons for obsolescence are manually changed forecasts, sudden drop of demand, low durability for gadgets and demand peaks that has affected the forecast. The cost for low frequent items is not that great since these items are ordered in small quantities. The long life time for Alfa Laval plates also reduces the risk for obsolescence and is another reason why we want to keep low frequent items in stock.

6.2. Specific questions

In the following section the five specific question of the report will be answered one at a time.

- *What will happen if Alfa Laval classify from the opposite way? E.g. 96 % of all picks will define items as SI, 97-99 % as NI and the rest as RI.*

If the classification method changes the borderline between stocked items and non stocked items becomes variable instead of fixed. In order to have a variable limit, items with the same amount of picks have to be separated by a new second criteria, e.g. volume or turnover value. The advantage of doing this is that all DC’s now have the possibility to keep the same percentages of demand in stock and thereby offer the same service for all customers. Classification in this way facilitates inventory management and control and is required to create new and more powerful classification methods.

- *What is the handling cost for items within each class?*

An activity based costing model has been developed by Sören Krarup to estimate the handling cost for different items. The calculated cost consists of a fixed cost and a variable cost for each item. The fixed cost covers the cost for the main processes at the warehouse, e.g. order reception and pick & pack. It depends on the class of the item and is carried out for each order line. The variable costs covers management cost and inventory holding costs such as interest and costs of obsolescence. This cost depends on the price and ordered volume of the items and is carried out as a %age of the ordered value. Stocked items have a low fixed cost but a high variable cost, while requested items have a high fixed cost and a low variable cost. The cost for a non stocked item lies between a stocked item and a requested item.

- *What is the effect of looking at statistics for more than 12 months?*

Our analyse shows that Alfa Laval receives better forecast results when the time period is increased from 12 to 24 months. If the period is increased to 36 months the forecasted result will decrease to a level below the results for 12 months.

When forecasting demand for items with low and very variable demand, a very common situation for C-items, our recommendation is to use the exponential smoothing method with a low α-value over the moving average method. For the remaining items with higher but still variable demand, Alfa Laval should use the moving average method based on a period of 24 months.

The statistics also tells us that there are several items that have a low but steady demand during several years. When the inventory classification is based on only one year these items are not classified as stocked even though the demand is continuous. Our suggestion is to take this into consideration by classifying in two steps. In the first step items with a demand above a certain limit during the last year should be classified as stocked. In the second step the remaining items below this limit should be examined and all items that show a steady demand during several years should then also be classified as stocked. This discussion is further developed in chapter 5.5.

- *A lead time analyse. An item maybe does not need to be classified as SI if the lead time is short enough.*

A stocked item can only be reclassified to none stocked due to its lead time under one condition. This is when the lead time from a supplier or from manufacturing is shorter then the required delivery time from the customer. However this is seldom the situation at the DC's within Alfa Laval. In general, customers of spare parts demands short delivery times while lead times within Alfa Laval are very long. Even when a customer of an item normally accepts longer delivery times there is always a risk of an unplanned breakdown when the item is needed immediately. Another reason to keep items in stock is from an economic point of view. The set up cost for manufacturing are high and to gain economy of scale items should be manufactured in batches instead of lot for lot.

However there are some situations when an item has a shorter lead time then the requested delivery time. This is the case for all unique combinations of plates and gaskets that are manufactured and assembled at the DC in Staffanstorp. This is an excellent example of postponement where Alfa Laval avoids storing low frequent items but still manages to have a short lead time. But in order for this to work we can not forget that the original plates and gaskets have to be stored at the DC in the first place.

- *Can Alfa Laval use other companies, the authors and universities ideas and if so, what are the plus and minus compared with our setup?*

Throughout this master thesis we have presented several ideas of how Alfa Laval can improve their item classification and inventory management. The present setup at Alfa Laval is basic and in conformity with theory. It has a good foundation to build further on and does not show any direct faults. However when having all the right requirements we believe that it is time for Alfa Laval to take one step further and start to manage there inventories more closely. Some simple measures can be done that will effect in great savings and an increased service for the customers.

Alfa Laval states that a simple method is the best way to control their inventory, but in our benchmarking it can be seen that most other company's uses more advanced methods. Most other companies also keep a larger share of their demand in stock. We recommend Alfa Laval to apply similar strategies.

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Peter Persson, Manager Inventory Management, Alfa Laval DC Staffanstorp.

Richard Persson, Project Manager, OP Alfa Laval Lund.

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Ulf Grevillius, Portfolio Manager, Alfa Laval Lund.

Åke Skarstam, Senior Manager Operations Development, Alfa Laval Lund.

