



**LUND INSTITUTE OF TECHNOLOGY**

Lund University

Department of Design Sciences

Packaging Logistics

# **Transport of Packed Food**

## **How to Find an Evaluation Route Describing the Transport Reality**

**Master Thesis  
Lund, 2004**

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Anette Immelborn, Tetra Pak**



## **Preface**

This master thesis is my report written from work done at Tetra Pak Research & Development AB, Lund, during the period from November 2003 to March 2004. It was done to deepen the understanding in the area of transport testing. Assigner was Tetra Pak Technical Package Development who contributed with knowledge, workspace and necessary resources for this project.

Working on this project has been evolving and interesting. I have had an opportunity to apply knowledge and way of thinking acquired during several years of university studies. To get a first sample of real life outside the university has been very motivating in finishing the work and gaining my degree.

I want to thank my supervisor at Tetra Pak, Anette Immelborn, for ideas and point of views that has helped to proceed in my work. I also want to thank my supervisor at Lunds Tekniska Högskola, Fredrik Nilsson, for valuable support during the course of my work and good feedback and comments on my work.

I also want to express my gratitude to all people who have helped in my work, from sharing knowledge and information to help with testing and evaluation.

*Lund, 22 March 2004*

FREDRIK BODIN

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## **Summary**

When developing new packages with low cost as main focus, new aspects of the packages durability come into focus. The mechanical abilities of the package become the deciding factor for the design and choice of material, this increase the need for testing early in the development process. The need for more knowledge within this area was the foundation for this thesis.

The transport reality varies very much depending on the conditions of the market the product is sold in. Handling can vary from fully automated handling with the best transports to only manual handling without an established distribution system, where the packages are carried in baskets transported by foot or on animals. To show the differences, the most developed markets, advanced markets, and the least developed markets, emerging markets, have been chosen as the focus areas in this thesis.

The work was focused on a benchmark to learn more about how other companies handled transport testing on a global market, a field experiment to acquire more knowledge about the vibration test currently used at Tetra Pak, and finding a way to develop new testing routes for use in development of new package.

The results from the benchmark gave good results concerning general understanding, but less information on detailed testing. An important conclusion from the benchmark is that there is a trust in the package producer from the customer that has to be maintained. To do this it is important to maintain and increase the advantage of knowledge in transport testing.

Tetra Pak already has knowledge in the area of transport testing, however, this information is spread within the company at the different departments that have conducted transport tests. By organizing and centralizing this knowledge a powerful tool could be created to be used in the work with transport testing.

The field experiment indicated that the vibration test used for the Tetra Fino Aseptic package is tougher than the conducted truck transport.

When developing new testing routes there are several aspects to consider, before deciding on which methods to use. A combination of tests would give a better understanding of how the different tests affect the package. By mapping actual handling chains at real customers a better base for deciding which tests that are relevant will be obtained. After this information is gathered it will be much easier to determine what tests and what approval levels that reflect the actual strain the package needs to be able to manage. The possibility to conduct each test at several intensity levels will also give more information about the package properties.



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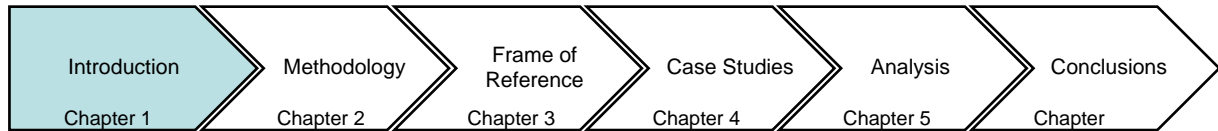
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# 1 Introduction

*This chapter gives a brief introduction to the background and why this is an important area to learn more about. The problem is discussed and formulated into a purpose of this thesis. Furthermore the focus area is specified and the stakeholders to this thesis are briefly introduced. As the last part of the first chapter the thesis disposition is presented and explained.*



## 1.1 Background

Packaging of food has an important role in today's society. It has made many of the things possible that we take for granted in everyday life, like having fresh milk always available for example.

### 1.1.1 What Makes a Good Package?

To protect food safely and efficient from where it is produced to where it is consumed is the most important function of food packaging. Paine<sup>1</sup> says “a correct package is the principal way of ensuring safe delivery of a product to the ultimate user in good condition at an economic costs”. In a later publication Paine<sup>2</sup> argues that the package is an essential link between the product maker and the consumers, and if it is not performed correctly the reputation of the product will suffer and goodwill from the customers will be lost. The value from developing and producing the product will be lost if the product does not reach the consumer in the correct condition. In this view the package is an equally important component of the product as the rest of the product. The package has a fairly wide span of benefits, which are mainly the following<sup>3</sup>.

- Protection: packages protect the contents from light, microorganisms and air, and the environment from the contents of the package.
- Preservation: good packages can help preserve food and prolong its shelf life during storage, transport retailing and consumption.
- Communication: packages carry important product information about ingredients, quantities, nutritional value, use, shelf life and much more.
- Convenience: packages provide convenience for the consumer, enabling the food to be handled, served and then stored what is left for future use.

“A good package should save more than it costs” is a principle stated by Ruben Rausing<sup>4</sup> some years ago, a principle that is still valid in the development of new packages. In more direct terms a good package must meet the requirements of the areas stated above and also use a minimum of resources to produce, store and transport the package and its content. Consequently, good packages not only protect the product they contain, they also protect the resources invested in producing and handling them.

Conclusively, a good package saves food, raw materials, energy and the environment<sup>5</sup>.

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<sup>1</sup> Paine F. (1985) *Practical Packaging*, PIRA International, Surrey

<sup>2</sup> Paine F. (1990) *Packaging Design and Performance*, PIRA International, Surrey

<sup>3</sup> [www.tetrapak.com](http://www.tetrapak.com) 2003-11-19

<sup>4</sup> Ibid

<sup>5</sup> Ibid

### 1.1.2 Developing New Package

When creating a new package concept success factors are attractiveness to target consumers, meeting key customers innovation needs, and most importantly a profitable business proposition for Tetra Pak.

The primary package should have an attractive appearance, be easy to understand and handle and of course be aseptically tight. The secondary package should be designed so that the primary package is delivered without leakages and with a nice appearance at the point of sales.

In a strategic aspect the package influences the total cost in two ways, according to Johansson<sup>6</sup> et al. One is the direct cost related to the package and its components, namely the cost of packaging materials and the cost of handling the package materials. The other influence on the costs is semi direct, namely costs that indirectly influence the costs in the flow of products. For example, less capital tied up in storage because of smaller packages or easier information capture because a bar code is used on the package.

Schematically, the relation between the cost of the package and the cost of damaged goods can be described with the graphs in figure 1.

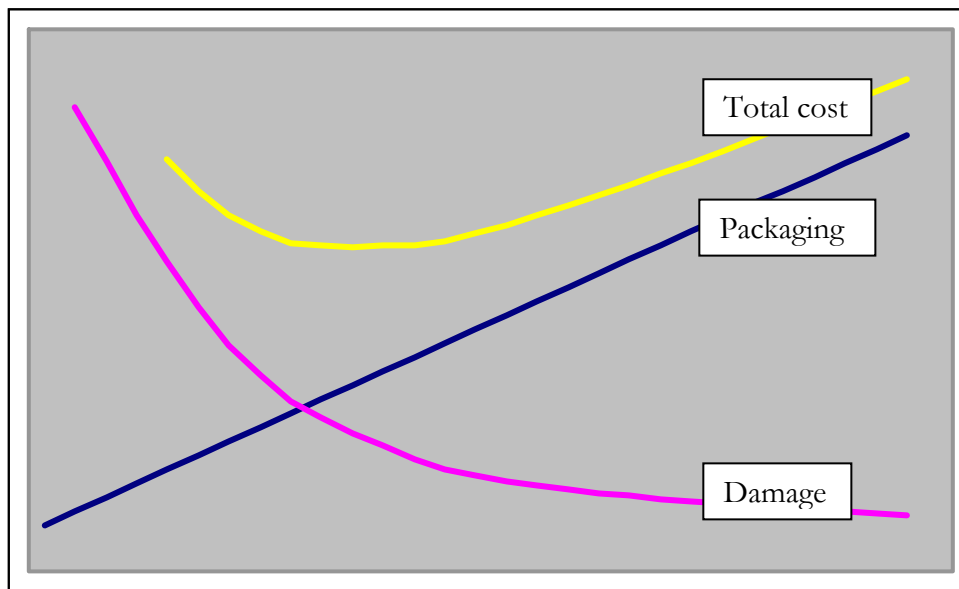


Figure 1. Optimization of cost factors<sup>7</sup>

This shows that it is important to consider the level of protection of the package in the overall concern of total cost.

When considering a new packaging concept the economy of the project is vital. It has to be a profitable business possibility. A main factor is to keep the material cost as low as possible since that is a major part of the entire package cost. On the other hand the package cannot be made of too little or low quality material, because then it will not meet the demands on a good package and therefore it will not be good business to try to sell it.

<sup>6</sup> Johansson K., Lorentzon A., Olsmats C., Tilander L. (1996) *Förpackningslogistik*, Packforsk, Stockholm

<sup>7</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, p 5.

## **1.2 Problem Discussion**

Since it is so important to keep the cost of the package low, while still having to meet the demands that are put on the package, there is a need of developing methods fulfilling both these criteria. The mechanical strain on the package is the most extensive during transport and handling. This makes it a natural focus area when trying to set the requirements that the package has to meet.

To evaluate if the new package meets the mechanical requirements Tetra Pak uses today a transport simulation method (ASTM 4728). The method has been used for the Tetra Brik Aseptic package (see Figure 2) for a long time both in Lund, Sweden and Modena, Italy. When developing new packages like pouches, stand-up pouches and retortable cartons, which differ from the traditional “box”, the simulations are slightly modified according to common sense.



*Figure 2. Tetra Brik Aseptic*

However, questions have been raised about how appropriate this testing method is in the area of package of liquid foods. There are examples<sup>8</sup> when this testing method has resulted in considerably more damaged packages than comparisons to real transport situations. These doubts have resulted in other questions concerning transport testing. Those are questions like, which other methods exist, and how do other players on the market test their products.

There are of course other aspects of testing to consider. The testing has to add more value to the process of creating new packaging concepts than it costs in terms of effort, time and money. This indicates that there could be a certain point when more testing is not contributing in a profitable way to the developing process.

## **1.3 Problem Formulation**

To be able to test in an adequate way, there needs to be an understanding of the transport reality. This reality then sets the parameters of what and how it is possible and meaningful to test. The problem for Tetra Pak is to find out if there is a way to test or simulate the entire handling of a package from producer to consumer. In addition Tetra Pak would like to learn more about which methods that are available today to become more aware of the possibilities of testing packages mechanical abilities.

For Tetra Pak, the potential business opportunity is the most important factor and this requires cost efficiency in both new packages and product development. To create business, it is also important to be competitive in comparison with competitors on the market. Thus there could be a need for a better understanding of how the next step in the value chain secure the reliability of

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<sup>8</sup> Tetra Pak development report from 1992

their packages. One way to gain this understanding is by doing a survey on the market of fast moving consumer goods.

### 1.4 Purpose

The purpose of this thesis is to increase the knowledge in the area of transport testing and transport reality for food package in compliance with the needs of Tetra Pak Research and Development.

Objectives in the work will be to do an evaluation of the vibration test used today and to find a method to find a testing evaluation route that best describes the transport reality for Tetra Pak products.

### 1.5 Focus

Focus in this thesis was concentrated on mechanical testing methods on package of liquid foods. There are of course other aspects of the package that has great influence on the final outcome, but they have a place in other parts of the development process.

The focus on transport reality will be based primarily on emerging markets and advanced markets. Tetra Pak Research and Development will be naturally prioritized and comparison will also be made with Tetra Pak Carton Ambient.

### 1.6 Stakeholders

The assignor for this thesis is Tetra Pak Research and Development, who has a direct interest in the result of the thesis. The division of packaging logistic, department of design sciences, and Lund University also have an interest in the result of the thesis since the area of transport reality is an area that is a pressing issue in current academic research.

### 1.7 Disposition

A short description of the structure will be given to guide the reader of this thesis.

#### 1.7.1 Disposition

Every chapter starts with a short summary of the contents of that particular chapter. Also, in the beginning of each chapter, there is a figure that indicates the location of the chapter in the thesis (see Figure 3).

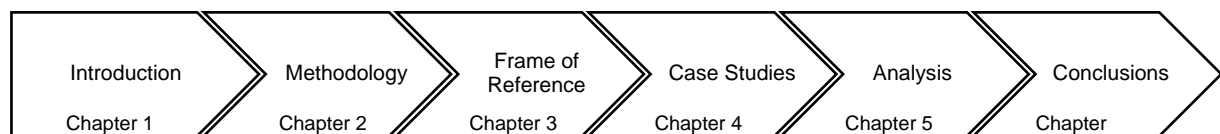


Figure 3. Thesis disposition.

The introduction describes the background and the discussion that leads up to the problem of focus in the thesis. The methodology chapter describes different methods for research and explains the methodology used. The frame of reference defines the more general background for the thesis and is meant to give the theoretical frame. In the case studies, the relevant information gathered is presented and form the foundation for the analysis. In the analysis the information in the case study chapter is analyzed with regard to the problem formulated in the introduction. The last chapter contains the conclusions that can be drawn from the analysis and these conclusions will fulfill the objective given in the introduction.

