EXECUTIVE SUMMARY

This Diploma Thesis consists of the definition, identification and calculation of the Costs of Quality in the company Willy Vogel AG, in their main facility in Berlin, during the first quarter of 2008.

The project is structured into three main parts. The first part provides the necessary theoretical basis to define the concept of Cost of Quality and the PAF model is presented as the one used to classify quality costs. It is discussed how to optimize this costs, and some benchmarks are given. The second part develops the case study in Willy Vogel AG. First of all, quality costs are identified, then they are classified and finally, they are estimated. The procedure is based on the previous theoretical basis. Finally, the third part is an attempt to identify what could be improved by providing input based on the results obtained.

The goals of this project are to measure as accurately as possible the Costs of Quality, to identify what could be improved in order to optimize costs and processes, and to set up a framework for the collection and analysis of quality costs.

The total cost of quality adds up to 2.25% of the net sales. In comparison to recent benchmarks in the manufacturing sector it results to be rather small. Current studies estimate this rate is around 5% of the turnover. However, variations in the application of quality costs, in the business itself, in accounting systems, and in overall performance, make each company unique. Therefore, comparisons with others might be meaningless, whereas this result should be compared and analysed periodically to past indices within the company. At the same time, the long experience of the company in quality management and quality assurance explains the positive result obtained.

Analysis of the data indicates basically two problem areas to focus on: on one hand, the scrap in the manufacturing, on the other hand the disproportionate expenditure for the appraisal activities. In addition, and from the point of view of the collection of data, it is suggested to improve the actual accounting system in order to improve overall cost effectiveness.
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1. **GLOSSARY**

**COQ.** Cost of Quality.

**FMEA.** Failure Mode and Effects Analysis. It is a procedure for analysis of potential failure modes within a system for classification by severity or determination of the effect of failures on the system.

**IG.** Incoming goods.

**ISO.** International Organization for Standardization.

**L1/L2.** Labour type 1 or 2.

**LOGI:** Logistic.

**PAF.** Prevention, Appraisal and Failure.

**Q1.** First quarter.

**QM.** Quality Management.

**QA.** Quality Assurance.

**QCS.** Quality Cost Supplier.

**QVZ.** QualitätsZahl/Vogel. VOGEL’s quality rate for suppliers.

**R&D.** Research and Development.

**TQM.** Total Quality Management. “*TQM is a management approach for an organization, centred on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society*”.

**SC.** Service Centre.

---

1 Defined by ISO 8402:1994
2. FOREWORD

2.1. Motivation of the project

Quality management has a real impact on the results of enterprises. However, many companies do not realize that quality has an impact on profits until costs rise due to quality problems. Management, in general, may not directly translate quality or lack of quality into its true impact on their company. To achieve the most effective improvement effort, management should make clear that quality and costs are complementary and not conflicting objectives. Traditionally recommendations were made to management that a choice had to be made between quality and cost, since major quality meant more cost and made production more difficult. Nevertheless, it has been proved that good quality leads to a major productivity, reduced quality costs, increased sales and more profits.

The concept of cost of quality was developed in the early fifties and nowadays it is becoming more and more popular among those companies experienced in quality management. The rising costs of raw materials and the competitiveness of markets lead companies to find ways of increasing quality and reducing costs.

It is in this context, when the company Willy Vogel AG decided to explore this field and tried to make a first approximation about the quality costs and the improvement opportunities to reduce it. As a result of my personal interest in quality management, I was willing to write the Diploma Thesis about a topic, which would combine engineering knowledge with economic aspects. Therefore, the chance to carry out this study seemed absolutely challenging and exciting to me. As a result, the project has been developed with enthusiasm and plenty of motivation.
3. INTRODUCTION

3.1. Goals of the study

First of all, what it is intended in this study is to identify, according to the existent models, the quality costs in the VOGEL Group’s main facility, in Berlin. As a second goal, it is attempted to measure, during the first quarter of 2008, the identified quality costs. Thereby, quality costs will be reported on a base, such as net sales, with the objective of obtaining a general overview and to compare it with benchmarks in the manufacturing industry.

This survey pretends to go further and focus not only on the accounting of quality costs, but also on the highlight of improvement opportunities e.g. cost reduction, reduction of internal failures. Certainly, performance improvement starts with the identification of problems, defining a problem as an area of high quality costs. Thus, problems will be identified in order to gain an opportunity for profit improvement. However, and due to the wide scope of the study and the tight schedule, some boundaries must be set. For this reason, improvement opportunities might be identified and discussed, rather than deeply developed.

In addition, and since the company VOGEL does not have any established quality cost system, another goal of the study is to set a framework for the collection and control of quality costs. With regard to collection, it is pretended to define which departments should be committed to the collection of data, what data should be exactly collected, and what would be the methodology to report it. It is expected to encounter some difficulties in the measurement of certain costs and for this reason, it is also and objective of this study, to point out the importance of certain costs that might be hidden and might be considered overheads.

On the other hand, in order to control quality costs, these must be compared to an applicable base, resulting in an index which may be periodically analyzed in relation to past indices e.g. percent of net sales, although other bases could also be used.

Finally, it is also an objective of this study, to make the Quality management aware of the usefulness of a Quality cost system, by providing input and feedback to their quality program.
4. THEORETICAL BASIS

4.1. Introduction to the management of Quality Costs

Many companies promote quality as the central customer value and consider it to be a critical success factor for achieving competitiveness. Any serious attempt to improve quality must take into account the costs associated with achieving quality, since the objective of continuous improvement programs is not only to meet customer requirements, but also to do it at the lowest cost. This can only happen by reducing the costs needed to achieve quality, and the reduction of these costs is only possible if they are identified and measured. Therefore, measuring and reporting the cost of quality (COQ) should be considered as an important issue for managers. Moreover, in experimental studies, it has been showed that managers who have access to quality cost data make different decisions than managers who do not have quality cost data available. It is important to point out that COQ programs by themselves do not improve quality. They provide input and feedback to quality systems which are responsible for quality improvements. This leads to the conclusion that while the accuracy of a COQ system can be evaluated on a stand-alone basis, the effectiveness of that program is linked to how well the quality management system uses the COQ information.

4.2. Cost of quality concept

There is no general agreement on a single broad definition of quality costs. However, COQ is usually understood as the sum of conformance plus non-conformance costs, where cost of conformance is the price paid for prevention of poor quality (for example, inspection and quality appraisal) and cost of non-conformance is the cost of poor quality caused by product and service failure (for example, rework and returns).

The formalization of the concept of quality developed out of the work of Joseph Juran (1951), Armand Feigenbaum (1957) and Harold Freeman (1960). Juran defined the concept of the cost of poor quality as "the sum of all costs that would disappear if there were no quality problems" [1].
Probably it wasn’t until Philip Crosby’s publication of *Quality is free* (1979), that the biggest boost to popularizing the COQ concept beyond the quality profession was provided. According to Crosby, quality is free, what costs money is all the actions that involve not doing things right the first time.

It is now widely accepted that quality costs are: the costs incurred in the design, implementation, operation and maintenance of a quality management system, the cost of resources committed to continuous improvement, the costs of system, product and service failures, and all other necessary costs and non-value added activities required to achieve a quality product or service.

### 4.3. Historical development and classification

The most commonly accepted typology divides quality costs into prevention, appraisal, internal failure, and external failure costs. This typology is often referred to the PAF model (prevention, appraisal, and failure) and is one of the most commonly used general costs of quality model in the United States and Great Britain. Nevertheless, this world wide model has changed in the last years.

#### 4.3.1. The PAF classification

Most COQ models are based on the P-A-F model. Joseph Juran (1951) initiated the concept of quality costing, the economics of quality and the graphical form of the COQ model, and Armand Feigenbaum (1956) later proposed the now widely accepted quality cost categorization of prevention, appraisal and failure (internal and external) costs. These costs can be defined as follows [2]:

- **Prevention costs**: are “the costs of all activities specifically designed to prevent poor quality in products and services”
- **Appraisal costs**: are “the costs associated with measuring, evaluating, or auditing products or services to assure conformance to quality standards and performance requirements”
- **Internal failure costs**: are “the costs resulting from products or services not conforming to requirements or customer/user needs (which) occur prior to delivery or shipment [. . .] to the customer”
• **External failure costs**: are “the costs resulting from products or services not conforming to requirements or customer/user needs (which) occur after delivery or shipment of the product, and during or after furnishing of a service to the customer”.