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Mattsson, Stig-Arne. Adjunct professor at Department of Industrial Management and Logistics. Lund University.

Appendix 1

Questions and answers to the benchmarking

Frågeformulär till företag

1 **Företags/Avdelningens/Svarandes namn**

2 **Hur många artiklar har ni i ert sortiment?**

3 **Hur många av dessa är lagerförda artiklar?**

4 **Hur stor del av efterfrågan motsvarar dessa artiklar?**

5 **Hur mäter ni efterfrågan i detta fall?**

6 **Hur avgör ni om en vara ska in på lager?**

7 **Hur ofta ser över huruvida era artiklar bör vara lagerförda eller ej?**

8 **I fråga 6 och 7, hur lång tidsperiod av historiska data tittar ni på?**

9 **Om ni har ändrat längden på tidsperioden i fråga 8, har ni sett några effekter av detta?**

10 **Använder ni er av ABC klassificering för era lagerförda produkter.Hur är den i så fall framtagen? (t.ex. Volymvärde, plockfrekvens, volym)**

11 **Hur ofta uppdaterar ni er ABC-klassificering?**

12 **Använder ni er av större centrallager (DC:s) eller många små lager nära kund?**

13 **Har ni delat upp era produkter i familjer? T.ex. Alfa Laval har delat upp sina i tre familjer: thermal, separation och fluid.**

14 **Har ni hela sortimentet på alla lager eller har varje DC (ev. lager) sin ansvarsdel? Vad har ni grundat det beslutet på?**

15 **Har ni undersökt hur kostnaderna förändras när ni lägger en vara på lager jämfört med att ha varan som beställningsvara?**

16 **Har ni samma pålägg för lagerhanteringskostnader på alla artiklar? Får t.ex. kundordertillverkade varor bära en del av lagerhållningskostnaderna för varor tillverkade mot lager? Är det ett % pålägg eller en fast summa pålägg?**

17 **Hur fördelas lagerhållningskostnader på era artiklar? Vilka kostnadsdrivare (t.ex. per tidsenhet, lageryta, per kundorder) använder ni er av?**

18 **Servicenivå i lager är ett uttryck för förmåga att leverera direkt från lager.Begreppet kan allmänt definieras som sannolikheten att en kundorder kan levereras från lager i enlighet med kundönskemål eller att ett material kan plockas från lager till en tillverkningsorder i enlighet med uppgjorda planer. Vilket/vilka mått mäter ni er lagerservicenivå i?**

19 **Vad baseras servicenivån på?**

20 **I fråga 19, varför har ni valt just denna metod?**

21 **Har ni en servicenivå där tar ni med även beställningsvaror (alltså ej lagerförda varor) i måttet? Alltså en mer övergripande servicenivå mot kund.**

22 **Har ni genomfört något slags ledtidsanalys? T.ex. vissa artiklar kanske inte behöver vara lagerförda då ledtiden är så pass kort att man kan tillgodose kundens krav i alla fall. Om ja, berätta gärna hur ni har resonerat och vad ni kommit fram till.**

23 **Har ni genomfört någon livscykelanalys för era produkter, t. ex. om de befinner sig i sin introduktionsfas, mogen fas eller slutfas? Har ni isåfall använt er av den analysen i er lagerstyrning?**

1 Alfa Laval Lund AB/OL-EUL/Peter Persson + Anders Granelli

2 54478 st

3 1219 st

4 52%, 40%

5 Andel av antalet plock, volymvärde

6 Policy baserad på plockfrekvens + lite A. manuell bedömning. Centralt beslut.

7 En gång per år.Men vi kan ju inte vara så låsta att vi aldrig lagerlägger en artikel förutom vid den 1:e Januari varje år. Ingen regel utan undantag.

8 Ett år

9 Nej, variationen i efterfrågan är för stor så det finns inte någon anledning att se på längre tid. Detta har man kommit en diskussion med samtliga lager.

10 Plockfrekvens

11 Varje månad

12 Större DC

13 Se frågan

14 I Europa finns ett lager för varje familj. I USA ligger allt under samma tak.

15 Ja, ibland på enskilda artiklar, inte allmänt på hela sortimentet.

16 Samma %-pålägg

17 % på standardpris

18 SERV 1

19 Vårt huvudmål är availability, dvs andelen orderrader som kan levereras omgående från DC:t. Detta gäller produkter som är klassade som stocked items.Till detta kommer ren kunordertillverkning och här har vi framförallt ett mått som följs och det är leverans enligt första löfte mot kund.:

20 Centralt beslut

21 Ja

22 Nej. Inte generellt, men vissa artiklar som är sammansättningar av andra lagerprodukter kan med kort ledtid sättas ihop på lagret istället för att ligga färdiga på hyllan.