### **1.7.2 Reading instructions**

Every reader may not have interest in all parts of this report. Some may only be interested in the result and the analysis that have been made, while other can be more interested in methodology and course of action to complete the thesis. This is why a short explanation is given of what the different parts cover.

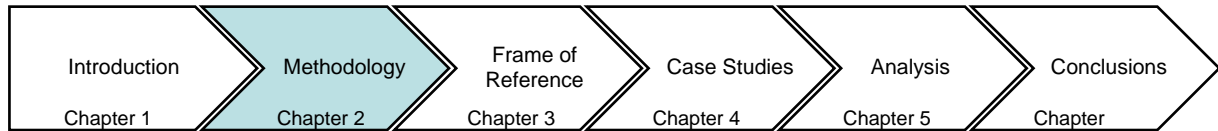
Those interested in the subject the thesis covers should read the introduction because this explain the background and the problem discussion. The case study contains all the facts that the research is based on and perhaps the most important part to understand the subject. From the case study the analysis of the problem follows with the different aspects in focus.

If more interested in methodology and course of action the methodology chapter and parts of the case study would be of most interest, since this clarifies some parts of the course of action.



## 2 Methodology

*This chapter covers how the subject was specified and divided into manageable parts. Furthermore, the research approach and course of action is presented to give the reader an understanding of how the work has proceeded over time. Finally some factors that can influence the result is looked at and discussed.*



### 2.1 Choice of Subject

Tetra Pak R&D decided this area of research. The department for Technical Package Development experienced difficulties within the area and decided to start a master thesis to examine the issue. In the beginning the problem was quite general in its formulation and it had no real specification as to how to proceed and what to focus on.

Together with Tetra Pak three main focus areas were determined. First, a desk search and investigation within the area of transport testing had to be conducted. This was considered the only way to start in order to have a foundation for the rest of the work with the upcoming interviews and test.

Secondly there was a significant interest in how other companies in the area were handling the issues concerning transport testing. The decision was to do a benchmark with companies in the area of interest.

The primary focus so far had been the actual testing equipment that existed within Tetra Pak, a vibration table. After recent tests questions had been raised regarding the toughness of the test when using it to design new types of packages. To address this problem it was decided that an experiment should be made where the vibration table was to be compared with real truck transport.

### 2.2 Research Approach

It is possible to collect data in different ways. Usually data can be divided into primary and secondary data. The researcher produces primary data by for example observations or interviews, while secondary data already exist in external sources.<sup>9</sup> Dividing the data should not be considered as a ranking of data in different quality. The type of data chosen is dependent on the type of information that is required and secondary data can often be of the same or better quality than primary data. In this thesis both primary and secondary data were used to obtain a foundation that is as reliable as possible for the analysis.

When collecting data it is essential to separate source and methodology.<sup>10</sup> A source is a collection of information that already exists and is ready to use, while a methodology is a way to obtain information. How the source is used as well as which methodology that is chosen, has great influence on the result of the search. It is also important to find the right source and be able to pick out the interesting parts of the information.

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<sup>9</sup> Lekvall P., Wahlbin C. (2001), *Information för marknadsföringsbeslut*, IHM förlag, p 212

<sup>10</sup> Ibid, p 85

## 2.2.1 Primary Data

Most of the material used in this thesis is collected as primary data. A combination of case studies and survey studies was used to get information on how transport testing is used today and which results that has been presented before. Interviews were the main method of gathering the information for the studies. A field experiment was the foundation for the comparison of the vibration test and a normal truck transport.

### **Case Study**

The case study research is suitable for deeper and more detailed analysis of specific cases. It is an appropriate approach when there are questions on what is important to investigate.<sup>11</sup> Knowledge is continually increased and more interesting areas are discovered during the course of the research. Case studies can involve either single or multiple cases, and numerous levels of analysis. The process of building theory from case study research is iterative.<sup>12</sup> The research can use multiple investigators and multiple data collection methods as well as a variety of cross-case searching tactics. Each of these tactics involves viewing evidence from diverse perspectives. Case studies are most often used to acquire a broader knowledge or to gain understanding in a specific case.

### **Survey Research<sup>13</sup>**

Survey research is the method of gathering data from respondents thought to be representative of some population. The method is often used to investigate different aspects in the subjects chosen. The information gathering is often done through interviews or questionnaires. The results are considered to be quantitative in its form. However, survey research can be conducted with a more exploratory direction with deeper interviews and a lesser number of subjects, the survey then become more qualitative.

### **Interviews**

Interviews have been the primary data collection method used in the case study and survey research. The different kinds of interviews that are possible are personal interview, interview by phone, and group interview.

There are different ways to approach the interview. One way is to conduct the interview based on a structured questionnaire containing predefined questions. Another approach is to let the interview be centered on some key questions from which a discussion is more freely based.<sup>14</sup> The situation should determine which approach that is used. Interviews by phone should be structured and prepared in advance to prevent them from being too long to loose the interest from the respondent.

In this thesis mainly personal interviews have been chosen when possible, although interviews by phone have been used when so called for. In an attempt to keep an exploratory approach the interviews have been focused on key questions to keep a flexibility and openness to initiatives from the interviewees.

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<sup>11</sup> Lekvall P., Wahlbin C. (2001), *Information för marknadsföringsbeslut*, IHM förlag, p215-216

<sup>12</sup> Eisenhardt K. (1989), *Building Theories From Case Study Research*, Academy of Management Review, Vol. 14, No 4, p 532-550.

<sup>13</sup> Lekvall P., Wahlbin C. (2001), *Information för marknadsföringsbeslut*, IHM förlag, p216-217

<sup>14</sup> Ibid, p265



## **Field Experiments**

Field experiments are a method suitable to investigate an object and verify or discard an assumption.<sup>15</sup> Data are collected by actively influence the area of interest, to manipulate one or more factors while controlling all other variables at fixed levels, and not only observing an event. Most often an experiment is made in a controlled environment, a laboratory, which provides a high level of control. When needed experiments can also be performed in an actual environment.

### **2.2.2 Secondary Data**

Research that exclusively is based on primary data are practically nonexistent.<sup>16</sup> There is almost always some part in an investigation that requires secondary data. This type of data are often used as a complement to primary data collections, but can also with good results be used as an independent gathering method. In this research secondary data are used to gain an initial knowledge and base for the upcoming primary data gathering.

Secondary data have been gathered through desk search. Sources used in this search were mainly the Internet, reports from PackForsk and development reports from Tetra Pak.

### **2.2.3 Benchmarking**

Since an important part of this research from Tetra Pak's point of view was to gain an understanding on how other companies acted in the area a benchmark seemed like a good approach. A benchmark requires a systematic and well-prepared approach that can be divided into six steps.<sup>17</sup>

- Identify and understand the processes within the company.
- Agree on what to compare and who to compare with.
- Gather data.
- Analyze data and identify differences.
- Plan and initiate improvement work.
- Conduct renewed review.

Every step has to be done and ended before proceeding to the next step. The first two steps are very important to determine and verify to ensure the success of the benchmark.

## **2.3 Course of Action**

The work with a master thesis can be described as a process with a given start point and a set end date. In the work to complete this thesis the work has been divided into different areas as follows.

### **2.3.1 "Mapping" Area of Knowledge**

To prepare for upcoming interviews, there was a need to have knowledge within the area to be able to determine how to proceed and determine who to interview and what to ask.

#### **Desk Search**

As a first step a desk search was initiated. With help from the department of Technology Intelligence at Tetra Pak the first search for material in the area of transport testing and transport reality was initiated. As complements to this search further work was done at the Lund university

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<sup>15</sup> Wallén, (1996), *Vetenskapsteori och forskningsmetodik*, Studentlitteratur, p 67

<sup>16</sup> Lekvall P., Wahlbin C. (2001), *Information för marknadsföringsbeslut*, IHM förlag, p 212

<sup>17</sup> Cook S. (1995), *Konkurrensfördelar med benchmarking*, Docendo läromedel, p 21.

library and over the Internet. The results were not as extensive as hoped for but material was found primarily in form of reports from PackForsk and standards for transport testing.

### **PIRA**

To further expand the knowledge in the area contacts were taken with PIRA in the UK. This resulted in a visit and tour of their facilities as well as an extensive interview with an expert in the field.

### **2.3.2 Benchmark**

The benchmark was a request from Tetra Pak where ideas already existed on which companies to approach and what areas were of highest interest.

#### **Choosing Benchmarking Companies**

A number of criteria for companies suitable for this survey were set before deciding which companies to approach. Since they had to match Tetra Pak in several aspects three main criteria were set. The companies had to act on a global market, they should handle food, and do business in consumer products.

The need for global players were that there are vast difference in transports in different parts of the world and one aspect should be if there had to be a difference in testing depending on which market was to be supplied.

The motive for choosing companies that handle food was that food has completely different demands on handling and storage than most other products.

Dealing in consumer products was also an important aspect since it would be an advantage for the investigation if the supply chain were similar for all the companies' distribution to their customers.

These criteria effectively decreased the number of potential benchmarking companies. Together with the instructor from Tetra Pak it was decided to approach five companies and set the goal at three respondents. The chosen companies were Nestlé, Unilever, Coca-Cola, PepsiCo, and Procter & Gamble.

#### **How to Approach**

After the companies were chosen a strategy to approach them had to be set. It turned out that all of these companies were important customers to Tetra Pak and had a special contact within the Tetra Pak organization, an International Key Account Manager (IKAM). It was decided that the best way was to approach through existing channels and the high organizational level of the contact could increase the chances of a successful benchmark.

### **2.3.3 Field Experiment**

The single most contributing reason for this whole master thesis project was the need for better understanding of the results from the vibration tests at Tetra Pak. Therefore, an experiment on how the current level of strain relate to real transports were an essential part of this project.

It would have been interesting to test the relation between a normal transport in India or China, since the conditions are worse considering roads and trucks, and the vibration test method. However, due to time, cost and location reasons it was decided to settle for a road test in a regional location.

To get a measurable result was of highest interest and that fact combined with the special interest of the pouch and stand-up pouch packages led to the choice of Tetra Fino Aseptic package, TFA, (see Figure 4) for use as the test package in the field experiment.

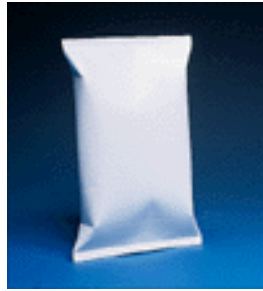


Figure 4. Tetra Fino Aseptic, TFA

The pouch and stand-up pouch is not as rigid as the more classic packages (e.g. Tetra Brik Aseptic) and would therefore probably not withstand the strains from transports and hence produce a more easily measurable result in the form of leaking packages.

## **2.4 Influencing Factors**

Since the background and opinions of the writer or researcher influence methodology, analysis and results a short description of this person could be in order. However, it is not only the attitudes of the researcher that can affect the result, the opinions from the assignor can also leave its mark.

### **2.4.1 Researchers Background**

When the work is initiated the writer or researcher starts from his or her theoretical and practical background, which is the foundation for the understanding of the problem. To be able to grasp this understanding a short summary of the author's academic background will be given.

The author is studying to receive a master of science in mechanical engineering at Lunds Tekniska Högskola (Lund Institute of Technology). During the later years of the education a specialization is chosen. In this case the author has chosen a specialization towards logistics and industrial economics with extra courses within the area of packaging logistics.

### **2.4.2 Writing with an Assignor**

An assignor is often a company or an organization that has a special interest or a specific problem within a certain area of expertise.<sup>18</sup> The reason for the assignor's interest is most often that they would like suggestions for course of action when facing a specified problem or a need for more knowledge concerning a special subject. Most often a company is not interested in general knowledge rather than the specific knowledge they have a need for.<sup>19</sup> This can often become a somewhat conflicting situation since the university places demands for the academic contents and contribution in the thesis while the assignor only has an interest in the result.<sup>20</sup> Sometimes this is solved by writing two separate papers, one for the academy and one for the assignor. In this thesis it has been solved by reading directions in the first chapter.

Another common problem is that the assignor influences the result of the thesis by the information that is presented.<sup>21</sup> Since the student is responsible for the result of the thesis, the

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<sup>18</sup> Paulsson U. (1999), *Uppsatser och rapporter – med eller utan uppdragsgivare* Studentlitteratur p 21

<sup>19</sup> Ibid, p 31

<sup>20</sup> Ibid, p 24

<sup>21</sup> Ibid, p 53-54

information given by the assignor should be interpreted and valued with respect to the background and history of the source before it is used.

Economical compensation is another factor that can influence the result.<sup>22</sup> The author can feel obliged to reach a certain results that comply with what the assignor want to achieve. However, this type of compensation also has positive effects, as increasing the motivation and commitment of the author. It is also important to state that the fact of having an assignor also increases the commitment from the author. From the company's point of view, the amount of commitment is most often influenced by the importance and actuality of the assignment, but also from the need of recruitment in the near future.

## **2.5 Method Criticism**

By method criticism is meant criticism towards methods and course of action used in the research. Usually method criticism is divided in to three areas, validity, reliability, and objectivity.