Example of theses costs, are:

<table>
<thead>
<tr>
<th>Preventions costs</th>
<th>Appraisal costs</th>
<th>Internal failure</th>
<th>External Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality planning</td>
<td>Checking and testing purchased material</td>
<td>Rework</td>
<td>Complaints</td>
</tr>
<tr>
<td>Supplier evaluation</td>
<td>In-process and final inspection/test</td>
<td>Delays</td>
<td>Repairing goods and redoing services</td>
</tr>
<tr>
<td>New product review</td>
<td>Field testing</td>
<td>Re-designing</td>
<td>Warranties</td>
</tr>
<tr>
<td>Error proofing</td>
<td>Product, process or service audits</td>
<td>Shortages</td>
<td>Customers’ bad will</td>
</tr>
<tr>
<td>Capability evaluations</td>
<td>Calibration of measuring and test equipment</td>
<td>Failure analysis</td>
<td>Losses due to sales reductions</td>
</tr>
<tr>
<td>Quality improvement team meetings</td>
<td></td>
<td>Re-testing</td>
<td>Environmental costs</td>
</tr>
<tr>
<td>Quality improvement projects</td>
<td></td>
<td>Downing</td>
<td></td>
</tr>
<tr>
<td>Quality education and training</td>
<td></td>
<td>Lack of flexibility and adaptability</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1. Example of quality costs

Total quality costs are the sum of the above costs. It represents the difference between the actual cost of a product or service and what the reduced cost would be if there were no possibility of substandard service, failure of products, or defects in their manufacture.

4.3.2. Classic model of optimum quality cost

This classical view of quality cost behaviour in the PAF model holds that an optimum economic quality exists at the level at which the cost of securing higher quality would exceed the benefits of the improved quality (fig.4.1). Prevention and appraisal costs portrayed as rising asymptotically as defect-free levels were achieved.
Depending on the quality costs distribution three zones are identified [3]:

- **Zone of improvement**: on the left side of the optimum. In this zone, the company might not have implemented a COQ program. Typically, 70% of the total cost of quality is due to failure costs and less than a 10% is invested in prevention. Therefore, it is suggested to invest in prevention and appraisal activities, since failure costs are too high.

- **Zone of indifference**: the optimum level is achieved. That means that investing an additional monetary unit to Prevention and Appraisal; contribute exactly to reduce one monetary unit from failure costs. From this level, the cost of securing higher quality would exceed the benefits of the improved quality. Usually, 50% of total cost of quality is due to failure costs, and 40% is due to appraisal costs.

- **Zone of perfectionism**: on the right side of the optimum. It is recommended to reduce the number of preventive and corrective measures since reducing defects seems very difficult. Failure costs can arise up to 40% of the total quality costs.
4.3.3. New model of optimum quality cost

Recent successes have resulted in revisions to the classic model of optimum quality costs. The new model rejects the idea of an ‘optimal point’ below zero defects and suggests that increased prevention expenditures make 100 percent conformance economically feasible. New technology has reduced inherent failure rates of materials and products, while robotic and other forms of automation have reduced human error during production, and automated inspection and testing have reduced the human error of appraisal. These developments have resulted in an ability to achieve perfection at finite costs. Figure 4.2 shows that the minimum total cost is achieved at 100% perfection.

Figure 4.2. New model of optimum quality cost

However, some authors\textsuperscript{2} suggest that both views can be reconciled within one model. In certain time constrained conditions, as an accurate static representation of quality cost economics, the classical view would be preferred. Nevertheless, the modern view would prevail under an infinite time horizon since in dynamic, multi-period settings, failures costs can continue to decline over time with no corresponding increase in prevention and appraisal costs.

\textsuperscript{2} Burges 1996
The classic cost classification was also reviewed. Crosby (1979) established a new quality costs classification similar to the PAF scheme. Crosby sees quality as “conformance to requirements”, and therefore, defines the cost of quality as the sum of price of conformance and price of non-conformance. The price of conformance is the cost involved in making certain that things are done right the first time, which includes actual prevention and appraisal costs, and the price of non-conformance is the money wasted when work fails to conform to customer requirements, usually calculated by quantifying the cost of correcting, reworking or scrapping, which corresponds to actual failure costs.

The model is used in companies that measure quality costs; however, most of the time it is only a different terminology describing a P-A-F model and the two costing structures are used interchangeably.

4.3.4. Hidden quality costs

The importance of opportunity and intangible costs has been recently emphasized. However, the effect of intangible quality costs is difficult, if not impossible, to place a Euro value on. Intangible costs are costs that can be only estimated such as profits not earned because of lost customers and reduction in revenue owing to non-conformance. Opportunity losses may be broken down into three components: underutilization of installed capacity, inadequate material handling and poor delivery of service. They express total COQ as revenue lost and profit not earned.

But the most important of all intangible quality costs is the impact of quality problems and schedule delays on the company’s image in the eyes of its customers, with all of its implications for the profit picture and the company’s future.

The following Figure 4.3 compares true failure costs to an iceberg, with the most commonly measured failure costs just at the tip of the iceberg. The bulk of failure costs are ‘hidden’ below the surface and are usually responsible for ‘sinking the ship’.
4.4. Goal of a quality cost system

The most costly conditions occur when customers find defects. In case the manufacturer or service organisation finds the defect through much inspection, testing, and checking, a less costly condition occurred.

The goal of any quality cost system is to facilitate quality improvements efforts that will lead to operating costs reduction opportunities. The strategy for using quality costs is quite simple:

- Take direct attack on failure costs in an attempt to drive them to zero.
- Invest in the right prevention activities to bring about improvement.
- Reduce appraisal cost according to results achieved.
- Continuously evaluate and redirect prevention efforts to gain further improvement.

This strategy is based on the premise that for each failure there is a root cause, so, causes are preventable and prevention is always cheaper.
4.5. ISO 9000 and the quality costs

One of the most striking and universal trends in the management of quality in the past few years has been the drive by all type of businesses to become certified to the quality system standard published by the International Organization for Standardization known as ISO 9000 [4].

The ISO 9000 and related standards define and specify the elements of a quality system. The quality system can be viewed as the organizational structure, the documented procedures, and the resources that an organization uses to manage quality. Since money is the universal language of business, the ISO 9000 Standards recommend a financial measurement of quality.

There are two relevant ISO documents pertaining to quality costs:

- ISO 10014 Guidelines for Managing the economics of Quality.

The ISO 9004-1 includes traditional costs of conformance and non-conformance as well as all costs incurred in fulfilling customer’s needs. ISO 10014 extends the domain of ‘economics of quality’ one step further to take into account increasing revenue or other desired beneficial effects, as well as cost reduction.

4.5.1. Collection and report of quality costs

ISO 9004-1:1994 gives three models for approaching quality costs without excluding others. They are the following:

- **Quality-costing approach**: is the conventional approach of classifying quality costs as prevention, appraisal and failure. Applying this approach normally involves investing in a relatively modest increase in the cost of prevention to achieve a more significant reduction in the cost of failure, and finally a reduction in cost of appraisal, thereby reducing the total cost of quality. Quality costs are usually reported as a percent of some base, such as sales or production costs. This process is normally carried out for an entire organization but can also be applied to an individual process.
• **Quality-loss approach**: attempts to capture the intangible as well as the tangible costs, or losses, due to poor quality. The tangible losses are the commonly measured failure costs, and the intangible losses are the ‘hidden failure costs’. This approach permits only a rough estimate of quality costs, although in some instances it may be the only feasible method because of the lack of available cost data.

• **Process-cost approach**: focus on cost for a process rather than on a product or on a profit centre. The cost of conformance is the actual process cost of producing products or services first time to the required standards by a given specified process, whereas cost of non-conformance is the failure cost associated with the process not being executed to the required standard. These costs can be measured at any step of the process. Process-cost approach may be particularly effective for organizations whose quality improvement efforts have matured to the point that tangible quality costs are relatively small and other tools of TQM are being used.

### 4.5.2. Maturity level and cost distribution

The ISO Q9004-2000 standard provides a formal framework for classification of quality systems based on performance maturity levels. These levels are shown in Table 4.2.