23 Nej

1 SAPA Profiler AB, Logistik, Jonas Hernborg

2 Ca 70 000 st

3 Ca 2000 st olika artiklar

4 Ca 30 %

5 Andel av volymvärde

6 Kombination av: Manuell bedömning från artikel till artikel.Policy baserad på både plockfrekvens(eller frekvens) och Volym
Ledtidsberoende

7 Vi har en rutin där vi går igenom och klassificerar våra lagerartiklar 1 gg per kvartal. Dessutom skickar vi ibland ut listor till fsg som avgör vikla som bör tas bort som MTS. Detta gör också då man vet att artiklar ska upphöra som MTS => volymnedgång

8 Ett år. I mätningen per kvartal använder vi data för 1 år tillbaka. I övrigt granskar vi kundbehov. Pga att ha en löpande kontroll samtidigt som vi försöker ta bort onödiga lager då allt är kundunikt.

9 provat,men ej genomfört.pga säsongsvariationer och livslängd på<5år

10 Ja. Volymvärde

11 En gång per kvartal. För att artiklarna är kundunika och vi då vill kunna se trenderna så snabbt som möjligt.

12 DC:s till större delen, men utvecklar VMI koncept.

13 Nej.

14 Sortimentet är kundunikt och anpassat efter det på respektive lager.

15 Ja, detta gör vi vid nästan varje upplägg som går via logistik.

16 Nej. Detta ska vara ett separat prisvillkor och ska belasta produkten i fråga.

17 Vi tar lagerhållningskostnader per enhetslast el. artikel. Räknar även in kapitalbindning.

18 med respektive kund

19 kundprioritet. Tex låg priokund erbjuds ej lagerhållning.Bara mervärde för kunden att lagerhålla.

20 Ej medvetet val. Kundfokuserat. Lager för kundens behov.

21 Ja, mäter hel order som levereras enligt överrenskommelse med kund.

22 Ja, och svaret är ganska invecklat… man kör många olika typflöden.

23 Analys vid upphandlingarna. Infasningsperiod, mognad och en utfasning som oftast triggas av säljaren.

1 Sandvik Tooling/TST/Johan Rissler

2 Ca 30000 färdigartiklar, dvs produkter som säljs till kund. Till detta kommer ca 12 000 komponenter och råmaterial. Som komplement till detta definierade sortiment har vi ett icke fördefinierat kundorderstyrt sortiment.

3 Alla ovan => ca 42000 st

4 Ca 85 %

5 Andel av volymvärde

6 Vid starten av ett nytt produktprojekt bestäms produktrymden och den kompletteras i ett senare skede med artiklar samt prognos per artikel. I detta läge tas en diskussion mellan markandssida samt produktions/logistiksida vad som är rimligt att lagerlägga. Det finns vissa tumregler som används som riktmärke men i slutänden är det markadssidan som har sista ordet för att kunna erbjuda ett komplett sortiment. Produkterna som vi säljer kan till stor del betraktas som konsumtionsvaror och våra kunder förväntar sig att de ska finnas lagrlagda. Det stora flertalet av våra kunder får leverans inom 24 timmar efter order.

7 Varje halvår.

8 Våra produkter ändrar inte kategori från lagerlagd tll icke lagerlagd eller omvänt under en produktlivscykel utan lever kvar i den grupp som den introducerades i. Vad gäller utfasning av en produkt så tittar vi bla på historiska data men även vilka kunder som beställer produkterna. Är det några av våra key accounts så kan produkten leva kvar som lagerlagd även om volymen är låg och fasas i detta fall inte ut förrän vi har konverterat kunden till nya produkter.

9 Ej svarat

10 En kombination av antalet orderrader samt styckvärde

11 En gång per månad

12 Vi använder oss av en DC struktur bestående av 3 centrallager, ett per region.

13 Ja, vi har huvudfamiljer som även går att bryta ner i mindre beståndsdelar.

14 Vi har ett komplett sortiment per DC. Detta för att kunna stötta kunderna med en hög servicenivå. Lagerstyrningen sköts inte av DC:na utan sker på global nivå av en central kontrollfunktion. Lagernivåer osv anpassas på så sett till det globala behovet.