### **2.5.1 Validity**

The term validity means to what extent what is thought to measure really is measured.<sup>23</sup> In this research interviews have been used as a primary source of information. Interviews are often criticized as a scientific method since they are considered to be too dependent on the involved persons. However, individuals' knowledge is a great source of information and foundation of new knowledge that can't be overlooked and interviews is the best way to get hold of this knowledge. Although the knowledge is tainted from the persons experience and not completely objective, it is still a part of the truth and by combining and comparing it with other interview results a better understanding of the actual picture can be obtained. In this thesis interviews have been made with several persons in most areas covered, in an attempt to get good validity.

The most difficult part of validity is to determine whether a method is valid or not. To make this judgment a method that gives the true result is needed for comparison and in that case the second method could be used instead.

In the field experiment it is important to consider that no other variables than the ones in focus affect the result.<sup>24</sup> This requires that the occurrences meant to measure have to be clearly specified and an assumption made on which factors that affect the result is made. When the experiment was conduct all efforts were made to ensure as little outside effects as possible would influence the result to gain as high validity as possible.

### **2.5.2 Reliability**

Reliability indicates to what extent the result will be the same if similar measurements at the same conditions are conducted.<sup>25</sup> In interviews the reliability can be somewhat low since the interviewee can remember different extent from for example an event. It can also be the case that the interviewee can be selective in the responses depending on who is asking the questions or how the question is formulated. The interviewee could also get tired of answering questions and become less informative than would be the case if the research were preformed at another time.<sup>26</sup> Hence, it is difficult to get good reliability in research based on interviews.

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<sup>22</sup> Paulsson U. (1999), *Uppsatser och rapporter – med eller utan uppdragsgivare* Studentlitteratur p 22.

<sup>23</sup> Halvorsen K. (1992), *Samhällsvetenskaplig forskningsmetodik*, Studentlitteratur, p 41.

<sup>24</sup> Wallén G. (1996), *Vetenskapsteori och forskningsmetodik*, Studentlitteratur, p 65

<sup>25</sup> Halvorsen K. (1992), *Samhällsvetenskaplig forskningsmetodik*, Studentlitteratur, p 42.

<sup>26</sup> Paulsson U. (1999), *Uppsatser och rapporter – med eller utan uppdragsgivare* Studentlitteratur p 42.

Since this is an area where there has not been so much development at Tetra Pak in recent years, the reliability becomes a bit higher when several persons have similar knowledge.

### **2.5.3 Objectivity**

Objectivity stands for to what extent different values affect the result of the research.<sup>27</sup> Since most part of this research is founded on interviews it can't be considered to be completely objective. The facts that come to light are affected of how the interviewee has conceived the original facts or original situation and how the interviewer interprets the information the interviewee supply. To totally avoid these problems is impossible since even if the facts that are supplied are totally objective they have to be interpreted and analyzed of the researcher to give a conclusion. Hence, in the area of objectivity it is sometimes referred to sufficient objectivity.

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<sup>27</sup> Paulsson U. (1999), *Uppsatser och rapporter – med eller utan uppdragsgivare* Studentlitteratur p 42.



### 3 Frame of Reference

*This chapter describes the underlying foundation for this area of knowledge. An understanding of what happens during transport is necessary for further work in the area of transport testing, therefore the different types of strains are described. This is followed by a part on the existing transport testing methods.*



#### 3.1 Transport Reality

Physical distribution is often divided into two main categories, namely administratively and physical.<sup>28</sup> The physical activities can vary depending on the situation, but usually include:

- Storage at one or several levels
- Reception, handling and picking from storage
- Packing and wrapping
- Transport and terminal handling
- Handling of return flows

All these activities involve handling of the goods in some way and when goods are handled it is subdued to mechanical strain.

Mechanical strains are the determining factor in the majority of transport damages. As much as 80% of the damages are caused by vibration and shock.<sup>29</sup> Forces and movement is included in the term mechanical strain. They can be of many different origins, for example shocks from rail switching, ship movement, truck vibrations, stress from stacking, centrifugal force from going through a curve, or over pressurized containers.<sup>30</sup> This can result in different types of damages, like direct material breakage, exhaustion break, abrade, puncture, load displacement, lids, or components that come loose and so on.

##### 3.1.1 Static Load

Static forces are of the nature that they form equilibrium of forces with certain duration. This indicates that the entire system is either at rest or moves with constant velocity in a certain direction. Forces that causes speed change, change in direction or is a consequence thereof (inertia force) is then called dynamic.<sup>31</sup> The distinction is not absolute. Inertia forces like centrifugal force can for example often be static in its characteristics. In addition, slowly varying strains from high sea can be considered as (semi) static.

Strains from stacking of goods, inner or outer pressure, and sideway strains are types of static loads that are common during transport (see Figure 5).

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<sup>28</sup> Persson G., Virum H. (1998) *Logistik för konkurrenskraft*, Liber Ekonomi, p 73.

<sup>29</sup> Ostrem F. E., Godshall W. D. (1979) *An assessment of common carrier shipping environment*, Forest Products Lab FPL 22.

<sup>30</sup> Kjell G., Pettersson T., Torstensson H., Trost T. (1989) *Karakterisering av transportmiljö*, Packforsk, Stockholm, p 2.

<sup>31</sup> Ibid, p 57.

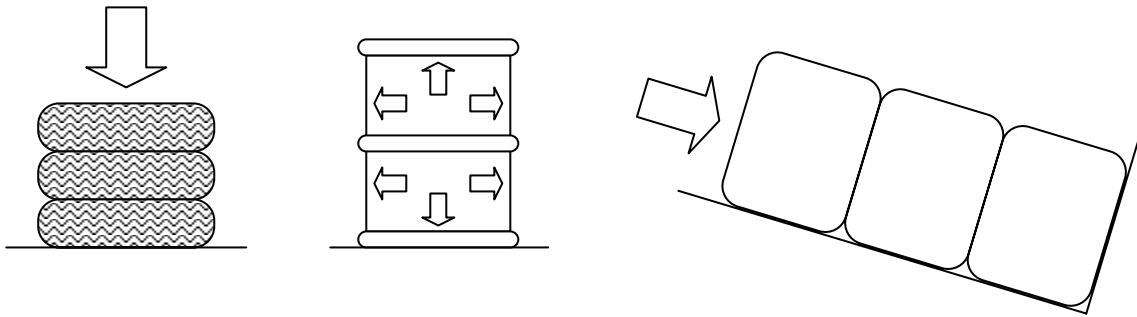


Figure 5. Examples of static load<sup>32</sup>

When stacking goods the highest strains occur vertically and are of course the highest in the bottom layer. When overloading, the result is deformation and the packages with their contents could be damaged in different ways. If overloading is the cause, then contributing causes could be choice of material, high temperature or moisture.

Overloading could be an effect of inertia forces that have not been considered, for example at high sea. The actual load could be as much as 1.8 times the original load.<sup>33</sup>

When a side of a box breaks it starts as elastic bending of the side. The load then results in a greater bending momentum that easier exceeds the materials ability to withstand load (see Figure 6).

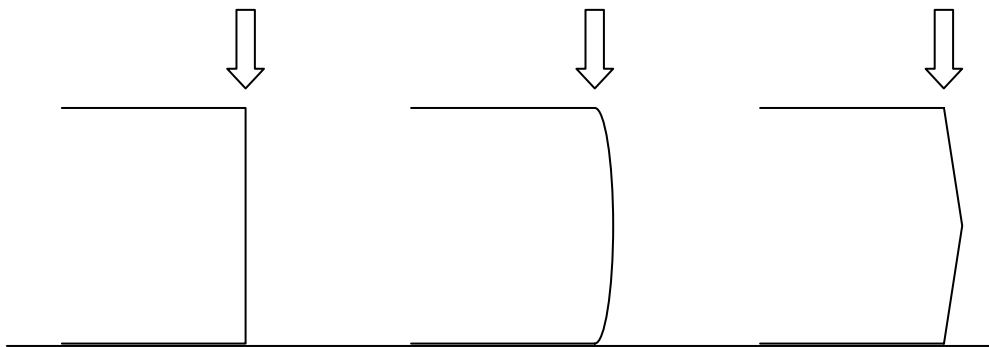


Figure 6. The course of events when load brakes box side.

Moisture and high temperature in corrugated cardboard or plastic reduces the stiffness and increase the risk of breaking.

### 3.1.2 Impact

Impacts are a kind of dynamic strain that occurs on transported goods due to acceleration or breaking of the load carrier, uneven motion, rail switching or if the goods are dropped, tipped over, thrown, or run into. Impacts ought to be the most common direct cause of transport damage.<sup>34</sup>

The effect of an impact is dependent on both the size of the force and the duration of the impact. The direct measurement of an impact is the concept of impulse. The impulse is directly related to the change in velocity of the mass. However it is not always true that a greater impulse results in a greater damage.

<sup>32</sup> Kjell G., Pettersson T., Torstensson H., Trost T. (1989) *Karakterisering av transportmiljö*, Packforsk, Stockholm, p 57.

<sup>33</sup> Ibid, p 58.

<sup>34</sup> Ibid, p 59.



The most severe mechanical strain usually occurs during free fall, when the goods hit the surface below. Therefore it is important to eliminate these events to the furthest extent possible. It is known that larger units of goods result in lower drop heights. This is mainly because they are harder to handle manually and cannot be thrown. To combine goods into larger loads can therefore be a good preventive action to get fewer damaged packages.<sup>35</sup>

Deformations and breakages are the most common damages that occur from impacts, either in the packaging material or in the actual product. The cause is that the impact force and hence the tension in exposed parts become greater than the material or seals can bear. It is also possible for components to be torn loose and cause function disturbances.

### **3.1.3 Vibration**

Vibration is periodically, non-periodically, or stochastically occurring dynamic strain. It can be temporary, fast out dampened, so-called transient vibration.<sup>36</sup> Transient vibration is very similar to impacts that are covered in the previous chapter.

Stationary vibrations occurs for a longer period of time in an oscillating system, often excited by machine vibration on ships or unevenness in the road during truck transport. At high levels of load can this type of vibration cause exhaustion damages.

Other damages that can occur are that seals, screws, components or load securing material come lose or wearing damages due to vibration. Often can vibration make it easier for damages to be caused by impact when securing material come loose or packages are displaced.

## **3.2 Transport Testing**

For many years, transport testing has been a method used in the industry. Although it has been around for quite some time it often occurs that companies have wrong or misleading testing methods. This can be for a number of reasons, for example old standards, unrealistic demands from customers, lack of knowledge etc. This can result in inappropriate strains during testing and lead to over testing or under testing.<sup>37</sup>

Over testing can result in that the product must be redesigned to a high cost and the total cost of the product will be too high, due to increased production and material costs.

When under testing occurs, the extra cost does not appear until the product is out on the market and the reclamations start coming in. This may result in great costs and loss of reputation. These goodwill losses can become very extensive and expensive. The extent is often hard to estimate. In general customers have become less tolerant to defects in products and packaging.

Product endurance testing regarding transport environment is most often conducted when the goal is to find out how fragile a product is and from those results construct a package. The intent of transport testing or package testing is primarily to test and evaluate the protecting capacity of the package. It is of course possible to obtain information regarding design and dimension of transport packaging or knowledge about the products capacity to withstand the strains of transport from this kind of testing.

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<sup>35</sup> Kjell G., Pettersson T., Torstensson H., Trost T. (1989) *Karakterisering av transportmiljö*, Packforsk, Stockholm, p 59.

<sup>36</sup> Ibid, p 60.

<sup>37</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, p 5.

### 3.2.1 Testing Standards

Existing standards are designed for products during transport.<sup>38</sup> Since the basis for the methods are measured during transport, it is vital that the products are packed in their transport packages. Transport refers to “the four” ways of transportation (i.e. road, rail, sea or air) and in relevant situations handling and storage.

A transport-testing program is usually divided into different elements of testing that follows the distribution chain. This leads to higher strain and stress on the tested package the further the test proceeds. The first elements in testing focuses on lower strains in the early part of handling and storage. Thereafter, vibration test follows that simulates transport on truck. A simulation of truck is chosen because it has the highest level of vibration. Horizontal impact testing is used to simulate impacts from forklift handling and rail changes. The toughest impacts often occur when a packed product is dropped during manual handling, such as reloading or arrival at customer.

The following standards are a selection of the most common transport testing standards.<sup>39</sup>

ASTM:	American Society for Testing and Materials,
BSI:	British Standards Institution,
CEN:	Comité Européen de Normalisation, The European Committee for Standardization,
DIN:	Deutsches Institut für Normung e.V.,
ETSI:	European Telecommunications Standards Institute,
IEC:	International Electrotechnical Commission
ISO:	International Organization for Standardization,
ISTA:	International Safe Transit Association
PACKFORSK:	Packforsk – The Institute for Package and Logistics,
SRETS:	Source Reduction by European Testing Schedules
SS:	Swedish Standard
TELCORDIA:	Telcordia Technologies, (earlier Bellcore)

### 3.2.2 Testing Methods

The different transport testing programs are commonly divided into specific testing elements.<sup>40</sup> Each of these elements is supposed to simulate and replicate the different strains that exist in reality during transport, handling, and storage. By “testing program” a sequence of testing methods are implied, for example a drop test is followed by a compression test which is followed by a vibration test.