<table>
<thead>
<tr>
<th>Maturity Level</th>
<th>Performance level</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No formal approach</td>
<td>No systematic approach evident, no results, poor results or unpredictable results</td>
</tr>
<tr>
<td>2</td>
<td>Reactive approach</td>
<td>Problem- or corrective-based systematic approach; minimum data or improvement results available</td>
</tr>
<tr>
<td>3</td>
<td>Stable formal system approach</td>
<td>Systematic process-based approach, early stage of systematic improvements; data available on conformance to objectives and existence of improvement trends</td>
</tr>
<tr>
<td>4</td>
<td>Continual improvement emphasized</td>
<td>Improvement process in use; good results and sustained improvement trend</td>
</tr>
<tr>
<td>5</td>
<td>Best-in-class performance</td>
<td>Strongly integrated improvement process; best-in-class benchmarked results demonstrated</td>
</tr>
</tbody>
</table>

Table 4.2. Performance maturity level [5]
Quality experts have suggested that the distribution of quality costs changes as the quality system matures (see Figure 4.4). An immature quality system would be expected to have high total costs of quality with most of the expenses occurring in the external and internal failure categories. As the system matures, most of the expenses occur in the appraisal and internal failure categories while external failure costs decline. In a fully mature quality system, the largest category of expenditure is prevention costs.

![Figure 4.4. Quality costs and system maturity](image-url)
4.6 Benchmarks

A brief description of documented cases of use of COQ systems is given in the following table:

<table>
<thead>
<tr>
<th>Company</th>
<th>Industry</th>
<th>Base for COQ calculation</th>
<th>Reported gains</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allis-Chalmers Corporation, US</td>
<td>machinery manufacturing</td>
<td>% of net sales</td>
<td>COQ reduced from 4,5% to 1,5% in 3 years</td>
<td>Kohl, 1976</td>
</tr>
<tr>
<td>York International, UK</td>
<td>Air conditioning and refrigeration supplier</td>
<td>% of net sales</td>
<td>COQ reduced from 13,5% to 3,7% in 8 years</td>
<td>Knock, 1992</td>
</tr>
<tr>
<td>Hydro Coatings, UK</td>
<td>Industrial coatings manufacturing</td>
<td>% of net sales</td>
<td>COQ reduced from 4,1% to 2,5% in 4 years</td>
<td>Purslove &amp; Dale, 1995</td>
</tr>
<tr>
<td>Raytheon’s Electronic systems</td>
<td>software</td>
<td>% total project costs</td>
<td>COQ reduced from 65% to 15% in 8 years</td>
<td>Campanella, 1999</td>
</tr>
<tr>
<td>Generic</td>
<td>Electrical</td>
<td>% of net sales</td>
<td>Reduction from 5,4% to 4,6%</td>
<td>Campanella, 1999</td>
</tr>
<tr>
<td>Generic</td>
<td>Pharmaceutical</td>
<td>% of net sales</td>
<td>COQ reduced by 11%</td>
<td>Malchi and Mc Gurk, 2001</td>
</tr>
<tr>
<td>Generic</td>
<td>machinery manufacturing</td>
<td>% of net sales</td>
<td>COQ 4.8%</td>
<td>Industry and Energy Department, Spain 2005</td>
</tr>
</tbody>
</table>

Table 4.3. Main benchmarks [6]

Other surveys have estimated the total cost of quality at 20-35 percent of sales for manufacturing and service companies in the USA³, at 10 percent of revenues⁴, or at 5-15 percent of turnover for companies in Great Britain⁵.

The majority of the statistics estimate the total cost of quality between 2,5 and 4 percent of the net sales for Japanese companies, whereas the percentage for the American and the European companies is between 5-40 percent of the sales [3].

---
³ Crosby, 1984
⁴ Feigenbaum, 2001
⁵ Kent, 2005
4.7. Conclusions

Since improving quality costs and improving quality performance are synonymous, quality costs must be measured and must reflect cost or lost opportunities to the company. A quality cost system has the potential to become an excellent tool in the overall management of a business. It can provide an indication of the health of management performance in many areas of the company. However, quality programs may fail because COQ information is used as a scorekeeping tool rather than as a driver for continual improvement, or because of underestimation of the depth and extent of commitment required to be made to prevention.

Total quality costs are intended to represent the differences between the actual cost of a product or service and what the cost would be if quality were perfect. More specifically and according to the PAF classification, quality costs are the total costs incurred by investing in the prevention of non-conformances to requirements, appraising a product or service for conformance to requirements, and failing to meet requirements. Intangible failure costs, such as lost sales due to customer dissatisfaction or loss of company’s image, may result much more costly than is expected. Therefore these costs should not be underestimated.

Regarding the two conflicting views of the economic level of quality cost, both models can be reconciled or at least, both can be useful depending on the study. Despite this continuing discussion, the basic principles of PAF categorization are still recognized and accepted.

The quality-costing approach is a proven means of tracking, guiding, and motivating quality improvement. It offers a rapid way of identifying quality costs and guides and motivates teams in quality improvement. The other approaches are based on less experience but have their own advantages, particularly in situations in which it is desirable to include TQM concerns, such as efficiency and customer satisfaction. On the other hand, combinations of the three approaches are possible.

Based on documented cases, the most common quality cost classification used at companies is the classical prevention-appraisal-failure model. Nevertheless, the PAF categorization is only a basic concept and the concrete costing system still differ considerably from company to company. Every model is usually adjusted according to the company’s needs; different subcategories and groupings are used; and the various costs and elements are defined in a different way.
Thus, benchmarks should be carefully contrasted since they could be meaningless; variations in the application of quality costs make each company unique.
5. PROJECT FRAMEWORK

5.1. General information about Willy Vogel AG

5.1.1. Definition of the activity

WILLY VOGEL AG is a world’s leading supplier of centralized lubrication technology for machinery, systems, commercial vehicles and railway vehicles. It was founded in 1929 in Berlin by Senator Willy Vogel and nowadays has a world-wide presence as the representative of the lubrication platform of the Swedish SKF Group.

5.1.2. Organization

The VOGEL Group comprises of Willy Vogel AG, with headquarters and main facility in Berlin, an operation in Hockenheim (South Germany), as well as six international subsidiaries. As part of the international production network, VOGEL manufactures additional machinery and systems for the centralised lubrication sector at the Hockenheim plants and VOGEL France in Saumur. The VOGEL plants in Japan, the USA and the Netherlands assemble mainly for their domestic markets.

Given its international subsidiaries, and despite its large size of more than 1000 employees, Willy Vogel AG has retained the character of a medium-size business. This means: a flat hierarchical structure and well-defined areas of responsibility contribute to efficient information flow and quick decision-making capabilities.

Since July 2004, Willy Vogel AG, along with all subsidiaries, joins the SKF Group. SKF is one of the world's leading suppliers of products, system solutions and services in the ball-bearing/packaging, seals, mechatronics, lubrication systems and services industries.
5.1.3. Production

Production at VOGEL is essentially divided up into manufacturing and assembly. The facility in Berlin assumes sole responsibility for parts production.

Approx. 130 processing machines, 70% of them program-controlled, are used in production. Milling, grinding, honing, chamfering, deep-hole drilling and metalworking in-house are some of the performed manufacturing processes. Approx. 2.5 million parts pass through production yearly.

5.1.4. Products

5.1.4.1. Centralized Lubrication

Centralised lubrication systems feed lubricant from a central reservoir to the points on a machine or machining system at which friction occurs. In this way, undesired wear is minimised and sometimes some of the heat generated by the friction is dissipated with the help of the lubricant.

5.1.4.2. Minimal Quantity Lubrication (MQL)

Minimal Quantity Lubrication (MQL) is the clean alternative to wet machining and the ideal supplement to dry machining. Instead of conventional aqueous cooling lubricants (emulsions, solutions) MQL makes use of non-water based eco-friendly lubricants, which can be optimised for the respective machining operation through the addition of additives. With the LubriLean and Vectolub range of products, VOGEL offers solutions for practically all cutting processes.

5.1.4.3. Spandau Pumps

Spandau Pumps are not only used to feed cooling lubricants in machine tools. Spandau pumps also deliver a wide variety of fluids to assure the operation of lasers, printing machines, beverage-cooling systems, laboratory and medical equipment, electroplating installations, stone saws and temperature-stabilisation equipment.
5.1.5. Quality

The highest quality standards are symbolic for VOGEL’s products during their entire life cycle. This is why the company achieves top marks for consistently high workmanship. Numerous audits attest to this fact. VOGEL quality management is certified according to DIN EN ISO 9001:2000. In VOGEL quality is the daily guideline for the staff in all functions within the organization. Quality is their commitment and challenge.
6. WORK METHODOLOGY

6.1. Project phases

A methodology has been used for the achievement of the purpose of this case study. In order to accomplish the objectives of the project within the established period of time, a clear definition of the different working steps was required. As it shown on Figure 6.1, the working process consists of 5 phases: recognise, identify, measure, analyse and define.