15 Ja. Det har gjorts omfattande analyser om kundorderstyrd produktion och vilka konsekvenser detta skulle få ur ett totalekonomiskt perspektiv. Utgångspunkterna har under de senaste åren varit flera men det senaste utgick ifrån att produkter som låg under en viss årsprognos skulle kundorderstyras. En genomgripande analys gjordes och slutsasten var att Sandvik Coromant hade mer att förlora än att vinna på att införa en generell regel för när kundorderstyrd produktion ska användas. Även om vi under de senaste åren har reducerat våra ordersärkostnader samt ställtider så innebar det på total nivå en kostnadsökning samt en serviceförsämring att genomföra detta. Coromant skulle samtidigt få genomföra ganska omfattande investeringar för att kunna ersätta tappad kapacitet pga ökade ställ.

16 Nej, kundorder bär enbart produktions samt distributionskostnader.

17 För närvarande slås våra kostnader ut per orderrad och den är samma för alla produtker. Vi har ett förhållandevis homogent sortiment.

18 Vårt huvudmål är lagertillgänglighet, dvs andelen orderrader som kan levereras omgående från DC:t. Detta gäller produkter som ingår i vad vi kallar standardsortimentet, dvs katalogprodukter. Till detta kommer ren kunordertillverkning och här har vi framförallt ett mått som följs och det är leverans enligt första löfte mot kund.

19 Policy för lämplig kundservice fastställd av t.ex. ledningen. Detta kombineras sedan med fortlöpande analys av framförallt kapitalbindningen.

20 Våra produkter är att betrakta som konsumtionsprodukter och servicenivå betraktas som en viktig konkurensaspekt. Logistiksidans uppgift är att belysa olika kostnadsbilder utfrån den önskade servicenivån som ledningen eftersträvar. Ser vi att önskad servicenivå leder till höga kapitalkostnader med befintliga styrmodeller kan fortfarande beslutet vara att gå mot önskad servicenivå samtidigt som logistiksidan får på sig att se över sina styrmetoder.

21 I dagsläget mäter vi inte en total servicenivå utan delar upp den i två komponenter, en för lagerlagda produkter samt en för kundorderstyd produktion.

22 Vi övervakar kontinuerligt ledtiden och det finns delar i vår produktrymd som inte är lagerlagda. Detta är framförallt produkter med låg volym eller där det är omöjligt att beskriva produktrymden.

23 Se fråga 8

1 Scania Parts Logistics / Business Development & Information Systems / Henrick Engberg

2 ca. 65.000 st

3 ca. 65.000 st

4 nära 100 %

5 Volym

6 Lastbilen bryts ned till de artiklar som vi anser ska vara reservdelar, i stort sätt alla dessa lagerläggs. Undantaget är i princip kundspecade artiklar.

7 Varje kvartal görs en översyn vad som inte ska vara lagerlagt längre och det baseras på försäljningen i antal.

8 Eftersom produklivscykeln för våra produkter är väldigt lång så jobbar vi med historik från de senast 5-10 åren.

9 Ej svarat

10 Lagerstyrningsmässigt sker i klassificering baserat på volymvärde. Lagerhanteringsmässigt sker en klassificering baserat på plockfrekvens och volym.

11 Månad

12 En kombination av det: två centrala lager, ett i Sverige och ett i Belgien. För att klara ledtidskraven finns även fyra regionala lager runt om i Europa samt att alla våra återförsäljare har ett eget lager med reservdelar. Återförsäljarna levererar till egen verkstad och över disk försäljning till slutkund.

13 Det finns förstås olika grupper av artiklar men inte som har någon betydelse för styrning eller lagerläggning.

14 Vad som finns på varje lager grundar sig på försäljningen i antal.

15 Nej, det är inte aktuellt pga av ledtidkrav från slutkund.

16 Ej svarat

17 Ej svarat

18 Vi mäter andelen komplett levererade orderrader som kan levereras direkt från lager dvs efterfrågan=10, levererans=10 è 100 %, efterfrågan=10, leverans=5 è 0%.

19 Policy för lämplig kundservice fastställd av t.ex. ledningen

20 Vår servicegrad är ett konkurrensmedel i förhållande till vår konkurrenter.

21 JA

22 Ej applicerbart

23 Ej svarat

1 Volvo Group/ Volvo Parts, Logistics Concept Development, Patrik Ström

2 250.000 st

3 100.000 st

4 99.9%

5 A. Andel av antalet plock
B. Andel av antalet sålda enheter
C. Andel av volymvärde
En kombination av A, B och C, men framför allt volymvärde

6 Värde på artikeln och plockfrekvens i olika tabeller för om det skall lagras i central-, region- eller återförsäljarlager

7 Jämt, vi flyttar artiklar uppströms eller nedströms i försörjningskedjan hela tiden baserat på antalet plock och artikelns värde. Ju billigare artikel desto färre plock fordras för att den skall ligga lagrad hos en återförsäljare. En lastvagnsåterförsäljare har ca 5000 artiklar i lager och vi har ca 75000 aktiva lastvagsdelar i centrallagret och ca 25000 på resp regionlager.