The elements are conducted in a certain order on purpose. Early in the distribution chain the package is handled carefully before it is placed in storage. It is stacked in a warehouse or in a vehicle before it is transported out, normally by truck. Sometimes there also is rail transport with rail switches. Reloading is not uncommon and that means more handling of the goods.

Usually the level of strain on the tested package increase during the course of testing. This because internally in a company, handling is often more careful with the company’s own product. The further away from the original producer the product goes, the more anonymous it gets and this often means rougher handling.

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<sup>38</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, p 6.

<sup>39</sup> Ibid, p 8.

<sup>40</sup> Ibid, p 6.

All strains from the distribution chain, transport by truck, train, ship or plane and manual handling, storing, forklift handling etc. are always a part of general, unspecified transport testing programs. The entire testing is done with the same package and product. Normally are not all kinds of transport used in one specific shipping, but it is seldom known exactly which ways of transport that is going to be used. Since all ways of transport is included in the testing, knowledge is acquired of how the package handles different strains. This means that a certain margin of error is built in to the package. The testing programs reproduce the “highest normal” strains that occurs during transport. Crashes and mishaps are not included in the testing. To design for such events would be far too expensive.

The tests are conducted in a laboratory environment.<sup>41</sup> This is supposed to be the best way of maintaining control of the different steps that are gone through. Another important aspect of why the tests are done in a controlled environment is to be able to reproduce the testing. There is also considerable timesaving compared to field tests since the tests are normally conducted on one or two days. Since it is possible to continuously inspect for damage it is easier to determine when and why the damage appear.

Serial produced products and packages should be used for testing because there is less variation in quality between the different units. Testing could also be done with prototype package and/or prototype product, although there is a risk of difference in quality between different units. At the same time it is desirable to test as early as possible to find any weaknesses and make necessary changes. Usually one has priority over the other in this matter.

Dangerous goods, easily spoiled foods and art or antiques need special treatment. Of obvious reasons dummy products are used when transport testing is done on package solutions in these product groups.

### **Drop Test**

Drop tests are conducted to learn about what happens when the package is dropped. This may occur during packaging, loading, unloading, repacking etc. The risk of higher drops is greater during reloading than during internal handling.<sup>42</sup>

When testing single goods the drops are most often conducted towards the edges or corners of the package (see figure 7). Sometimes drop tests could be done on one of the packages sides but in reality the risk is considered to be higher for a fall on the edge or corner.

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<sup>41</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, p 11.

<sup>42</sup> Ibid, p 12.

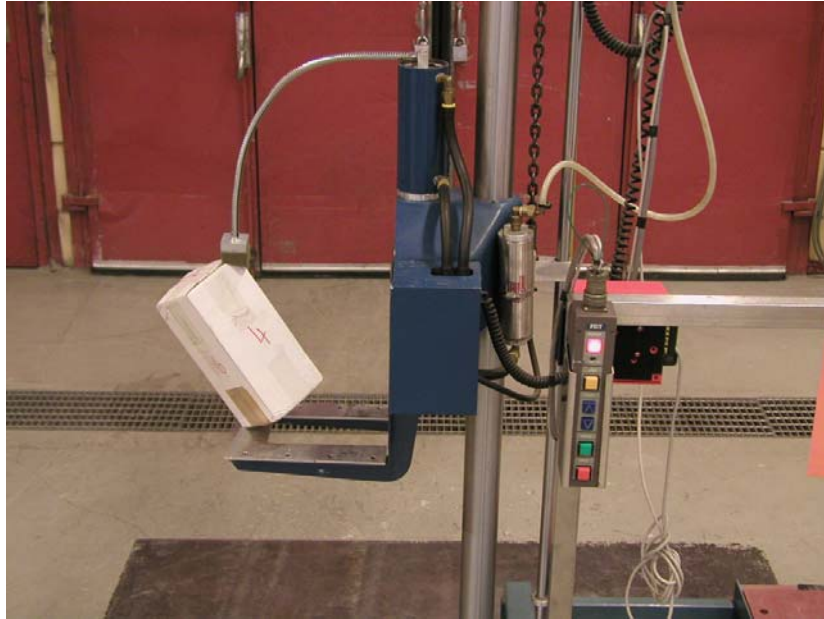


Figure 7. Drop test of single package.<sup>43</sup>

Drop test on entire pallets are done slightly different depending on which standard that is applied. Most common is to lift one edge or corner 10-20 cm above the ground (se figure 8), often with some kind of block. The block should represent a pavement edge, other pallet or something similar.



Figure 8. Drop test of pallet.<sup>44</sup>

The drop is then made against a level steel surface from the set height. Most often it is oriented so it will fall on an edge or corner, alternatively on the area with the lowest level of protection.

<sup>43</sup> [www.packforsk.se](http://www.packforsk.se) 2003-12-04

<sup>44</sup>Ibid

### **Compression Test**

The compression test is a form of load- or stack test where pressure is applied on top of the tested package (see figure 9). After packaging the goods probably ends up in storage or on the back of a truck where it could be stacked together with other goods. The purpose of the test is to establish what level of load it can be stacked with in form of other packages and goods before it collapses<sup>45</sup>. This is important to know when setting demands on the package.



*Figure 9. Compression test of pallet.*<sup>46</sup>

### **Vibration Test**

Of all the four ways of transport truck, train, ship and plane it is by truck that the highest level of vibration occurs.<sup>47</sup> Testing can be conducted for different types of vibration, but random vibration is preferred since it is most similar to reality. Sine vibration can cause damages that rarely occur during real transport, since there is a risk that the test is performed for a longer period of time at the products own resonance frequency.

The test is conducted on a vibration plate where the test item is placed and supported on at least one of the sides (see figure 10). The test is then performed during a certain time and at a level of vibration defined in the specific testing standard.

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<sup>45</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, p 12.

<sup>46</sup> [www.packforsk.se](http://www.packforsk.se) 2003-12-04

<sup>47</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, p 13.



Figure 10. Vibration test of pallet.<sup>48</sup>

### **Horizontal Impact Test**

To replicate the impacts from sudden braking or the switching of railcars horizontal impact testing is carried out<sup>49</sup>. The goods are driven towards a firm wall (see figure 11) and on impact it is stopped against the wall. Depending on which standard is used there can sometimes be two pallets on the testing ramp to get the full impact from the second pallet onto the first when it hits the wall.



Figure 11. Horizontal impact test of pallet.<sup>50</sup>

<sup>48</sup> [www.packforsk.se](http://www.packforsk.se) 2003-12-04.

<sup>49</sup> ASG, SJ Gods, Bilspedition, Packforsk Godstrafik inom Europa till och från Sverige – Förpacka Säkert, p. 9

<sup>50</sup> [www.packforsk.se](http://www.packforsk.se) 2003-12-04.

### **Tipping/Tilting Test**

Tipping test is performed on high goods, for example refrigerators and wardrobes, which could be lying down during transport.<sup>51</sup> An example of tipping test is that the goods is place lying down and is lifted 45 cm at the top end, from where it is dropped.

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<sup>51</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, p 13.





## 4 Case Studies

*This chapter contains the information the analysis is based on. At first the situation at Tetra Pak is described, followed with the benchmark information. Then the field experiment is presented in detail and at the end the knowledge from the visit to Pira is accounted for.*



### 4.1 Today at Tetra Pak

The vibration table has a very central role in transport testing at Tetra Pak today. It is frequently use by other departments for them to conduct tests of their product.

The table is managed by one experienced operator who conducts almost all tests on assignment from the different parts of Tetra Pak organization. Currently the table is fitted with an old software and hardware configuration that limits the possibilities to vary the settings for testing.<sup>52</sup> The level of vibration is today set according to ASTM, intensity level 2 (medium), and the only adjustable variable is time. These restrictions in variety give this vibration table a rather limited possibility to conduct different types of tests.

The set levels of testing for different types of packaging were defined many years ago. There are indications that the earlier testing programs of the table, before it was set at ASTM standard, had a relation between time and distance were 30 minutes corresponded to 600 km.<sup>53</sup> This level seem to have set the standard for most testing today, since 30 minutes on the vibration table is the standard setting for most packages, except for pouches were 15 minutes are standard.<sup>54</sup>

The vibration table as a resource is today separated from the other organizational departments that most frequently use it for testing. As a resource it is just taken into use to conduct the individual vibration tests as defined from the orderer. A consequence of this is that there are no possibilities to access earlier results since other departments have them by themselves.

#### 4.1.1 Tetra Pak Carton Ambient (TPCA)

Carton Ambient is one of the departments that use transport testing quite regularly. Mainly the tests are used as comparative test to get information on different secondary packages and package patterns. The data are then used to make recommendations to customers for example concerning secondary package and handling.

The testing is used since the type of damages on the packages are the same kind that is caused in real situations (mostly wear and abrasion) and the testing can be used to stress a package until it breaks, which discovers the weakest parts of the package and hence helps to prioritize on what to focus. In these types of test it is necessary for the test to be tougher than reality to give real measurable and usable results.

Apart from field tests, primarily on emerging markets, almost no other simulation methods are used.

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<sup>52</sup> Interview with Robert Hellström, Tetra Pak, 2004-01-28.

<sup>53</sup> Interview with Eskil Andreasson, Tetra Pak, 2003-11-27.

<sup>54</sup> Interview with Christel Andersson, Tetra Pak, 2003-12-12.

### 4.1.2 Tetra Pak Research and Development (TPRD)

At the department for research and development the demands are a bit different from those of a department with existing products. The vibration table is used quite extensively for tests, both as comparative and for absolute tests. The comparative tests are mainly conducted to get information on which material or design that is better, while an absolute test is an evaluation if the package actually can withstand a certain amount of stress. It is especially when conducting this second type of tests, absolute tests, the questions have been raised about which level of strain that is appropriate.

Some other test methods are also used when designing new packages. Secondary and primary package drop tests are very useful for pouches and stand up pouches, since they are more sensitive to impacts than other more traditional Tetra Pak packages. Compression tests are also used, primarily when designing secondary packages.

## 4.2 Transport Reality

The transport reality for Tetra Pak's packages are diverse, much due to that ownership of the distribution chain is always in an other companies possession and that Tetra Pak has customers all over the world. The transport reality can range from well packed pallets on nice trucks to randomly stowed packages in baskets that are carried by man or elephant (see Figure 12).



Figure 12. Hand packing in baskets in an emerging market.

The lack of control and influence of the filling line as well as the distribution chain has made it much more complicated for Tetra Pak to get knowledge about what really happens to the package after it leaves production.

Tetra Pak has divided its markets into three main parts Advanced, Developing and Emerging. In this thesis focus is on the first two and the later will not be discussed.

### 4.2.1 Advanced<sup>55</sup>

In the advanced markets distribution and handling is at a high level of refinement. The advanced market segment includes for example Western Europe, USA, and Japan.

In these locations the production process takes place in controlled environments and at set levels for surrounding conditions, which gives good quality. Packaging into secondary packages is often

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<sup>55</sup> Interview with Kenneth Andersson, 2004-01-14.

automated with high control and secondary packages of high standard. Also handling of secondary packages and pallets are automated, which results in good handling with little damages. Infrastructure and transport vehicles are most often of good quality and high standards. However, production is often centralized and one plant often supply products to a large area, which creates a need for long transport and often many centers in the distribution chain where handling is required.

#### **4.2.2 Emerging<sup>56</sup>**

Examples of emerging markets are India and China. These markets consist of countries that are less developed in terms of infrastructure and general level of technology.

Production can more often be conducted with less control over the surrounding environment with possibilities to wider variations in quality. Manual labor is cheaper and used to a bigger extent in packaging and handling. The variations in distribution units are also larger in these markets and pallets cannot always be assumed to be used. Road conditions also vary with possibilities for all types of conditions from good highways to donkey trails. These variations of course also exist in vehicles and other modes of transport, ranging from nice western trucks through really old trucks without suspension to donkeys and manual carrying of the packages. It is more common on these markets for smaller suppliers to deliver regionally than on advanced markets. However, there can also be times when very long transports are required.

### **4.3 Information from Benchmarking**

In general it was difficult to get information regarding transport testing from the chosen companies. Some of the contacts that have been available have only been able to give general answers either because they are not allowed giving out more information, or because they do not really have a deeper knowledge within the area.

#### **4.3.1 Unilever<sup>57</sup>**

At Unilever transport simulations is not a part of the regular methods when determining which package and distribution type a product should be sold and handled in. Experience from other activities and products in the field are the main factor used to choose a suitable solution.

Predicting the outcome on a specific market for a certain product is of course easier when dealing with well-known package types like the TBA. In cases with this type of packages the knowledge and experience combined with the rigid performance of the package makes the predictions be quite to the point and very usable to determine the final distribution solution.

When using stand-up pouches or other more sensitive packages the situation is considered to be so complex that it is not possible or worth the effort to try to construct a testing method for that specific case. The work and costs needed to make such extensive testing for every specific situation exceed the use and information obtained by the possible test results.