![Figure 6.1: Working steps](image)

The first step to take, is to **recognise** what the company has done referring to quality cost. Although it is already clear that VOGEL does not have any special program to report quality costs, it is necessary to figure out what kind of accounting system they have implemented, as well as how the cost of the quality organization is accounted.

The second step is to **identify** all those tasks or functions performed by different departments that can be considered quality costs. Then, using as a guide the definitions given in the PAF model, these tasks can be fitted into the proper category (prevention, appraisal, internal failure, external failure).

Once the quality costs have been identified and categorized, it is possible to start to **measure** and collect the data. Probably there might be hidden costs that are not able to be prior identified, and come up during the data collection. This phase turns out to be the longest one at the beginning of a quality cost system implementation, due to the fact that some data is complicated to collect.
After measuring and collecting quality costs, an accurate **analysis** must be carried out. The case study is a static example of a quality cost analysis. The data presented is analysed over a sufficient period of time, in conjunction with basic quality measurement data, to determine and verify current opportunities for improvement. However, once a quality costs program is implemented and has already experience, this analyse can be extended to trend charts to compare present cost levels to past cost levels.

Finally, once the quality costs have been collected and analysed, they must be used to justify and support quality performance improvement. In addition, when costs are displayed, the opportunity to identify problem areas is given. Therefore, the last phase of the study case, consists of defining possible future directions that provide improvement for certain problems.

### 6.2. Work schedule

The project was planned to be finished within 6 months. It was started on the 17th of March 2008, and planned to be finished at the end of September 2008. Figure 6.2 shows how work was scheduled and carried out.

![Figure 6.2. Work schedule](image-url)
The first step was to learn the operation of the company, indeed the quality department. From April until the beginning of May, while searching literature and defining what was needed, it was evaluated the availability and accessibility of data.

Once it was decided what information and what data was required for the achievement of the study purpose, the collection of data was started. At the same time and in order to proceed faster, it was planned to start the processing of data. Since by the end of June a presentation of first results had been arranged, it was decided to begin with the analysis of the results in the middle of June. The report was planned to be written in the last two months. Thus, it was started in the middle of June and finished at the beginning of September. Finally, 3 weeks were left in order to correct and control all the writing as well as to introduce modifications.

To sum up, there are four distinguished phases: firstly, from March to May when frameworks are defined, secondly, from May to the beginning of July, when data is processed and results are obtained, thirdly, from mid June until September, the report is written, and finally, the last month is dedicated to the control and correction of the work.
7. COST ANALYSIS IN WILLY VOGEL BERLIN

7.1. Identification of Quality Costs

7.1.1. The quality organization

The Quality Management department is responsible for ensuring that all processes fulfil the guidelines certified by the ISO 9000. It is also in charge of coordinating the FMEAs, i.e. a procedure for analysis of potential failure modes within a system for the classification by severity or determination of the failures' effect upon the system.

The Quality Assurance department is responsible for ensuring continual transparency on all quality related issues. Therefore, individual departments- QA-Supply, QA-Internal and QA Service Centre- work together so as to guarantee that the customer, VOGEL and supplier are networked together. A management department coordinates the three of them (Figure 7.1).

![Figure 7.1. Quality Assurance organization]
The QA-Supplier unit daily inspects the incoming goods according to several different criterions. In special cases, when supplier performance conforms to excellent quality levels, inspection is skipped. Incorrect or defective deliveries are notified, blocked and claimed. Furthermore, the worst listed suppliers are audited in order to set up measures, together with them, to improve the delivery quality. An internal report is created weekly. All the activities performed in this department are considered costs of quality.

The QA-Internal is responsible for the internal quality issues, mainly the in-process and the final inspection/test. Calibration of measuring, test equipment, products or process audits, verification, production check and FMEAs, are tasks developed by this unit. Every failure is notified and discussed, and measures are specified together with other departments such as Production, Assembly or R&D. Again, the obtained results are reported weekly. As well as in the QA-Supplier department, the whole costs of this unit incur in the cost of quality.

The QA-Service Centre is responsible for processing customer complaints, including customer returns, warranty claims, and product recalls. Moreover they offer maintenance service as well as repairs. In this case, only those activities related to the recognized claims are considered quality costs. There are three different kinds of recognized claims: technical claims, logistic claims and sale claims. Technical claims are those related with technical problems, logistic claims occur due to an incorrect shipment or because ware has been damaged within the shipment, and finally, sale claims consist of incorrect or incomplete deliveries. Technical claims are repaired if possible and logistic and sale claims are managed in cooperation with the logistic and the sales department.

Finally, the QA-Management supervises all the issues covered by the three units and make sure that the whole process conforms to quality standards i.e. from product development to delivery, covering production processes, complaints, repairs, etc.
7.1.2. Product cycle description

By analysing the standard product cycle, most of the common quality costs can be identified. It is attempted to identify not only the activities performed by the Quality department during the standard product cycle, but also those which might be performed by other cost units. Next, the standard process is explained into three steps: from the incoming goods to the manufacture, then, from manufacture to delivery to customer, and finally, from delivery to customer, to the end of the cycle. Tasks, activities and facts that incur in the costs of quality are listed and coloured in the following charts.

a) Incoming goods-Manufacture

The Quality Assurance department is in charge of quality inspection of the incoming goods. As Figure 7.2 shows, in case the ware does not conform to quality standards, or to customer requirements or it is simply incorrect, a complaint process must be carried out. The quality department must notify the defect, and then, the complaint process is transferred to the purchase department. They decide, after a previous negotiation with the supplier, whether to return the defective ware, or rework it internally or through an external service, in case an urgent delivery is required.

![Figure 7.2. Product cycle from the incoming goods to the manufacturing process](image-url)
Those goods considered correct, are stored in the warehouse, and afterwards are led to manufacture. Not all the incoming goods are tested; goods coming from reliable suppliers (in terms of quality) are directly stored. Furthermore, they inspect samples of the received ware. Therefore, defective goods can be also encountered in further steps such as in manufacture, in the assembly, or they can even be detected through customer complaints.

To sum up, the activities that may incur in the costs of quality are:

- Quality inspection, failure analysis.
- Complaint procedure: failure notification, coordination Quality-Purchase, negotiation with suppliers.
- Internal/external rework, return to supplier.

b) Manufacture-Delivery to customer

Starting at the end of the manufacturing process, as illustrated in Figure 7.3, the pre-fabricated parts are controlled by the QA-Intern unit. Again, by measuring a sample, they check if parts conform to quality standards. Defective parts can arise due to manufacturing failures or, as said before, due to supplier failures. Manufacturing defects can be solved by reprocessing, but when parts can not be used anymore, they are scrapped.
In case the encountered defect is a problem of a supplier failure, the QA-Supplier unit is informed. Every failure must be notified and reported in order to analyse which is its cause, and how the process can be improved.

The non-defective parts are stored and then they are provided to the assembly. In the assembly, assembled groups as well as final products are tested. There are different sources of failure: assembly errors, manufacturing defects and supplier defects. In case of a manufacturing failure, the procedure is the same as described before ie. scrap or rework. But in case of a supplier defect, QA-Supplier is informed and a standard complaint process is started. Final tested products are stored in the warehouse, packed, and delivered to the customers. The activities that may be considered as quality costs are:

- Control activity in the manufacture
- Failure analysis and notification (by QA-Intern and QA-Supplier)
- Scrap, rework (manufacture and assembly)
- Test and proof in the assembly

Figure 7.3. Product cycle from manufacture to delivery
c) Delivery-End of process

Finally, the end product is delivered to the customer. If there weren’t any quality problems, customers would be satisfied and the product cycle would end here. Unfortunately, 100% quality is not always achieved, and, therefore, unsatisfied customers complain.

![Product cycle from delivery to customer](image)

Figure 7.4. Product cycle from delivery to customer

Figure 7.4 illustrates the procedure followed to manage complaints. The defective product is delivered to the incoming goods and led to the QA-Service Centre department. This unit, as described before, is in charge of managing all kind of complaints. First of all, it is identified if the company is responsible for the defect or not. If this is the case, the solution provided is free of charge i.e. reparation or new part or product, and new shipment, no matter how much it costs. Non-recognized complaints are repaired prior customer’s agreement. Maintenance service is also provided.