8 6 månader verkar vara gränsen. Sedan har vi ett reservdelsansvar som generellt är 15 ÅR efter det att lastvagnen, grävskopan osv gått ur produktion. Dock finns det reservdelar som är äldre än dessa 15 år, men här är det $tålarna som avgör, dvs tjänar vi fortfarande pengar på just den reservdelen så fortsätter vi ha den i sortimentet - om inte, så slutar vi köpa in och anskaffa. I en dell fall så skrotar vi tom reservdelarna om vi behöver lagerplatsen.

9 Se fråga 8

10 Se svar på fråga 7

11 Se svar på fråga 7

12 både och, se svar på fråga 7

13 Nej.

14 Sortimentet i hele försörjningskedjan baseras på att ge en så hög tilläglighet av reservdelar som möjligt men samtidigt begränsa kapitalet bundet i lager. Regionlagren finns endast för att minimera transportkostnaden från centrallager till återförsäljare. Finns inte artikeln i regionlagret flygs artikeln ut till återförsäljaren. Artiklar som skall ligga ute hos återförsäljaren fylls på automatiskt (innan de tar slut) och skickas med yttransport (bil eller båt) ut till återförsäljarna.

15 Ja, men för oss är det ingen skillnad på lagervara eller beställningsvara. Är det ett mycket stor försäljning skall artiklarna ligga ute hos återförsäljarna för momentan tillgänglighet det som säljs mindre sällan kommer till återförsäljaren före kl 09:00 nästa morgon om beställningen är gjord före kl 17:00 på eftermiddagen dagen innan. Det här konceptet har gjort att Volvo är bäst i automotivebranchen på att ha bäst tillgänglighet och dessutom har vi det till längst kapitalkostnad – något som vi är mycket stolta över.

16 Först och främst så sätter vi INTE några priser på resp reservdel, det gör resp affärsområde: Volvo Lastvagnar, Volvo Bussar, Volvo CE, Volvo Penta, Renault Trucks och Mack Trucks. Jag vet att de har olika priskalkyler. Några affärsområden har giganstika sjä'lvkostnadskalkyler där allt ingår, vilket gör att en del reservdelar får för lite pålägg och andra för mycket. Andra affärsområden här lite mer ABC-baserad prissättning, men troligen är det en "självkostnadskalkyl", med lite inslag av "bidragskalkyl".

17 Vi har en mängd kostnadsdrivare och de viktigaste är på gods ut sidan (dvs från det att artikeln ligger lagrad på centrallagret) är: antal order, antal orderrader, orderklass (automatisk lagerpåfyllnad av återförsäljarlager eller expressorder), storlek och vikt på resp reservdel, andel restorder

18 Vi mäter vid:
- orderläggningstillfället, dvs planerad servicegrad
- Vid utskriften av plock- och packunderlag
- Vid packrapporteringen, här mäter vi både andelen komplett levererade orderrader samt dellevererade orderrader och vilka hela eller delar av orderraderna som EJ kunde levereras.

19 Policy för lämplig kundservice fastställd av t.ex. ledningen, men se svar på fråga 18

20 Ej svarat

21 Ja alla artiklar ingår i den agregerade servicemätningen. Dock har vi ett relativt litet beställningssortiment. Exempel på det är kompletta lastbilshytter och vissa kabelmattor som görs på beställning.

22 Ja. Det är här tricket kommer in. En lastvagns återförsäljare saknar ca 70.000 artiklar i lagret. Lastvagnsföraren struntar i det, därför har vi olika lösningar på biltransport och flygtransport för att optimera tillgängligheten ute hos återförsäljaren då han ofta har en kund som det ”ryker ur motrn på”…

23 Ja vi jobbar med LCM (life cycle management), speciellt vid produktlanseringar där kundservice och varumärke etc är stora drivers. Vi har naturligtvis sett att vi jobbar alldeles för lite md LCM i reservdelens slutsked, men här är det framför allt ökande kostnader i form av kapitalbindning som är drivern.

1 Volvo Cars Customer service, Logistics Development, Manne Petersson

2 ca 97000st

3 ca 99%

4 99,50%

5 Andel av antalet plock

6 Eftersom vi är ett globalt centrallager och är beroende av hög leveransförmåga, så är grundregeln att vi själva tar lagerhållningsansvaret. Allt annat är undantag. Orsaker kan då vara explosiva eller vådliga produkter. Ytterligare enstaka kundunika produkter finns också. Vår distribution bygger på att nästa led inte har några säkerhetslager för inleveransosäkerhet. Därför är kraven på centrallagret extremt höga.