For optimization of pallets different palletization software's are used (CAPE, TOPS). This gives suggestions on a couple of alternative packing patterns for best pallet efficiency. Combining these alternatives with the existing experience within the organization gives the basis for choosing the best compromise between the pallets transport performance and pallet efficiency.

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<sup>56</sup> Interview with Kenneth Andersson, 2004-01-14.

<sup>57</sup> Interview with Ron Kahn, Unilever, 2004-01-22.

For ambient products the new product launches are often relatively small geographically, often regional or sometimes in one or two countries. With every new launch there is a final transit testing. This consist of one or two pallets loaded and packed according to the specifications of the specific product on that market, just as in future use. A real transport and handling in the actual environment is then conducted on the pallets. After the test is performed the pallets are stripped down and evaluated. All the packages are then extensively tested regarding to package appearance, micro fractures, leakages, and seal strength. If any problems are discovered the most common solution is to strengthen the pallet with cardboard on the sides or corners. It is very seldom that the actual package solution needs to be altered or adjusted.

### **4.3.2 Nestlé<sup>58</sup>**

Nestlé has identified transport testing as a mandatory part in their product development. Tests are to be done for all new products or product modifications.

Each market has someone responsible for conducting these tests in an appropriate way. Since there is no defined transport simulation method this is conducted as a real transport test trial. The organization with responsibility at each market provides a natural divider between different types of markets

Experience from the field within the company has been the base from which the testing is determined, there is no use of a specific testing standard of any kind.

The lack of generic guidelines and methods has resulted in a practice of testing perceived and organized as a challenge test, where the truck should be a bad one, the position of the palette to be tested is placed on most vibrating spot, etc. The experience of this way of testing is that it is sufficient for Nestlé's needs in the area.

### **4.3.3 Procter & Gamble<sup>59</sup>**

At Procter & Gamble the work with transport testing has been centralized in the meaning of that every new package concept is tested and evaluated once for the entire company.

The process starts with a system test, were the concept is evaluated with regards to input as pallet size, number of layers, and type of package. This is followed by a mathematical test were aspects of moisture, transport movement, and time factor are included. This work then results in a suggestion for packaging solution.

The completed packaging system is then subdued to transport testing. This is dependent on the resources at the specific location. At some locations there are possibilities for vibration tests and then it is used, otherwise truck transports are used as method to be able to evaluate how the package concept handles transportation

### **4.3.4 Coca-Cola<sup>60</sup>**

Coca-Cola was rather reluctant to share information about their transport testing routines. However, they made it clear that this is an area that they do work in, primarily together with PIRA when it comes to testing and they have a standard that is applied in all areas of business.

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<sup>58</sup> Interview with Dominique Chatard, Nestlé, 2004-02-09.

<sup>59</sup> Interview with Hovard Jörgenson, Procter & Gamble, 2004-03-09.

<sup>60</sup> Interview with Roger Moore, Coca-Cola, 2003-12-14.

On every new package launch there is an actual transport conducted at the specific location in the country where it will be used and afterwards a thorough evaluation of the load.

As to transport simulations Coca-Cola referred to PIRA for more information. PIRA on the other hand is not allowed to share information regarding their customers or partners.

### 4.3.5 PepsiCo

PepsiCo has chosen not to respond to the inquiry at all.

## 4.4 Field Experiment

The field experiment was carried out to be able to compare the effects of the vibration test with a real truck transport. The questions surrounding this issue are of great interest when developing new packages and making conclusions on how appropriate they will handle in a real transport situation.

### 4.4.1 Preparation

The chosen package Tetra Fino Aseptic 500 is normally transported and packed in to general ways, one is where the individual packages are placed in cardboard boxes specially designed for this purpose, and the other is in plastic crates where the packages are more loosely stowed and the crates are a part of a recycling system.

With this in mind the plan for the test was planned. It was decided that the test should be done in both cardboard boxes and in plastic crates on both the vibration table and in a real truck transport. From this decision a matrix was set up to illustrate the tests needed to be performed (Figure 13).

	Plastic Crates	Cardboard Boxes
Vibration test	% damages	% damages
Truck Transport	% damages	% damages

*Figure 13. Matrix over test*

In each test approximately a thousand packages should be tested for leakages. For this test it was enough to evaluate visually for water leakages.

### Producing the Packages

The packages were manufactured at Tetra Pak Carton Ambient facilities in Lund and manually placed on pallets (see Figures 14-16) from which they later were packed in their secondary package of cardboard or plastic, also by hand.



*Figures 14-16. Manual handling from production to pallet.*

### Packing

In each secondary package a number of primary packages were fitted, 24 (6 layers with 4 packages in each layer) primary packages in a cardboard box and 30 (3 layers with 2 rows of 5 packages in each layer) primary packages in the plastic crate (see Figure 17-18).



Figure 17-18. Primary packages in secondary

The secondary packages were then placed on pallets before the tests. In cardboard boxes the 960 packages did not fill an entire pallet, hence the extra space was filled with Tetra Brik packages just to get an evenly loaded pallet (see Figures 19-21). In the plastic crates the packages take up much more space and therefore there is a need for two pallets to load all 960 packages in plastic crates.



Figures 19-21. Pallets loaded with Tetra Fino Aseptic packages

### 4.4.2 Testing

Due to time and location resources the vibration tests were the first to be conducted. The entire pallets were placed one at the time on the vibrating table and vibrated for 15 minutes (Tetra Pak standard for Tetra Fino Aseptic) at intensity level 2 (see Figures 22-23).



Figures 22-23. Pallets on vibration table.

For the truck test a special round in Skåne was used (see Appendix), it has been used by Tetra Pak before the vibration table was acquired and at some times when the vibration table has been

out of order. The round is approximately 300 km long and consists of different types of roads from larger country roads down to minor gravel roads. The truck chosen for this test was a large truck from Tetra Pak's transportation department with a driver who has driven the route before. The pallets were loaded in the middle of the truck and a barrier was put up to prevent them from moving if the truck for some reason would have to brake hard (see Figures 24-26).



*Figures 24-26. Truck and pallets loaded in truck from behind and from front*

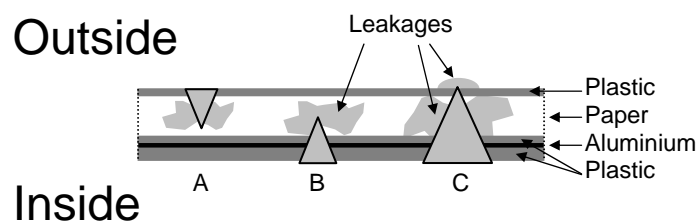
### **Evaluation**

For this experiment a visual evaluation of the primary packages is quite sufficient, other similar experiments conducted earlier have used the same evaluation method.<sup>61</sup>



*Figure 27, Visual evaluation of packages*

With visual evaluation (see Figure 27), every single package is inspected for water leakages through holes in the package material (see Figure 28). If just the outer layer is damaged (A) there can be a small moisture mark in the paper layer but the package is still intact. Damages that spoil the aseptic quality is either just through the inner layers (B), where the liquid penetrates the inner layers out to the paper or completely through the material (C), where the liquid leaks all the way through the package material.



*Figure 28. Schematic picture of packaging material with tree damages*

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<sup>61</sup> Interview with Kenneth Andersson, 2004-01-14.

## Results

The evaluation of the packages gave results on the amount of damages that were found in each test. The vibration test had more damaged packages than the truck transport (see Figure 29). The lack of leakages in the truck transport was somewhat anticipated since the Tetra Fino Aseptic package should be able to endure such a relatively easy transport. Nonetheless it would have been good for the evaluation of the test to have some figures that could describe the harshness of the truck transport.

	Plastic Crates	Cardboard Boxes
Vibration test	3A % damages	A % damages
Truck Transport	0 % damages	0 % damages

Figure 29. Matrix over test

Most damages that occurred on the packages were focused in the corner areas on the packages. 94 % of the damages were located within 30 mm of the corners of the package (see Figure 30), most common were damages in the corner (1), on the side edge of the package (2) or on the package panel close to the corner (3). The damages near the corners are a typical location for leakages on this type of package.<sup>62</sup>



Figure 30. Different damages on packages.

## 4.5 Pira International<sup>63</sup>

Pira is a leading commercial consultancy business which specializes in packaging, paper, printing and publishing industries. They are considered to be an authority in the field of packaging and hence it seemed like a good idea to contact them and get access to their expertise in packaging.

Pira works primarily with businesses that wants and expects good results fast. Through the years Pira have learned that most of the result is achieved rather quickly and the rest of the result that is much harder to acquire is often not worth the effort. This has led to that Pira works according to the “80 – 20 rule”, were 80 percent of the result is considered to be obtained in the first 20 percent of the time spent. Experience had shown that in transport testing there are so many factors that affect the true result that with 80 percent accuracy the tests are good enough for most cases.

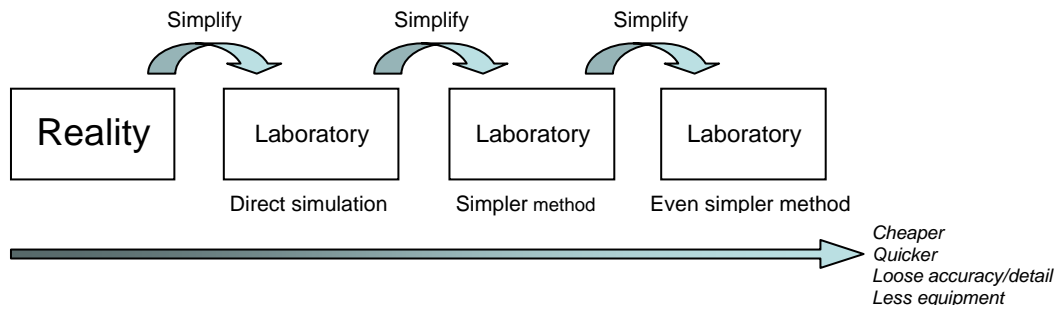
<sup>62</sup> Interview with Kenneth Andersson, 2004-01-14.

<sup>63</sup> Interview with Sam Sheppard Fiddler, 2004-02-10.



### 4.5.1 The Golden Rule

When it comes to simulation and tests Pira applies what the called the “Golden Rule” (see Figure 31). This rule states a relationship between reality and simulated test. There is often a possibility to conduct test that are direct simulations of reality, but it seldom worth the effort in cost and time. The more simplified a test method becomes, the cheaper and less time consuming it gets and the equipment needed is often less and simpler. However, at the same time the test is simplified and less accurate in describing the reality.



*Figure 31. The Golden Rule.*

An example of this can be drop testing, where in reality packages are dropped from various heights by accident. In a direct simulation packages are dropped from drop test equipment (shown in 3.2.2 figure 7) from different heights determined by measurements done in reality. A simplification of this could be to drop by hand from the same heights, thus reducing the need for special equipment but increasing risk of drops incorrectly conducted.

### 4.5.2 How to Determine Tests

At Pira three different approaches are used when a customer has a need for transport testing. Depending on how advanced testing that is needed, the allowed cost and time to establish different approaches are used.

The “off the shelf” methodology is used when the reality is simple and there is no greater need for extensive testing. This methodology is a fast and relatively cheap way to get a test method for a customer. In such cases Pira studies the product and the markets where it is in use and based on this information an already existing general testing standard is chosen. Since the method is quite simple and cheap it has somewhat of the markings of a “quick fix” and is not used that extensively.

At the intermediate level Pira uses a methodology of mapping the supply chain through interviews at the company and some visits on locations in the distribution. After this information is gathered a map is drawn of the handling (see Figure 32).

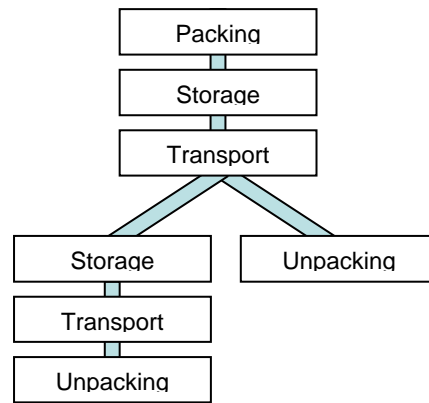


Figure 32. Example of mapped handling chain

Next step is then, as a desk exercise, translate the information about the different steps, through identifying risks, into appropriate test methods and approval levels. In this step special competence is needed from experience in testing and in distribution. This is one of the areas where Pira has good knowledge and years of experience.

The most detailed result of test methods is acquired through extensive measurements in the field, where actual data are collected on what happens in the distribution. Test transports are made where the vibrations are measured and different kinds of registration equipment are used throughout the distribution chain to identify exactly what happens. This method is very time consuming and expensive, hence it is seldom used to its full extent.