The activities that incur the costs of quality are the following:

- Transport and internal logistics activities involved in the incoming claims and the new shipments.
- Q-SC activity: claim management and all activities involved in providing solutions e.g. the repair, collaboration with other departments, etc.

It is assumed that only recognized complaints incur the costs of quality.
7.1.3. Quality cost and the profit centre

Quality costs for a profit centre consist of costs incurred in several activities i.e. work that shouldn’t be performed if quality was always perfect. So far, quality costs have been matched with the activities of the quality organization and also, it is been attempted to identify them by analysing the product cycle. Nevertheless, another point of view of the quality costs source must be taken into account. Figure 7.5 shows the build-up of costs from all functional departments into an overall quality costs analysis for the entire profit centre. As it can be seen, quality costs are incurred by all major functions in the company.

![Figure 7.5. Main profit centres and its quality costs](image)

Every department is somehow involved in the accounting of quality costs. All the activities performed by the quality assurance department are considered quality costs by definition. However, other departments may incur the costs of quality.

**Purchasing**
The purchasing department is in charge of ordering the required material for the plant and the offices, as well as of negotiating with suppliers when they fail to supply according to quality requirements. It takes time and consumes administrative resources, thus it costs money.
Manufacturing and Assembly
In the manufacturing, as well as in the assembly, products might be defective causing scraps and reprocesses which also represent a waste of money. Also both areas incur in the conformance quality costs e.g. calibration and measurement in the manufacturing, or testing in the assembly. Moreover, employees from both departments participate in the FMEAs.

R&D
In the R&D department all the costs incurred when developing a new product, in order to improve quality, should be considered quality costs. Scraps and reprocesses can also occur. R&D participates in the FMEAs as well as in the design for quality programs like Six Sigma. This unit has the best chance to prevent COQ.

Logistics
Logistic problems may also arise due to a false shipment. In addition, defective products are stored, packed and transported, so that costs are incurred.

Sales
The sales department may fail to advice regarding the appropriated product for a certain customer, so that money is wasted to produce a non-suitable product. They are responsible for processing all complaints which have to do with sales failures, and again, administrative costs are incurred.

Other departments and activities could be taken into account to estimate the cost of quality, however, boundaries must be set otherwise quality costs have no end. A detailed explanation of these costs is provided in the further accounting analysis.

7.1.4. Assignment to the quality costs categories
According to the PAF model, the costs described before can be fit into the proper category- prevention, appraisal, internal failure and external failure- as shown in Table 7.1.
### Table 7.1. Identification of quality costs

Most activities performed by the Quality Assurance and the Quality Management department are considered conformance costs. The Q-Management costs, as well as the management costs of Quality Assurance, belong to the prevention category. Both departments are committed to prevent poor quality.
The Q-Management, make sure that the company meet the guidelines defined in quality certificates e.g. ISO, and the management of the Quality Assurance plan and control the development of the quality program.

Costs of the QA-Supplier unit can be considered prevention, appraisal, and even internal failure costs. On one hand, it is attempted to prevent poor quality by auditing suppliers, in order to improve the quality of the delivery and avoid possible future internal or external failures. On the other hand, the inspection activity is, by definition, an appraisal cost. All the efforts made to deal with a failure are considered costs of internal failure since they occur before shipment.

The costs of the QA-Intern unit are mainly due to the appraisal activity. However, every defect encountered must be analysed and reported in order to prevent future defects. Therefore, some of the activity of this department is addressed to audit products or processes i.e. to prevent poor quality, and some is already considered an internal failure cost because it would not be done if there were not any failures.

About 30% of the activity in the QA-SC is considered as a cost of external failure. The costs that proceed from recognized complaints are the only ones that are taken into account.

When a product or a service fails, quality costs from other cost units occur. One department causes an internal or external failure and the others incur in several costs. For example the Purchasing department may have quality costs when complaining for a defective purchased material. Since it is a failure that occurs before shipment, it is accounted as an internal failure costs. The Sales department might fail to advise a customer in the right way, or to run the correct order. As the customer receives a non-suitable product, it is considered an external failure. The Sales department together with Service Centre has to deal with the customer.

In the production or the assembly, scraps or reworks take place. These are, by definition, internal failure costs. Furthermore, in the manufacturing, workers are responsible for measuring the pre-fabricated parts, so that tolerances are checked. Hence, conformance costs are identified. In the assembly several proofs stands test products to verify that they work; they are then, appraisal costs.
Logistic failure costs belong, mainly, to the external failure category. It could happen that the shipment was incorrect but the product was correct, and it could happen that the product was defective and then, all logistic costs should be counted as additional failure costs although it was not a logistic failure. Both cases are external failures since customers must complain. Nevertheless, when a supplier fails and the material must be returned, the associated transport costs are considered internal failure costs.

Finally, the activity of the R&D department can be considered mainly a prevention cost, since it aims to improve the quality of products, but also it might have internal failure costs because of failures during the construction of prototypes.

Summarising, the following table contains the so-called quality costs:

### 7.2. Measures of quality costs

#### 7.2.1. Previous considerations

Before going through the accountings of quality costs, it should be taken into account some comments with regard to the study period, to the limitations and the data source, and to the costs which are not included.

**Study period**

As it is attempted to estimate a reliable value for the total cost of quality in Willy VOGEL AG Berlin, it is required to collect and analyse the data during a representative period of time. Thus, this survey is based on the first quarter of 2008, i.e. from the first of January to the thirty-first of March, 2008. With regard to the calculations, it is assumed that the first quarter has 13 weeks, and every employee works 35 hours/week, i.e. 210 labour hours during the first quarter of 2008.

**Limitations and data source**

Concerning the availability of data, it has not been possible to estimate all the identified costs, as well as some of them must have been roughly calculated because information and data was missing. Since VOGEL produces over 30,000 different products, it is rather complicated to standardise processes and means of cost calculation. Accuracy is a consideration when trying to standardise and simplify processes of high complexity.
All costs from the different cost units have been provided by the Finance and Controlling department. Some others have been self-provided from the internal data software (SAP) and for this reason there might be the possibility for errors.

**Non-included costs**

The survey does not include the costs from the Research and Development department, although it has been mentioned its relationship with the cost of quality. VOGEL prefers to estimate the whole cost of R&D separately. In addition, the costs of special quality programs like a Six Sigma project have not been included for the same reason.

Furthermore, the time spent in testing in the manufacturing, the test equipment out of the manufacturing facility, as well as the activities carried out in the sales unit that are considered quality costs, have not been estimated due to the complexity of the data collection.

### 7.2.2. Prevention costs

As described in the previous chapter, the prevention cost category in VOGEL consists of:

- costs incurred in the Quality Management department
- costs incurred in the management department of Quality Assurance
- costs incurred in the QA-Supplier department
- cost incurred in the QA-Internal department
- cost incurred in the manufacturing and in the assembly due to FMEAs
- cost due to ISO certification

Next, each of these costs is detailed and calculated.

**QM and management of QA departments**

Since the activity of both departments, Quality Management and management of Quality Assurance, is 100% due to prevention, it has been simply assigned the total department cost. Costs for the first quarter of 2008 are detailed in the following table:
## Prevention cost QA-Supplier

In order to explain how much from the total department cost is due to prevention activities, it is required to select a criterion that allows assigning costs as accurate as possible. Thus, it has been found out the percentage of time every employee dedicates to prevention activities. If the total direct labour hours during the first quarter of 2008 are:

\[
\frac{35h}{1\text{week}} \cdot 13\text{weeks} = 210\text{hours}
\]

As shown in Table 7.3, every week 71.75 hours are dedicated to prevention activities, i.e. supplier audits and department management.