7 Kontinuerligt

8 Ej tillämpligt. Eftersom I princip allt är lagerfört, så behöver vi ju inga historiska data för att ta beslutet

9 samma som ovan

10 Nej vi har ingen ABC-klassning för logistikändamål. Men naturligtvis jobbar vi med pris och frekvensklassificeringar för styrningsändamål.

11 Se ovan

12 Ett globalt DC

13 Ja, vi kallar det produktslag: el, kaross, hjulupphängning mm

14 På DC.n har vi givetvis alla produktgrupper eftersom de är uppdelade efter bilens uppbyggnad och vi servar hela bilen.

15 Ja, eftersom vi har stora volymer blir det ofta extremt dyrt att ha beställningsvaror dvs korta serier.

16 Alltid marknadsanpassade priser. Vi har olika konkurrenter för olika ålder och typer av bilar. Vi gör en typ av priskorgar som styr prissättning.I grunden sätter vi ett marknadsanpassat pris, även om vi på enstaka artiklar inte täcker våra kostnader. I vissa fall kan det till och med bli så att vi inte täcker inköpskostnaden. Annars är det så att vi gör en bedömning baserad på ett %-pålägg för att beräkna vårt bidrag för en enskild artikel. Bakgrunden till att vi tillåter oss att sälja vissa artiklar med förlust, är att vår viktigaste uppgift är att hålla bilar i funktion. Att vi sedan skall göra detta med lönsamhet (totalt) är en sekundär (men ändå inte oviktig) uppgift.Därav svaret. Vi gör alltså inga lönsamhetskalkyler på enskilda artiklar, utan värderar i stället vad kunden kan tänkas vilja betala eller tycker är ett rimligt pris för en artikel. I botten ligger alltså inte någon påslagskalkyl eller något liknande. Men om ni vill komma så nära som möjligt så får vi väl säga att vi i så fall gör generella %-påslag eftersom det är helheten som skall vara lönsam, även om vi inte gör beräkningen på enskild produkt.

17 Yta, volym och kapitalkostnad och därmed också inleveransstorlek.

18 Andel av kundefterfrågan som levereras i tid. Vi har flera olika distributionssätt med olika typer av mätning. När vi levererar order direkt till en reparation av en specifik bil så mäter vi komplett order. När vi levererar till ett lager nedströms så mäter vi på orderradsnivå. Då mäter vi också andel av orderraden som levererats.

19 A.Baserad på bristkostnader
B.Baserad på en maximalt tillåten lagerhållningskostnad
C.Policy för lämplig kundservice fastställd av t.ex. ledningen
Kombination av ovanstående men viktigast är C och baseras på benchmarking med andra bilfabrikat.

20 Konkurrensen styr vad vi måste göra

21 Knappast tillämpligt. Men i de fall detta uppstår minskar detta servicenivån eftersom vi skall ge alla artiklar samma ledtid mot kund.

22 En bilägare kräver alltid kort reparationstid av sin bil. Beställningsvaror tar generellt längre tid än vad kunden accepterar.

23 Vi har ofta ganska långa livscykler. I början av livscykeln har vi vissa problem med prognoser pga ökningstakten I efterfrågan är osäker. Det är också svårt att hitta bra jämförbara artiklar att bygga historik på. Slutet av livscykeln börjar när en bil går ur produktion, då produktion av delar endast sker för servicemarknadsbruk. Ställkostnaderna blir då ofta extremt höga. Även här är det om möjligt ännu svårare att göra långtidsprognoser och hitta jämförbara mönster. Vi har alltså gjort analyser, men det är svårt att hitta användbara mönster.

1 Ph Nederman & Co AB/Logistikchef Christian Nilsson samt Peter Ferm

2 8600st

3 1650st

4 65%

5 Andel av volymvärde

6 Policy baserad på både plockfrekvens(eller frekvens) och Volym.Ville på så många kundorder som möjligt leverera direkt från lager om kunden vill.

7 Varje halvår.

8 Sex månader. Vi bygger prognosen på 6 månaders förbrukning, räknar fram den till en årskvantitet. Svaret är nog en kombination hur vi tar fram prognosen samt en känsla vi hade att 6 månader passar vårat produktsortiment.