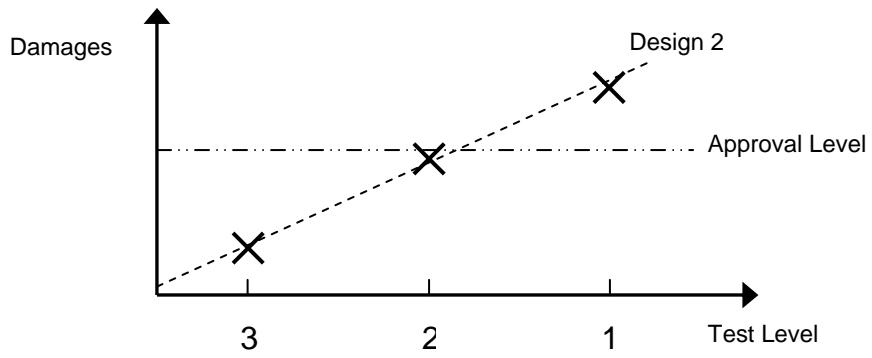
### 4.5.3 Using the Test Methods

To obtain more information from the established test methods, Pira suggests that several testing levels are used for each test. When this is performed much more information is acquired on where a package really lies in terms of strength and rigidity. In situations where different designs or materials are to be evaluated this type of testing not only can give indications of which material is better, but also give information if one material exceeds the requirements by far and hence could be too strong (and probably expensive) for this product (see example in Figure 33).

	Level 3	Level 2	Level 1	
Design 1	OK	OK	OK	To strong
Design 2	OK	OK	NO	Good
Design 3	OK	NO	NO	To weak

Figure 33. Example of testing schedule and conclusions.

Information obtained can then be used to draw graphs on the properties of designs or materials for better foundation of decision making later (see Figure 34). When combined with decisions of approval level and at what test level this should be applied these simple methods become powerful tools in development.

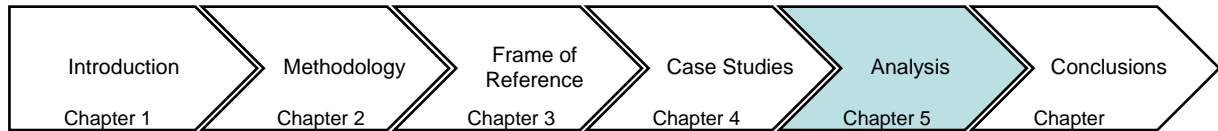


*Figure 34. Example of graph drawn from testing information.*



## 5 Analysis

*This chapter covers the authors' analysis of the material in the case study chapter. At first the vibration test in the field experiment is analyzed. Then the importance of testing is covered with the aspects from the benchmark in mind, followed by an analysis of how to find good evaluation routes for transport testing.*



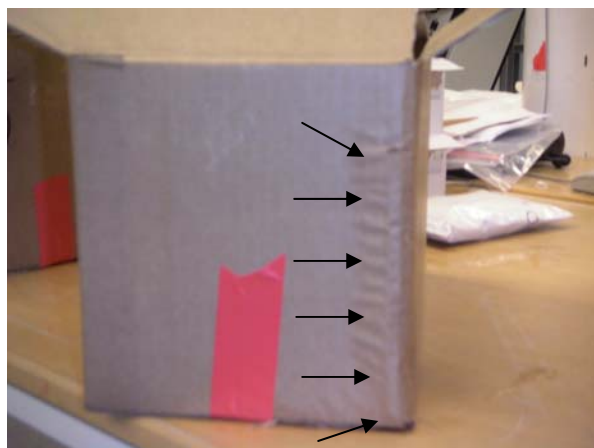
### 5.1 The Vibration Test

One of the questions that were raised in the beginning of the work with this thesis concerned the toughness of the vibration test that is currently in use. The experiment that was conducted has given an indication of the relative harshness compared to an actual truck transport in good conditions.

#### 5.1.1 Level of Strain

The result indicates a much tougher strain during the vibration test than during the truck transport. None of the packages that were used for the truck transport had any damages. This result is a good indication of that the packages can manage a transport without too much strain, a result that had to be expected since it is a commercial product that currently is in use in emerging markets, subdued to harsher conditions and is managing this well. However, the result from the vibration test gives indications that have to be considered. The Tetra Fino Aseptic package is, as stated earlier, currently in use in emerging markets. The package is doing reasonably well and can handle the demands the market has set. Since there is no problem with complaints at this date the conclusion has to be that the vibration test, not only is tougher than a truck transport in western conditions, but also tougher than the handling in emerging markets.

The fact that the current vibration test causes these damages to the packages has to raise questions on how appropriate it is to set the approval standard at this level of strain. The leakages that were found after the vibration test would have spoiled a quite large amount of the current load in a real shipment (see Figure 35). If the contents in this case would have been milk, which is the most common content, the probability of rejection, on the entire or at least major parts, of this shipment would be quite high.



*Figure 35. Picture of how leaking packages has spoiled the cardboard box.*

### 5.1.2 Secondary Package

From the vibration test there is a clear indication of the difference between secondary packaging. The plastic crates, where the primary packages are free to move, have a three times higher leakage rate than the more tightly packed cardboard boxes. With primary package leakages in focus there is a clear advantage for the cardboard box (see Figure 36).

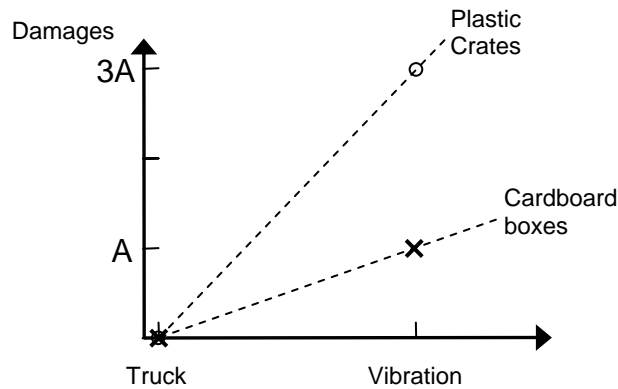


Figure 36. Result of field experiment.

Also considering the total load volume the cardboard box has a big advantage, the 960 packages in cardboard did not even fill an entire pallet while the plastic crates needed two entire pallets to handle the same amount of packages. The size of the plastic crates is of course a determining factor in this and the height of the crates could easily be halved if only the packaging were considered. However, these crates have been chosen since they are similar in size to actual crates used by customers in emerging markets.

An important factor when choosing secondary package is of course the cost and this is closely related to the local conditions and the distribution chain, for example plastic crates have the need for a recycling system while cardboard boxes become a considerable alternative if there is cheap supply of cardboard from a local manufacturer.

There are other factors to consider when reviewing this result and the choice of package solution. While packing the primary packages into the cardboard boxes a potential hazard was encountered. The cardboard boxes are designed to leave as little room for movement of the content as possible which has created a need for very accurate packing of the primary package. At the first attempt the primary packages were loaded directly into the cardboard boxes from the conveyor belt out of the machine. However, at this speed packaging was a little off, hence the result was that the boxes could not be completely closed (see Figure 37).



*Figure 37. Bulging lid on box due to inaccurate packing.*

If this problem is neglected it will most probably have a great impact on the final result. Stacking boxes on top of each other with bulging lids will increase the strain on the packages, since the primary packages then have to carry the load of the boxes on top instead of the secondary package.

## **5.2 Importance of Testing**

The testing has already proven itself at numerous occasions, primarily as a comparative tool when faced with a situation where a choice has to be made. The importance has increased when the tool has come into use as a defining test for what level of strain a package has to be able to manage.

### **5.2.1 Benchmark with Customers**

As the benchmark progressed there was somewhat of a lack of information in specific testing methods. The information compiled from the answers the companies in the benchmark still gave valuable information in the area of transport testing. The answers show that transport testing is handled differently and seems to have different priority in the participating companies. However, it seem like there is a trust in the packages chosen for their product, a trust that has to come from the supplier of the packages, for example Tetra Pak. To handle and manage this trust there is a continuous need for the package producer to ensure that they come up with good packages. One method to help ensure this is of course by conducting relevant transport tests. These indications give the package producer a big responsibility in being a part in the development and usage in the front line of testing. This since there seems to be a need for the package producer to stay one step ahead of their customers to ensure the high level of trust.

### **5.2.2 In Development**

The focus area has become more on how the testing can be used to aid in the design of a new package to make it fit for the requirements set. Testing has a very important role when one of the requirements is to create a package at as low cost as possible. Earlier, when this was not the main focus it was easier to add an extra safety margin and have the tests a little too tough. With the new focus the testing level will set the requirements for the new products and the indirectly set the level of costs the package will have to carry.

In the early stages of development there are restrictions on how much testing that can be done. These restrictions are primarily related to maintaining budget, in early development many companies are not prepared to spend too much money on an idea, and the lack of actual

packages to test. This contributes to the need for good and reliable testing methods in development

### 5.2.3 How to set Approval Levels

Using tests in this way puts much higher demands on how to choose the right levels for approval of the packages. However, setting approval levels is not an easy task. Many factors have to be taken into account. These factors can be divided into two primary groups, the first one is the actual level of strain the product is going to have to endure when introduced on the market, and the other is a more strategic decision that has to be made at a management level, namely what level of damage is accepted for this type of package in this market.

The first group of criteria can be handled more directly by measuring the conditions by field tests and applying experience from transports in the region. The later decisions, on which level of damage that has to be accepted can be much harder to decide, this is dependent on market related issues concerning the type on customer and end user Tetra Pak has in this area.

There is also an alternative where in-house tests are conducted and documented to form a base of recommendations to customers on what damage levels become results in different packaging system solutions. This information could then be used by the customers to decide on for example secondary package with relation to what damage levels that can be accepted.

### 5.3 How to Find Evaluation Routes

When aiming to find an appropriate way of testing new products for Tetra Pak R & D the goal has to be set at finding a method that includes the entire handling chain the package is subdued to. This is to ensure a more reliable test method and to be able to predict more on how the package will behave when used in reality.

The alternative is to keep doing one type of test, for example vibration test, at a harder level, which also could assure a package that can withstand the strains of handling. This however, will always be questioned in its appropriateness since it has no real connection with the actual handling and the acceptance of such a testing method has already proven to be low from within the company.

A better method would be to construct a series of tests that simulates an assumed handling chain and therefore gives a better understanding of what is tested (see Figure 38). This will hopefully lead to better results and higher rate of approval from both involved engineers and later from customers.

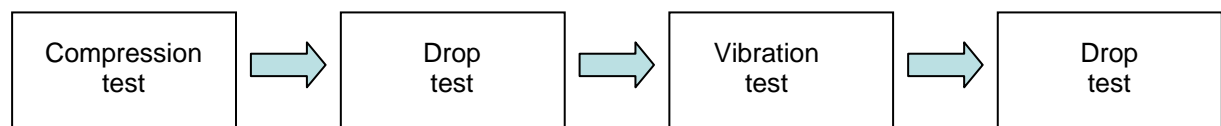


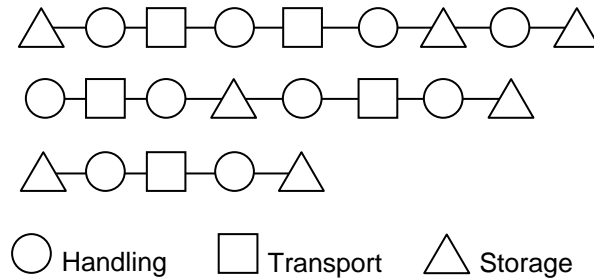
Figure 38. Example of test route.

To find these chains of tests data have to be collected on how the reality for the packages is situated today. Since the reality varies so much depending on market and customer a separation has to be made. There is a need for dividing the markets depending on the conditions. Tetra Pak has already done this for other purposes and it could be a good idea to keep this structure within testing also. The markets are, as mentioned earlier divided into advanced, developing and emerging, the biggest differences are found in advanced and emerging, hence these would be good to start with.



### 5.3.1 Mapping Markets

A good method for mapping the conditions on the different markets would be to use the same way as PIRA uses with flowcharts on how a package is handled throughout its transport from production to end consumer (see Figure 39). Since Tetra Pak has many customers in each market a recommendation would be to choose three customer in advanced markets and three customers in emerging markets to start with. Three companies in each market would be a good compromise between effort to put in and still be able to see differences in the separate markets.



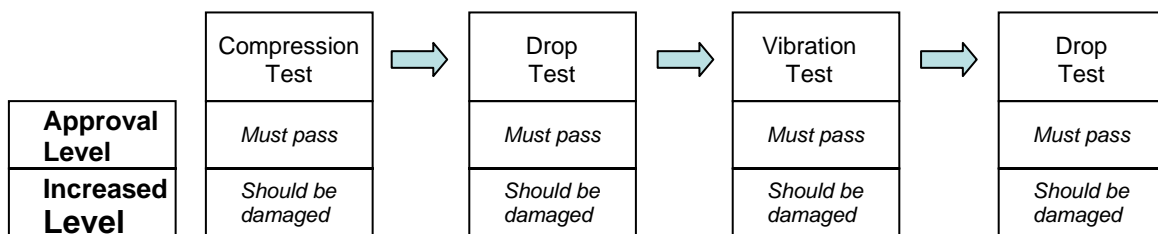
*Figure 39. Example of handling chains.*

When having chosen companies and examined their handling chains there would be need for expert advise on how to translate the found parts to appropriate testing methods. This expertise could be purchased as a project in cooperation with PIRA. The reason not to give the entire project including mapping handling chains to a consultant would be to keep internal control of the costs until the outcome is known of the first attempt.

After the appropriate testing methods for these examined handling chains have been found it would most probable be able to define somewhat of a compromise of a typical test methods needed in this market. With this information established a testing route for products in this market could be established with support in the preceding mapping.