<table>
<thead>
<tr>
<th>Employee</th>
<th>Prevention activity [%]</th>
<th>Hours/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (L1)</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td>B (L2)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C (L2)</td>
<td>0.05</td>
<td>1.75</td>
</tr>
<tr>
<td>D (L2)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E (L2)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F (L1)</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total prevention</strong></td>
<td></td>
<td><strong>71.75</strong></td>
</tr>
</tbody>
</table>

Table 7.3. Percentage of prevention activity in the QA-Supplier department

The percentage of prevention activity is

\[
\frac{71.25}{210} \cdot 100 = 34.2\%
\]
Since the whole cost is divided into prevention and appraisal, it is obvious that 65.8% is due to appraisal activities. Moreover, there are two kinds of salaries (L1, L2). It is required to find out how much of prevention they represent:

\[ L1 \rightarrow 1 \]
\[ L2 \rightarrow 0.05/4 = 0.0125 \]

Now, from the total department cost, is it possible to find out the so-called prevention cost:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost [€]</th>
<th>Assignment [%]</th>
<th>Prevention cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amortizations</td>
<td>369.00</td>
<td>34.2</td>
<td>126.08</td>
</tr>
<tr>
<td>Consumptions</td>
<td>620.95</td>
<td>34.2</td>
<td>212.16</td>
</tr>
<tr>
<td>Labour 1</td>
<td>47,219.94</td>
<td>1.25</td>
<td>590.25</td>
</tr>
<tr>
<td>Labour 2</td>
<td>31,861.23</td>
<td>100</td>
<td>31,861.23</td>
</tr>
<tr>
<td>Travel costs</td>
<td>3,762.53</td>
<td>100</td>
<td>3,762.53</td>
</tr>
<tr>
<td>External services</td>
<td>5,632.79</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Overheads</td>
<td>1,178.83</td>
<td>34</td>
<td>569</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90,645.27</strong></td>
<td></td>
<td><strong>37,121.24</strong></td>
</tr>
</tbody>
</table>

Table 7.4. Prevention cost assignment in the QA-Supplier department

Note that travel costs are entirely assigned to prevention, since they are costs due to visits to suppliers e.g. supplier audits, and external services such as maintenance of machines, belong to the appraisal costs.

**Prevention cost QA-Internal**

Prevention costs consist of costs resulting from preventive failure notification and from FMEAs. The QA-Internal is in charge of notifying every failure they encounter. However, they also create notifications in order to warn about potential failure and to prevent them. It is assumed that every employee spends, in average, 30 minutes for every notification. Table 7.5, shows the number of notifications and their source during the first quarter of 2008.
<table>
<thead>
<tr>
<th>Source</th>
<th>Number</th>
<th>Hours/not</th>
<th>Total h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>24</td>
<td>0,5</td>
<td>12</td>
</tr>
<tr>
<td>Assembly</td>
<td>8</td>
<td>0,5</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32</strong></td>
<td><strong>0,5</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

Table 7.5. Labour hours dedicated to notify potential failures, first quarter 2008.

Every employee is able to create a notification, thus the number of notifications has been distributed to both salary ranges according to the number of employees (8). Then the prevention cost for each range has been extracted taking into account the percentage of time dedicated to notify (Table 7.6).

<table>
<thead>
<tr>
<th>Employee</th>
<th>[%]</th>
<th>Notifications [h]</th>
<th>Total Labour [h]</th>
<th>Hours not/ labour h</th>
<th>Labour cost [€]</th>
<th>Prevention cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour 1</td>
<td>0,75</td>
<td>11,43</td>
<td>2730</td>
<td>0,004</td>
<td>60,547,82</td>
<td>253,47</td>
</tr>
<tr>
<td>Labour 2</td>
<td>0,25</td>
<td>4,57</td>
<td>910</td>
<td>0,005</td>
<td>34,828,8</td>
<td>174,96</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1</td>
<td>16</td>
<td>3640</td>
<td>-</td>
<td>95,376,62</td>
<td>428,43</td>
</tr>
</tbody>
</table>

Table 7.6. Prevention cost assignment due to notification

To calculate the cost of the FMEAs, it is assumed that only one employee participates. Again, the labour costs are calculated:

\[
\frac{5\text{hours}}{\text{FMEA}} \cdot 4\text{FMEA} = 20\text{hours}
\]

\[
\frac{35\text{h}}{\text{week}} \cdot 13\text{weeks} \cdot 1\text{worker} = 210\text{hours}
\]

\[
\%\text{hours FMEA} = \frac{20}{210} \cdot 100 = 9.52\%
\]

The labour costs for the employee are 17414,4€, so prevention costs due to FMEAs are:

\[
0.0952 \times 17414.4\text{€} = 1658,51 \text{€}
\]

Finally, total prevention costs in the QA-Internal are:

\[
\text{Notification costs + FMEAs} = 419,24\text{€} + 1658,51\text{€} = 2077,75\text{€}
\]
**Prevention cost manufacturing and assembly**

The prevention cost results from the FMEAs. Since it has been not possible to obtain the exact labour costs for both manufacture and assembly managers, it is assumed that it is the same as the cost incurred by the QA-Intern department:

\[
\text{Prevention cost} = 2 \times 1658.51\,€ = 3317.03\,€
\]

**ISO certification**

Every year VOGEL must pay for a compulsory audit in order to make sure that their processes conform to the ISO guidelines. Since in 2008 VOGEL has not yet incurred in this cost, it is assumed that the cost is the same than the year before and it is assigned to the first quarter. Since the Quality management department is responsible for it, it is included as an additional expense.

\[
\text{Auditing service} = 5810.77\,€
\]

\[
\text{Cost for the first quarter 2008} = 0.25 \times 5810.77\,€ = 1452.69\,€
\]

**Total Prevention costs**

To sum up, prevention costs during the first quarter of 2008 can be in the following Table 7.7 collected. The total prevention cost adds up to 113,923,71 €.

<table>
<thead>
<tr>
<th>Cost unit</th>
<th>Description</th>
<th>Prevention Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-Management</td>
<td>Department cost</td>
<td>13,402.47</td>
</tr>
<tr>
<td></td>
<td>iso certification</td>
<td>1,452.69</td>
</tr>
<tr>
<td>QA-Management</td>
<td>Department cost</td>
<td>56,552.54</td>
</tr>
<tr>
<td>QA-Supplier</td>
<td>Assigned depart. cost</td>
<td>37,121.24</td>
</tr>
<tr>
<td>QA-Intern</td>
<td>Notifications</td>
<td>428.43</td>
</tr>
<tr>
<td></td>
<td>FMEAS</td>
<td>1,658.51</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>FMEAs</td>
<td>1,658.51</td>
</tr>
<tr>
<td>Assembly</td>
<td>FMEAs</td>
<td>1,658.51</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>113,923.71</strong></td>
</tr>
</tbody>
</table>

Table 7.7. Prevention Costs, first quarter 2008.
7.2.3. Appraisal costs

The appraisal costs have been identified in the following cost units:

- department of QA-Supplier
- department of QA-Internal
- Manufacturing
- Assembly

**Department of QA-Supplier**

The same criterion to assign the appraisal costs from the total department cost is used i.e. percentage of time dedicated to appraisal activities. As described in chapter 7.8, all what is not prevention is appraisal cost and vice versa. Thus, the cost assignment is the following:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost [€]</th>
<th>Assignment [%]</th>
<th>Appraisal cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amortizations</td>
<td>369,00</td>
<td>65,8</td>
<td>242,93</td>
</tr>
<tr>
<td>Consumptions</td>
<td>620,95</td>
<td>65,8</td>
<td>408,79</td>
</tr>
<tr>
<td>Labour 1</td>
<td>47219,94</td>
<td>98,75</td>
<td>46.629,69</td>
</tr>
<tr>
<td>Labour 2</td>
<td>31861,23</td>
<td>0,00</td>
<td>0,00</td>
</tr>
<tr>
<td>Travel costs</td>
<td>3.762,53</td>
<td>0,00</td>
<td>0,00</td>
</tr>
<tr>
<td>External services</td>
<td>5.632,79</td>
<td>100</td>
<td>5.632,79</td>
</tr>
<tr>
<td>Overheads</td>
<td>1.178,83</td>
<td>65,8</td>
<td>609,83</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90.645,27</strong></td>
<td></td>
<td><strong>53.524,03</strong></td>
</tr>
</tbody>
</table>

Table 7.8. Appraisal cost assignment in the QA-Supplier department, first quarter 2008.

**Department of QA-Internal**

In this case, the entire department costs can be assigned to the appraisal costs. However, since prevention costs, as well as internal failure costs, are assigned from the department cost, at the end of the measurement, these costs must be subtracted from the following amount in order to not count them twice.
### Manufacturing

In the manufacturing, workers carry out test activities during the manufacturing process with specific test and measurement equipment to check if parts conform to the specified tolerances. The VOGEL Company in Berlin, does have more than 9,000 test and measurement equipments spread all over the plant.