9 Har inte ändrat.

10 Volymvärde baserat på 6 senaste månaderna.

11 Varje halvår. "vad fick er att välja denna period?" Känsla!

12 DC, men respektive säljbolag har ett litet lager av ”emergency” artiklar

13 ja

14 Varje DC har de artiklar på lager som passar deras marknad. Just nu två DC, ett i Hbg och ett i Toronto.

15 Nej

16 Samma pålägg och den är i %.

17 ABC kalkyl har använts med drivare kundorder och kundorderrader i detta

18 Vi styr mot en viss servicenivå mot vad som skall lagerföras. Annat läggs som inköpt och målet är att kunna hålla en 97% utlevereransprecision ställt mot gällande ledtider.

19 lämplig kundservice fastställd av t.ex. ledningen"

20 Ställt mot den försäljning av reservdelar Nederman har så har den avvägningen gjorts.

21 Ja

22 på volymvärde kunnat fastställas.

23 Detta görs kontinuerligt av produktchefer, dock kan jag inte påstå att detta inneburit något för hur vi styr reservdelar, överlag är detta område ganska eftersatt hos oss.

1 ITT Flygt AB Emmaboda Håkan Runesson

2 35000st

3 7000st

4 80%

5 Volym

6 Policy baserad på både plockfrekvens(eller frekvens) och Volym+ vissa strategiska artiklar. Optimerar lager och service bäst.

7 Varje halvår.

8 Ett år. Vid 1 år får du inget "nervöst" system. Men vi kommer nog ändå mer går in för 6 månader framåt då 6 månader är mer snabb reagerande.

9 Se fråga 8

10 Volymvärde

11 En gång per år + Övrigt. I stordatorn uppdaterar vi bara 1 gång/år då behovet inte är större. Men däremot har vi ett PC-baserat anskaffnings stöd (egenutvecklat) som uppdaterar anskaffningsparametrarna utifrån ifall det är en A, B, eller C artikel samt uttagningsfrekvens. Denna viktiga uppdateringen gör vi 1 gång/vecka.

12 I Europa har vi 2 st distributions center, ser lite annorlunda ut i Amerika och övriga världen.

13 Ja

14 Leveranstidskraven är avgörande ifall vi lagrar på bägge DC.

15 Nja, svårt att mäta kostnad för förlorad order etc.

16 Samma pålägg.

17 Samma % pålägg utifrån standardkost.

18 Vi utgår ifrån det vi ska leverera per dag/timme och mäter vad vi klarar utifrån det. Vi mäter till delar både servicegrad för position/produkt med även hel order som består av flera positioner (ganska ofta är inte delleverans tillåten).

19 Policy för lämplig kundservice fastställd av t.ex. ledningen

20 Tydligast. Kundservice/servicegrad är ett tydligt mål. Vi tycker även att det är rätt att utgå utifrån kunden.

21 Ja

22 Ja. Vi har framförallt arbetat igenom vårt reservdelssortiment för våra största produkter, där vi har klassat in sortimentet i olika leveransklasser utifrån leveranstidskrav och ledtider.

23 Det är mer marknadssidan som använder sig av livscykelanalyser och jag kan inte direkt saga att vi gör det i vår lagerstyrning. Däremot har vi manuell handpåläggning när vi vet att en produkt/artikel är på väg ut och då drar vi ner säkerhetslager etc. Vidare sätts utstatus på artikeln så du inte kan anskaffa längre än den lever och då få även information om att artikeln har U-status.

1 Atlas Copco Compressor AB/Admin & Logistics & IT / Sören Rodert

2 c:a 25000 st

3 c:a 5000 st

4 40-50 %

5 Andel av volymvärde

6 Policy baserad på volymvärde. Gjort en analys fast ej någon fördjupad analys på vilken policy som gett de lägsta kostnaderna. T.ex servicegrad vs. volymvärde. (Hela AtlasCopco jobbar med 'volymvärdes-tekniken')

7 Nästan kontinuerligt, via månatliga "lager-scorecards"

8 Två år, ger för oss bästa totals effkten ('värde-nytta')

9 Nej

10 Nej. Använder i princip samma servicenivåer och lägger lika stort administrativt arbete på samtliga artiklar.

11 se ovan

12 Små lager nära kund + ett akut-akut centrallager

13 Ja.,tre familjer ungefär som Alfa skulle jag gissa

14 Varje lager har sin ansvarsdel.
Kund/produkt-regionsanpassade lager

15 Ja,och har därmed ökat andelen best.vara

16 2 olika %-tal, vi har grupperat i "rena reservdelar" samt "produkter", 4 resp 3 %. Dvs en 'produkt' är oftast dyrare och blir därmed 1 % billigare att ta hem

17 Sk TIM –värde = turn-over-in month
alt TID-värde = turn-over-in days

18 Andel av efterfrågan som kan levereras direkt från lager (SERV 2)

19 Policy för lämplig kundservice fastställd av t.ex. ledningen

20 Ej svarat

21 Ja

22 Ja.'Servicenivå' med vårt mått mätt är att kund i Sverige skall få sin beställda reservdel inom 3 dygn med vanlig mark-transport. Vid akut-behov (flyg) gäller ett zon-system med grundtid 'inom ett dygn'. Ovanst. hänger ihop med lite med 'ej lagerfört pga låga ledtider hos underleverantör.Kan underlev. hålla våra tider lager för vi i regel ej själva (förutom ett litet säkerhetslager, utifall att..)