### 5.3.2 Utilizing Several Testing Levels

Having defined on which testing methods to apply in the testing route, the next step would be to implement several levels of testing to get better foundation for decisions concerning package development. Setting an approval level and then testing both this level and a more intense level gain more information on the package properties (see Figure 40). This information could be vital when trying to keep package costs to a minimum since if the approval level is set correctly the package should not perform to well at a higher intensity level of testing.



*Figure 40. Example of test schedule with two intensity levels.*

## 5.4 Centralize Knowledge

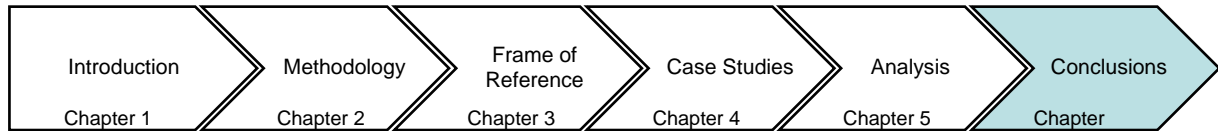
To further improve the work with transport testing within Tetra Pak center for testing knowledge should be created. This center should primarily collect all data from all transport tests made within the company, or at least at that location. Today there are similar tests made quite often but the data and knowledge of how the different packages perform are only to be found at the

department that ordered the test. As a result of this a similar test performed during the work with this thesis was conducted only a few weeks earlier, but the results were not accessible from Tetra Pak Carton Ambient so there was no choice but to do another test to get the data.

With data stored and accessible at a central location it would be easier to control if similar test had been done earlier and conclusions could be drawn about changes made over time. This would be a major advantage when developing new packages similar to other existing products, since some properties could behave similar and solutions to earlier problems would be easier to find and reuse. Especially if the data could be analyzed to find specific properties for the different kinds of packages, e.g. brick, classic, pouch and stand-up pouch. This could become a very powerful tool in the process of developing new and cost effective package concepts. If creating this potential database, the aspect of confidentiality has to be considered since products in the development stage are often confidential even for other parts of the company. However, a database located at the test center with different levels of confidentiality could contribute to several parts of the organization.

## 6 Conclusions

*This chapter covers the conclusions in the thesis. At first suggestions on transport testing is given followed by a method of finding evaluation routes. Thereafter centralization of knowledge is recommended and at the end further work in the area is suggested.*



### 6.1 Transport Testing of Food Package

When concluding the work done in this area it is done relating to the activities performed during the thesis.

#### 6.1.1 Benchmark

The benchmark with some of Tetra Paks customers gave valuable information in general understanding of transport testing, but less knowledge in detailed testing. A conclusion that can be made from the information is on the importance for Tetra Pak, as a package producer, to be well informed and experienced in transport testing to keep the advantage and trust that exist today.

#### 6.1.2 Case Study

When developing new package concepts with low cost as primary focus there is a great probability that today's vibration test is too tough. The vibration test is a very blunt instrument in the developing phase, it can be used for approval if the acceptance level is set and unquestionable. However, this needs a better investigation followed by a management decision on what safety level that will be applied.

The experiment conducted on TFA packages clearly suggests that the vibration test with the current settings is much tougher than a truck transport in advanced market conditions. Further testing has to be made to be able to clearly state the relation to transports in emerging market conditions.

New possibilities of diverse testing on at least two levels could be possible in the near future if the control hardware and software is exchanged. This will provide a better tool in mapping properties in different packages and materials.

### 6.2 How to Find Evaluation Routes

To obtain a tool that is applicable as an approving standard there is a need for better knowledge in how the reality is situated, primarily in emerging markets since there is less knowledge on conditions in that area.

The conditions between the different market types seem to be so different that there is an absolute need for different acceptance criteria when designing low cost packages for the different markets. To be able to have credibility when referring to in-house testing at a standard defined by yourself, there has to be a good foundation for the standard. When telling a customer about an in-house standard there has to be an explanation of how it was established so there is no room for doubts concerning its appropriateness. Doing this could even prove to the customer that

there is even deeper knowledge about transport testing than if an ordinary standard were used. The most cost effective way to go about establishing evaluation routes seems to be by doing the distribution chain mapping with own resources and purchasing the knowledge to translate the collected information into applicable testing methods and approval levels.

Combining these new testing routes with different testing levels including the approval levels will give a good insight in what is needed in performance and properties of new package. When more knowledge is acquired it would most probable to reduce the use of the entire testing routes to a few times during development. Since new knowledge would show what tests to be the most severe and would make a good quick test at more times during the developing phase.

### **6.3 Further Activities**

This is an important and interesting area of knowledge where work is done continually in different parts of the field. Since it is an applied science much of the work is not very well documented and spread to others in the area. New knowledge can become a business advantage and such knowledge is often kept within the company. Further work at Tetra Pak is much implied in the results and conclusions in this thesis. However, a summation of further activities makes it easier to continue working in this area.

#### **6.3.1 Identify Transport Route in Emerging Markets**

The area in which the knowledge gap is the most extensive is in emerging markets. Work done in emerging markets will then have a great impact on knowledge and possible improvements. Hence, the recommendation is to map a couple of transport routes in emerging markets to create a base for deciding on future testing routes. After these transport routes are mapped PIRA could be contacted to aid in the work to translate these transport routes to appropriate testing routes and approval levels.

#### **6.3.2 Centralize Knowledge**

Tetra Pak has actually done a lot of work in the area of transport testing. The information is just spread throughout the company with different people and different departments. If this knowledge or at least the results of conducted test could be gathered at one single location this would become a very large center of knowledge. This center could be utilized when designing new products to use knowledge from already existing packages to aid in the development. For example, similar problems could have similar solution even if the designs differ.

If there is an interest to learn more about new markets the knowledge center could be used for comparison with field tests since most products already have been tested in-house. With current conditions new in-house test would most probably have to be made since results from earlier test are spread throughout the organization. In conclusion a center of this sort would be half the knowledge needed when learning about new aspects, since most new knowledge had to be compared with previous results to be applicable practically.

#### **6.3.3 Computer Simulations**

An area that could be interesting to develop is concerning computer simulations and calculations on how different strains affect the packages. Finite element analysis has proven to be a contributing tool in related areas and could possibly be used in transport testing also. A potential benefit could be the ability to conduct computer simulated tests with no packages needed in the early development. This could speed up development by reducing the number of test needed with actual packages.

#### **6.3.4 Determine Defining Criteria in Different Markets**

Another area that could be of interest to investigate is which criteria that are defining the mechanical requirements of the packages in different markets. In emerging market where price is the most important transport tests could be the defining factor but maybe in advanced markets the final decision should be based on other criteria.



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[www.iec.ch](http://www.iec.ch) 2003-12-02

[www.iso.org](http://www.iso.org) 2003-12-02

[www.ista.org](http://www.ista.org) 2003-12-02

[www.sis.se](http://www.sis.se) 2003-12-03

[www.tetrapak.com](http://www.tetrapak.com) 2003-11-19

[www.packforsk.se](http://www.packforsk.se) 2003-12-04



## 8 Appendix

### **ASTM**<sup>64</sup>

ASTM-standard: D 4169-98. Standard Practice for Performance Testing of shipping Containers and Systems

Founded in 1898, ASTM International is a not-for-profit organization that provides a global forum for the development and publication of voluntary consensus standards for materials, products, systems, and services. Over 30,000 individuals from 100 nations are the members of ASTM International, who are producers, users, consumers, and representatives of government and academia. In over 130 varied industry areas, ASTM standards serve as the basis for manufacturing, procurement, and regulatory activities. Formerly known as the American Society for Testing and Materials, ASTM International provides standards that are accepted and used in research and development, product testing, quality systems, and commercial transactions around the globe.

### **BSI**<sup>65</sup>

BSI is a provider of standards covering every aspect of the modern economy from protection of intellectual property to technical specifications for personal protective equipment. British Standards is based in London, UK and has extensive relationships with National Standards Bodies (NSBs) throughout the world.

BSI relates its standards to ISO<sup>66</sup>.

### **CEN**<sup>67</sup>

CEN, the European Committee for Standardization, was founded in 1961 by the national standards bodies in the European Economic Community and EFTA countries.

Now CEN is contributing to the objectives of the European Union and European Economic Area with voluntary technical standards which promote free trade, the safety of workers and consumers, interoperability of networks, environmental protection, exploitation of research and development programs, and public procurement.

### **DIN**<sup>68</sup>

DIN, the German Institute for Standardization, is a registered association, founded in 1917. Its head office is in Berlin. Since 1975 it has been recognized by the German government as the national standards body and represents German interests at international and European level.

DIN Standards promote rationalization, quality assurance, safety, and environmental protection as well as improving communication between industry, technology, science, government and the public domain.

### **ETSI**<sup>69</sup>

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<sup>64</sup> [www.astm.com](http://www.astm.com) 2003-12-02

<sup>65</sup> [www.bsi-global.com](http://www.bsi-global.com) 2003-12-02

<sup>66</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, s 8.

<sup>67</sup> [www.cenorm.be](http://www.cenorm.be) 2003-12-02

<sup>68</sup> [www.din.de](http://www.din.de) 2003-12-02

<sup>69</sup> [www.etsi.org](http://www.etsi.org) 2003-12-02

ETSI (the European Telecommunications Standards Institute) is a not for profit organization whose mission is to produce the telecommunications standards that will be used for decades to come throughout Europe and beyond.

ETSI plays a major role in developing a wide range of standards and other technical documentation as Europe's contribution to worldwide standardization in telecommunications, broadcasting and information technology. ETSI's prime objective is to support global harmonization by providing a forum in which all the key players can contribute actively. The European Commission and the EFTA secretariat officially recognize ETSI.

### **IEC<sup>70</sup>**

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes international standards for all electrical, electronic and related technologies. These serve as a basis for national standardization and as references when drafting international tenders and contracts.

### **ISO<sup>71</sup>**

ISO is a network of the national standards institutes of 148 countries, on the basis of one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system.

ISO is a non-governmental organization: its members are not, as is the case in the United Nations system, delegations of national governments. Nevertheless, ISO occupies a special position between the public and private sectors. This is because, on the one hand, many of its member institutes are part of the governmental structure of their countries, or are mandated by their government. On the other hand, other members have their roots uniquely in the private sector, having been set up by national partnerships of industry associations. Therefore, ISO is able to act as a bridging organization in which a consensus can be reached on solutions that meet both the requirements of business and the broader needs of society, such as the needs of stakeholder groups like consumers and users.

### **ISTA<sup>72</sup>**

The International Safe Transit Association (ISTA) is an association of organizations and professional individuals dedicated to the development, design and evaluation of cost effective and protective transport packaging. The term used to describe this goal is Just Right Transport Packaging. Just Right Transport Packaging meets the protective needs of the product as well as the needs of the shipper and user of the product by reducing damage to a responsibly low level. Just Right Transport Packaging supports the economic viability of the parties in a business transaction and encourages stewardship of natural resources by using only the minimum practical packaging and always using materials in the most efficient ways.

### **PACKFORSK<sup>73</sup>**

Packforsk is a center of knowledge about package and distribution in the Nordic region. They have as a goal to be an attractive partner for all parties active within the area of packaging. Packforsk has extensive expertise in all aspects of the package life cycle – from raw material to

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<sup>70</sup> [www.iec.ch](http://www.iec.ch) 2003-12-02

<sup>71</sup> [www.iso.org](http://www.iso.org) 2003-12-02

<sup>72</sup> [www.ista.org](http://www.ista.org) 2003-12-02

<sup>73</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, s 10.

used package, disposal/recycling – and the strains in various distribution environments. Packforsk also have many years of experience in material-, product- and package testing.

**SIS**<sup>74</sup>

SIS (Swedish Standards Institute) is an independent non-profit organization. As a part of a global and European network one purpose is to care for Swedish interests in ISO and CEN, in which SIS is a member.

**SRETS**<sup>75</sup>

The aim of the project SRETS (Source Reduction by European Testing Schedules) was to gather data from a number of sources and a wide range of packed products being transported through Europe. The collected data formed the basis for setting up test methods and test schedules of packages and products.

The background for this project is the very high costs that are associated with damage occurring during the distribution of products and the wide variety of testing standards that exists today.

**Telcordia**<sup>76</sup>

Telcordia (earlier Bellcore) is the North American equivalent to ETSI.