According to the finance department, these devices are amortized when purchased price is over 410 €, and the amortization splits the amount into 5 years. For the first quarter of 2008 are included the expenses on equipment under 410 €, the amortization concerning this period of time, and the amortization of all devices bought in the past 5 years. As the provided data is only for 2007 and 2008, it is assumed that the amortization of goods during 2004-2006, is the same then, the following tables summarize the expenses:

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amortization [€]</td>
<td>538,34</td>
<td>538,34</td>
<td>538,34</td>
<td>538,34</td>
<td>50,52</td>
<td>2,203,88</td>
</tr>
</tbody>
</table>

Table 7.10. Amortization of the equipment, 2004-2008.

<table>
<thead>
<tr>
<th>Total Amortization [€]</th>
<th>Expenses 2008 [€]</th>
<th>Total cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,203,88</td>
<td>2,498,71</td>
<td>4,702,60</td>
</tr>
</tbody>
</table>

Table 7.11. Cost of appraisal equipment, first quarter 2008.

---

7 See B.1 in the appendix
Assembly

In order to find out the cost of the test activity in the assembly, it is again necessary to define an assignment criterion. Since almost 71% of the cost in the entire assembly area is due to labour costs, the percentage of testing hours has been taken as criterion.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amortizations</td>
<td>48,914,3</td>
</tr>
<tr>
<td>Consumptions</td>
<td>231,871,73</td>
</tr>
<tr>
<td>Labour</td>
<td>725,457,75</td>
</tr>
<tr>
<td>Travel costs</td>
<td>818,99</td>
</tr>
<tr>
<td>External services</td>
<td>5,920,99</td>
</tr>
<tr>
<td>Overheads</td>
<td>18,045,68</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,031,029,44</strong></td>
</tr>
</tbody>
</table>

Table 7.12. Cost of the assembly area, first quarter 2008.

The following table shows the time dedicated to test activity in the entire assembly.

<table>
<thead>
<tr>
<th>Hours [h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total hours/week</td>
</tr>
<tr>
<td>Test hours/week</td>
</tr>
<tr>
<td>Test h/Total h</td>
</tr>
</tbody>
</table>

Table 7.13. Time due to test activity

Then, if twenty-three percent of the working time in the assembly is due to test activity, the total appraisal cost is:

\[ 0.25 \times 1,031,029,44 = 236,804,09€ \]

**Total Appraisal cost**

Summarising, the total appraisal costs adds up to 402,204,36 € in the first quarter of 2008. They can be split up into the different cost units involved in this category cost as it shows Table 7.14:

<table>
<thead>
<tr>
<th>Cost unit</th>
<th>Description</th>
<th>Appraisal Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>QA-Supplier</td>
<td>Assigned depart. cost</td>
<td>53,524,03</td>
</tr>
<tr>
<td>QA-Intern</td>
<td>Department cost</td>
<td>111,876,24</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Calibration</td>
<td>4,702,60</td>
</tr>
<tr>
<td>Assembly</td>
<td>FMEAs</td>
<td>236,804,09</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>402,204,36</strong></td>
</tr>
</tbody>
</table>

7.2.4. Internal Failure costs

The next estimations are developed following the classification of internal failure costs from Table 7.1. The different unit costs that incur in these costs are:

- QA-Supplier, due to rejected purchased material notifications
- QA-Intern, due to failure notifications
- Manufacturing and Assembly, due to scraps and reworks
- Purchase department, due to rejected purchased material processing
- Logistics, due to transports of rejected purchased material

**QA-Supplier department**

For each defective purchased material it is required to make a notification. Features of the product, reference number and kind of defect, must be introduced in the internal information software in order to provide the purchasing department with all the information to complain to the supplier.

It is assumed that every employee spends in average 30 minutes for every notification. In the next table are presented the labour hours due to notifications introduced during the first quarter of 2008, divided into the failure source:
Table 7.15. Labour hours dedicated to notify rejected purchased material

Note that the source of the defect is also provided in order to extend the detailed information, although, so far, it is not useful to assign the total notification cost to each source. Next, the total failure cost is estimated for the first quarter of 2008 (Table 7.16). There are 6 employees and only 5 are in charge of the notifications. Therefore, the number of notifications has been distributed among 5 according to the salary ranges.

<table>
<thead>
<tr>
<th>Employee [%]</th>
<th>Notifications [h]</th>
<th>Total Labour [h]</th>
<th>Notification/ Total labour</th>
<th>Labour cost [\€]</th>
<th>Failure cost [\€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour 1</td>
<td>60</td>
<td>40,2</td>
<td>1820</td>
<td>0,02</td>
<td>47219,94</td>
</tr>
<tr>
<td>Labour 2</td>
<td>40</td>
<td>26,8</td>
<td>910</td>
<td>0,03</td>
<td>31861,23</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1</strong></td>
<td><strong>67</strong></td>
<td><strong>2730</strong></td>
<td></td>
<td><strong>79081,17</strong></td>
</tr>
</tbody>
</table>

Table 7.16. Internal failure cost assignment due to notification.

**QA-Internal department**

The QA-Internal department has to notify every time a defect is found. It consists of reporting the failure cause, the material reference and the adopted measure on agreement with manufacturing. The procedure to estimate the cost of failure notifications is exactly the same as followed in chapter 7.2.2, for the calculation of preventive costs due to notifications. Thereby, Table 7.17 shows the total labour hours:
Next, the labour costs due to notifications of failures are presented for the first quarter of 2008. Note that again, any employee can create a notification.

<table>
<thead>
<tr>
<th>Employee</th>
<th>Notification (%)</th>
<th>Total Labour [hours]</th>
<th>Notification/ Total labour</th>
<th>Labour cost [€]</th>
<th>Prevention cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour 1</td>
<td>0,75</td>
<td>21,79</td>
<td>2730</td>
<td>60547,82</td>
<td>483,18</td>
</tr>
<tr>
<td>Labour 2</td>
<td>0,25</td>
<td>8,71</td>
<td>910</td>
<td>34828,8</td>
<td>333,53</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>30,5</td>
<td>3640</td>
<td>95.376,62</td>
<td>816,70</td>
</tr>
</tbody>
</table>

Table 7.18. Prevention cost assignment due to notification

**Manufacturing and Assembly**

As explained before, manufacturing quality costs consists of those costs involved in reworking and scrapping. There are three possible means of identification and evaluation of these costs. On one hand, reworks and scraps notified by the Quality Assurance. When suppliers deliver defective material, the QA-Supplier is the one who notifies, in case parts do not pass the quality control at the end of the manufacturing process, the QA-Internal department notifies whether parts have to be reworked or scrapped.

On the other hand, during the manufacturing and at every stage, it is possible that parts do not conform to quality standards and they are either reworked or scrapped. Then, for the three possible means of identification of internal failures, estimation has been carried out.

**Reworks reported by QA-Supplier**

Next, the costs involved in reprocessing defective purchased material are presented. During the study period no material was scrapped, although it could have happened. The cost of reprocessing is divided into the four possible stages where the defect can be encountered.
Scraps and reworks reported by QA-Internal

Table 7.20 contains, for both areas, assembly and manufacturing, the costs resulting from scrapping and reworking, reported by the QA-Internal during the first quarter of 2008. Rework time as well as scrapped units are also provided. It is worth highlighting the fact that the majority of scraps and reworks take place in the manufacturing.

<table>
<thead>
<tr>
<th>Time [min]</th>
<th>Cost [€]</th>
<th>Units [u]</th>
<th>Cost [€]</th>
<th>Total Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>4253</td>
<td>2977,10</td>
<td>176</td>
<td>1573,92</td>
</tr>
<tr>
<td>Assembly</td>
<td>60</td>
<td>42</td>
<td>40</td>
<td>241,67</td>
</tr>
<tr>
<td>Total</td>
<td>4313</td>
<td>3019,10</td>
<td>216</td>
<td>1815,59</td>
</tr>
</tbody>
</table>

Table 7.20. Reworks due to defective manufactured parts

Scraps and reworks in the manufacturing

The costs described above have been collected from the failure notifications of the QA-Internal department, whereas the following costs have been estimated by the author.

a) Scraps

The actual internal information software in VOGEL allows getting the number of scraps that have been registered by the workers in the plant. However, the following problems came up when trying to collect this information:

- Scrap notification is not always compulsory, then, the amount is not reliable
- The notified scrap is not valuated.