23 Ja, inte vi direkt men vårt tillv.bolag i Belgien har utvecklat analysmetoder och 'lagerhållninsteknik' map produkters livscykler

1 Kalmar Industries AB, Services Magnus Berg

2 220000

3 30000

4 50%, 80-90%

5 50% av antalet sålda art nr, 80-90% av volymvärdet

6 Policy baserad på plockfrekvens samt hur pass kritisk artikeln är för våra maskiners funktionalitet.

7 varje vecka

8 Två år. Relevant för vår bransch och produkter. Denna 24 månaders period viktas dessutom.

9 Ett år visar sig vara för kort period eftersom våra produkter har en livslängd>10 år. Längre perioder har inte undersökts.

10 Ja, värde, plockfrekvens och tillgänglighet, dvs vi har en tredimensionell klassificering.

11 varje månad

12 Ja ,3 st DC.

13 Ja

14 Vi baserar resp DC på vilken marknad och population av maskiner det skall supporta.

15 Ja. Olika krav på omsättningshastigheterna beroende på produkterna. Lageromsättningen ligger i genomsnitt på 3ggr/år

16 Samma % pålägg

17 Generellt pålägg

18 Leverans enligt överenskommelse med kund. Orderrader mäts om de kommit i tid samt andel kompletta ordrar.

19 Policy för lämplig kundservice fastställd av t.ex. ledningen

20 Relevant utifrån kunders förväntan och marknadskrav.

21 Ja, men det krävs också en kombinerad uppföljning på tillgänglighet utifrån alla inkomna order.

22 Ja, vi mäter ”backorder leadtime” som visar genomsnittlig leveranstid för varor som ej fanns i lager då vi erhöll ordern, idag ca 13 dgr i snitt. Utöver detta jobbar inköpsfunktionen kontinuerligt med analys, uppdatering och förbättring av ledtider. Dessutom ökar antalet buffertlager hos leverantör utifrån dessa diskussioner vilket ger lägre total kostnader för bägge parter.

23 Nej

Appendix 2

Example of ABC costing

(Olsson & Skärvad, 1995)

Example: A companies self cost for its major products based on a traditional accounting system				
	A	**B**	**C**	**Total**
dM (Direct materials)	50	250	500	800
MO(material overhead) 50%	25	125	250	400
dw(direct wages)	20	100	150	270
PO(production overhead) 800%	160	800	1200	2160
dP(remaining direct production costs)	10	75	90	175
TM(total manufacturing cost)	265	1350	2190	3805
AO(administrational overhead) 20%	53	270	438	761
SO(sales overhead) 15%	39,75	202,5	328,5	570,75
Self cost	357,75	1822,5	2956,5	5136,75

Example: A companies self cost for its major products based on an activity base costing calculation.

First the direct material for each product is calculated.

	A	**B**	**C**	**Total**
dM	50	250	500	800

Next the overhead cost for each activity is distributed.

MO	purchasing	100
	order reception	100
	warehousing	200
		400
PO	construction and preparation	445
	planning	400
	machine settings	200
	assembly	1100
	maintenance	460
		2605
AO	accounting	500
	Administration of staff	200
	management	61
		761
SO	marketing	350
	order processing	150
	sales management	70,75
		570,75

Finally the cost driver for each activity is identified and distributed over the products

	A	B	C	Total
dM	50	250	500	800
purchasing	30	30	40	100
order reception	25	50	25	100
warehousing	60	40	100	200
construction and preparation	95	150	200	445
planning	100	150	150	400
machine settings	50	50	100	200
assembly	300	200	600	1100
maintenance	50	160	250	460
accounting	150	150	200	500
administration of staff	50	50	100	200
management	15	20	26	61
marketing	50	150	150	350
order processing	40	20	90	150
sales management	10	30	30,75	70,75
Self cost (ABC)	1075	1500	2561,75	5136,75
Self cost (traditional mark up)	357,75	1822,5	2956,5	5136,75
Difference	717,25	-322,5	-394,75	0

Comments: If this ABC- calculation is correct, then product B and C has subsidized product A in the earlier case. Product A has not carried the correct share of the overhead costs.