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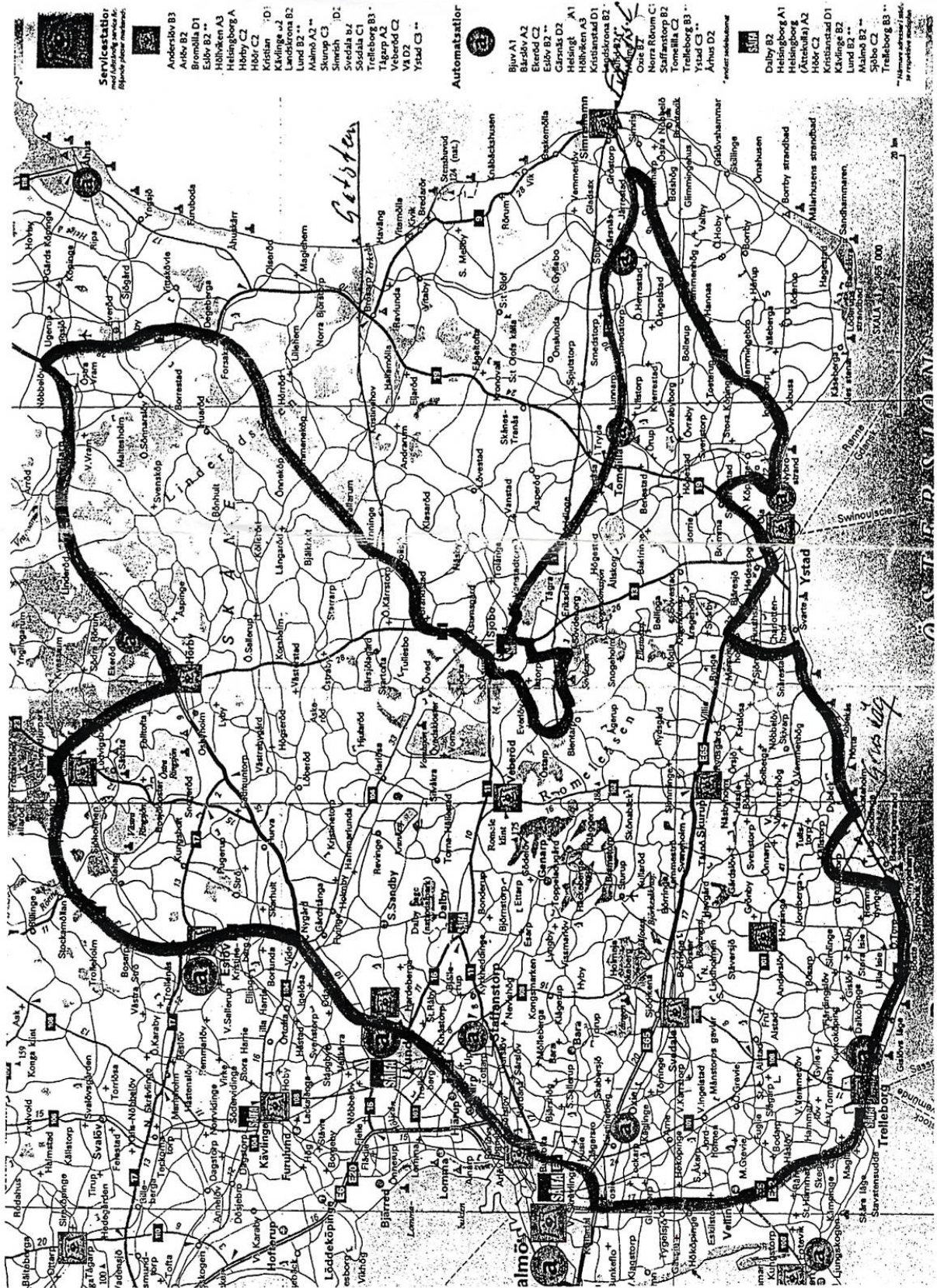
<sup>74</sup> [www.sis.se](http://www.sis.se) 2003-12-03

<sup>75</sup> Braunmiller U. Ed. (1999) *Source Reduction by European Testing Schedules (SRETS)*, Packforsk, Stockholm, s 1.

<sup>76</sup> Jacobson T., Trost T. (2002) *Transportprovning av produkter och förpackningar*, Packforsk, Stockholm, s 10.

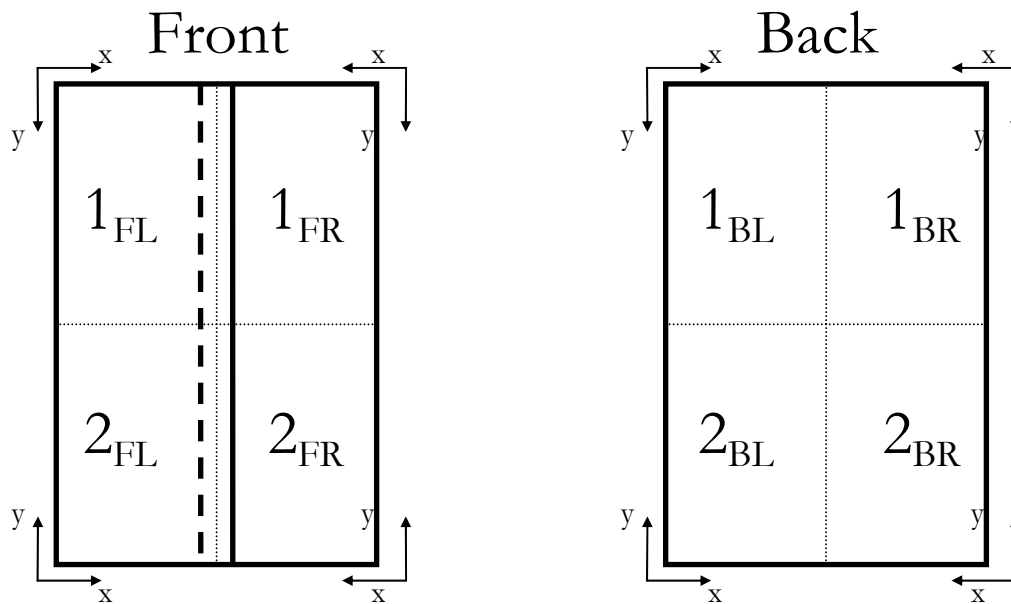


# Map of test route driven with truck



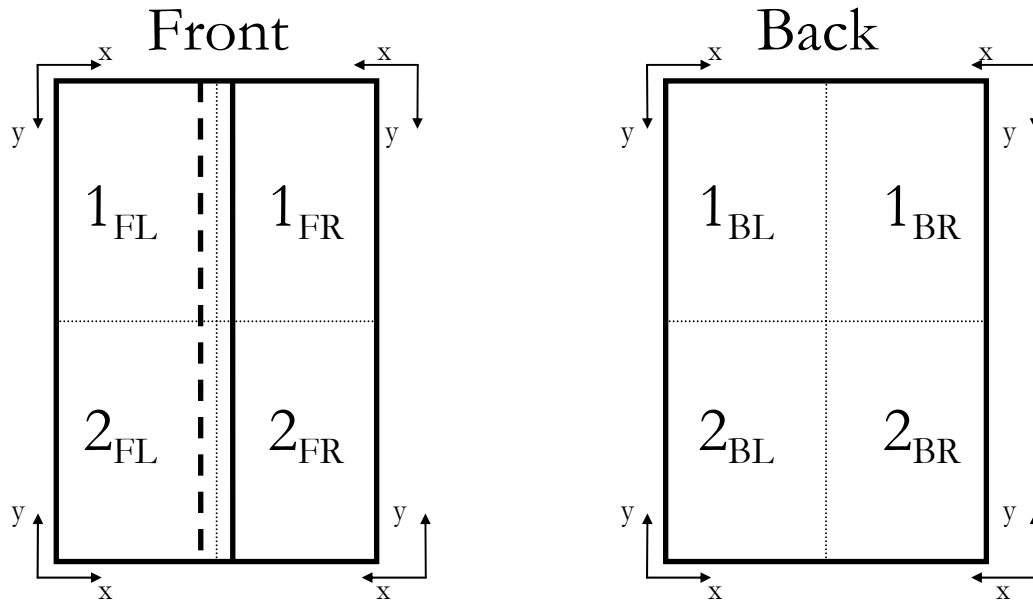


## TFA vibration test in cardboard boxes 2004-02-18



Nr	Water/Red ink	Level	Position	X (mm)	Y (mm)
1	W	3	1FR	4,55	14,83
2	W	3	2BL	1,65	13,06
3	W	3	1FR	4,65	25,48
4	W	2	2BR	8,84	11,81
5	W	2	1BR	0,00	4,55
6	W	2	2BR	7,98	11,40
7	W	3	2BL	0,00	15,37
8	W	4	1FR	0,00	0,00
9	W	3	2FL	0,00	9,35
10	W	5	2FL	0,00	0,00
11	W	5	1FL	0,00	16,38
12	W	4	2FR	0,00	0,00
13	W	5	2FR	0,00	0,00
14	W	5	1FR	9,45	20,14
15	W	4	1BL	17,17	14,58
16	W	5	1FR	0,00	0,00
17	R	5	1BL	55,42	0,94
18	R	4	2FR	11,48	11,68
19	R	4	1FR	1,52	14,88
20					
21					
22					
23					
24					
25					
26					
27					
28					

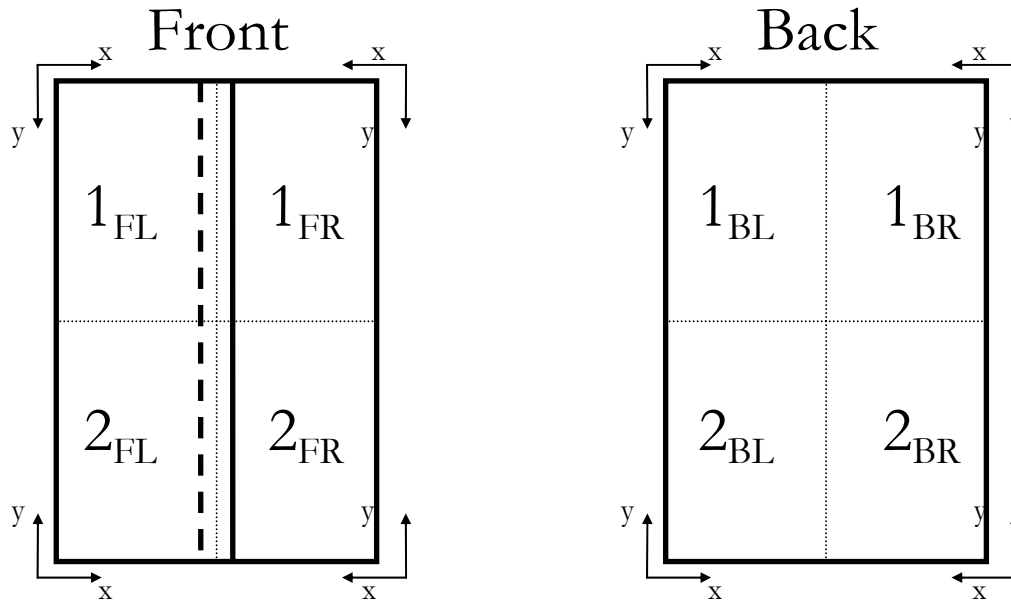
## TFA vibration test in plastic crates 2004-02-18



Nr	Water/Red ink	Level	Position	X (mm)	Y (mm)
1	W	4	2BL	11,82	4,84
2	W	4	1FL	11,32	14,78
3	W	4	1FL	8,01	15,87
4	W	4	2FR	13,27	20,44
5	W	4	2BL	5,57	64,70
6	W	4	1FR	9,69	21,91
7	W	4	2BR	5,36	9,94
8	W	4	1BR	4,50	17,66
9	W	4	1BR	13,10	27,23
10	W	4	2BR	0	9,87
11	W	4	2BR	12,32	15,03
12	W	4	2BR	6,97	12,35
13	W	4	1BR	2,27	17,71
14	W	4	1BR	6,15	15,84
15	W	3	1FL	8,28	14,02
16	W	3	2BR	18,01	70,79
17	W	3	2BL	5,07	83,77
18	W	3	1BR	5,98	10,60
19	W	3	1BL	11,18	23,80
20	W	3	1FL	7,11	15,75
21	W	3	1BR	0	14,54
22	W	3	2FL	20,12	54,53
23	W	3	2BR	0	8,39
24	W	2	1BR	3,32	17,18
25	W	2	1BL	6,43	17,46
26	W	2	1BR	5,64	14,85
27	W	2	1BL	0	15,61
28	W	2	1BR	7,49	13,36
29	W	2	2BL	0	10,93
30	W	2	1BR	6,07	12,43



## TFA vibration test in cardboard boxes 2004-02-18



Nr	Water/Red ink	Level	Position	X (mm)	Y (mm)
31	W	4	1FL	13,51	19,24
32	W	4	2BL	0	11,15
33	W	4	2FL	18,28	35,98
34	W	4	1BL	9,49	16,41
35	W	4	2BR	7,04	25,39
36	W	4	2BL	3,37	9,88
37	W	4	2BL	9,33	13,94
38	W	4	2BL	2,72	9,03
39	W	4	1BL	0	71,31
40	W	4	1BL	6,31	16,38
41	W	4	1FL	11,10	17,69
42	W	4	2BL	3,65	8,86
43	W	4	2BR	5,86	16,21
44	W	4	1BR	8,89	16,92
45	W	3	1BL	6,72	23,89
46	W	3	1FR	5,49	29,61
47	W	3	1FL	15,68	19,84
48	W	3	1FL	8,43	16,42
49	W	3	1BR	1,76	23,74
50	W	3	1BR	0	26,70
51	W	3	1FL	0	19,24
52	W	2	1FL	8,21	18,28
53	W	2	2BL	15,61	37,50
54	W	2	2FL	13,99	21,70
55	W	2	2FL	0	16,58
56	W	2	2BL	9,09	14,44
57	W	2	1BR	7,23	11,24
58	W	1	2BL	2,84	9,30
59					
60					