Therefore, it was attempted to figure out the exact produced amount of scrap by analysing the flow material i.e. comparison of number of pieces provided to the manufacturing, with the number of pieces registered after processing.
Through the internal data software, it is possible to get, for each order, the amount that should be processed, and the real number of parts registered at the end of the last workstation. This information can be checked for each workstation. The idea was to count scraps as the difference between what has been produced and what should be produced. Three different cases were observed:

1) Number of produced parts = Number of provided parts
2) Number of produced parts < Number of provided parts
3) Number of produced parts > Number of provided parts

To begin with, in case (1) there are no scraps produced, in case (2) the difference should be scrap, but the last case makes no sense at all. Therefore a further study in order to explain all the possibilities is required. Results show the following:

- The raw material might not be enough to produce what was planned. For example, a steel bar should be 3 m long and it is 2.95 m. That means that maybe, 2 o 3 parts less can be cut out of it.
- It can also occur the other way round. Raw material reach more than what it was expected.
- Workers may not count parts properly.
- The name of the order might be changed so that it appears as missing order.
- Orders that are processed more than once in one workstation are counted double.
- In some workstations, there is always one part wasted because of the adjustment of the machine.

For all these different scenarios, scrapping is possible. Obviously, it turns out to be rather complicated to estimate the real amount of produced scrap. Therefore, a sample was taken during two weeks (21.05.2008-4.06.2008), as an attempt to clarify and contrast the information that appeared in the internal system with what really happened in the plant. It consisted of reporting what was daily produced in 6 machines. However, this survey failed for the following reasons:

- 3 shifts/day made it really difficult to talk to the workers and ask them about the number of scraps and cause.
• The employees responsible for some areas in the production were not really aware of the scraps

Finally, it was decided to simply collect the reported scrap amount for the study period, although it is a rough estimation. In addition, and as explained before, the information system does not provide the added value of a part when it is scrapped. It has been assumed, otherwise it would not have been feasible, the following criteria:

• For each scrapped part it is assigned the added value after being completely manufactured.
• Value estimated for every single scrapped part during 01.04.08-22.04.08.
• Value estimated extended to the first quarter of 2008.

The results from measured scrap are:

<table>
<thead>
<tr>
<th>Month</th>
<th>Scrap [u]</th>
<th>Total cost [€]</th>
<th>Cost per unit [€/u]</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>2.305</td>
<td>16500</td>
<td>7,16</td>
</tr>
</tbody>
</table>

Table 7.21. Measured scrap value in plant

Estimating 7,16 € per scrapped unit, the resulting cost for the first quarter 2008 is:

<table>
<thead>
<tr>
<th>Month</th>
<th>Scrap [u]</th>
<th>Estimated cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>3.247</td>
<td>23.243,17</td>
</tr>
<tr>
<td>February</td>
<td>5.056</td>
<td>36.192,62</td>
</tr>
<tr>
<td>March</td>
<td>3.181</td>
<td>22.770,72</td>
</tr>
<tr>
<td>Total</td>
<td>11.484</td>
<td>82.206,51</td>
</tr>
</tbody>
</table>

Table 7.22. Estimated scrap value during the first quarter of 2008

The total estimated cost of the scrapped produced during the first quarter of 2008 is 82.206,51€. This value is probably far away from the real value. Later on chapter 7.3, different scenarios are discussed.

b) Reworks

Reprocesses decided and notified by the manufacturing unit itself are rather little. Normally, when an entire order or just some parts must be reworked, it is not officially notified. These costs were not able to be calculated.
Purchasing

The internal failure cost incurred by the Purchase Department is based on the administration costs due to claims processing. This department, in collaboration with the Quality Assurance, decides whether the defective material should be reworked, scrapped or returned. This department charges 51\(€\) to the supplier when administrative costs have been exceed, ie. it is not a regular charge. The author has taken this value in order to estimate claims processing costs. However, it might be possible that this amount includes a little margin of benefit. So, if we count 51 \(€\) for each rejection (Table 7.23):

<table>
<thead>
<tr>
<th>Rejections [u]</th>
<th>I.G</th>
<th>Manufacture</th>
<th>Assembly</th>
<th>Customer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>59</td>
<td>5</td>
<td>40</td>
<td>30</td>
<td>134</td>
</tr>
<tr>
<td>Processing cost [(€)]</td>
<td>3.009</td>
<td>255</td>
<td>2.040</td>
<td>1.530</td>
<td>6.834</td>
</tr>
</tbody>
</table>

Table 7.23. Rejections cost Purchasing

Logistics

Logistic internal failure costs are all packing and transport costs of the rejected purchased material. Although suppliers should assume these costs, it has been observed that few of these costs are paid back, or at least, in a short period of time. Some suppliers may pick up the defective material by their own, however, it represents approximately a 5 \%. After analysing packing and transport costs, the following average costs have been assumed.

- Packing cost= 10\(€/\)order
- Transport cost= 5\( €/\)order

Then, charging a total cost of 15\(€\) for each shipment, the total logistic internal failure cost is:

<table>
<thead>
<tr>
<th>Rejections [u]</th>
<th>I.G</th>
<th>Manufacture</th>
<th>Assembly</th>
<th>Customer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>59</td>
<td>5</td>
<td>40</td>
<td>30</td>
<td>134</td>
</tr>
<tr>
<td>Logistic cost [(€)]</td>
<td>885</td>
<td>75</td>
<td>600</td>
<td>450</td>
<td>2.010</td>
</tr>
</tbody>
</table>

Table 7.24. Logistic internal failure cost

Total internal failure costs

Table 7.25, summarizes the total internal failure cost in VOGEL during the first quarter of 2008.
<table>
<thead>
<tr>
<th>Cost unit</th>
<th>Cost description</th>
<th>Internal Failure Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>QA-Supplier</td>
<td>Notification rejected material</td>
<td>1,981,32</td>
</tr>
<tr>
<td>QA-Internal</td>
<td>Notification failures</td>
<td>816,70</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Reworks from suppliers</td>
<td>1,771,00</td>
</tr>
<tr>
<td></td>
<td>Scraps through QA-Internal</td>
<td>1,573,92</td>
</tr>
<tr>
<td></td>
<td>Reworks through QA-Internal</td>
<td>2,977,10</td>
</tr>
<tr>
<td></td>
<td>Reworks from Assembly</td>
<td>24,00</td>
</tr>
<tr>
<td></td>
<td>Scraps in plant</td>
<td>82,206,51</td>
</tr>
<tr>
<td>Assembly</td>
<td>Scraps through QA-Internal</td>
<td>241,67</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Rejection processing</td>
<td>6,834,00</td>
</tr>
<tr>
<td>Logistics</td>
<td>Shipments from rejected materials</td>
<td>2,010,00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100,454,22</strong></td>
</tr>
</tbody>
</table>

Table 7.25. Total Internal Failure Cost, first quarter 2008.

7.2.5. External Failure costs

As explained in chapter 7.1, the Q-SC department is the main responsible for processing customer complaints. Therefore, all the costs incurred by this unit, which are related to claim processing, are considered external failure costs. Note that only recognized claims, i.e. those which VOGEL assumes the responsibility of the failure, are taken into account. Additionally to the standard department costs, all logistic costs must be counted. It has been intended to standardise the complain process, in order to make clear all the costs that take place.

Figure 7.6, shows the standard process from the notification of a customer complain, to the recognition and classification of the claim.
Normally, defective products are sent back to VOGEL, which costs in average 5 € per delivery. Nevertheless, in case of international claims, it is cheaper to send a new product. All the claimed goods received in VOGEL must be unpacked and afterwards delivered to SC. Pienning is an external company which offers this service charging 1,50 € per unit.

In the Service Centre, products are examined and classified according to sales, logistic and technical categories. It is important to distinguish them since the way to proceed certainly differ.

The following figure describes the standard process for the Logistic and Sales complaints:
Logistic and sales complaints proceed in the same way. Two actions must be done at the same time. On one hand, VOGEL must provide the customer with the correct goods i.e. a new order must be carried out and, as soon as possible, it must be shipped again. On the other hand, customers get a credit memo for the returned good. In case this good is not useable any more, because it was specially designed for one customer and it is not possible to sell it again, it is scrapped. But usually, the returned good is stored by Pienning and later, if possible, sold again.

Technical complaints are processed differently (fig 7.8). First of all, an internal report must be created in order to notify the type of failure and the possible repair. Then, there are two possibilities, either to create a credit memo, or to fix the product.

In case the product is not repaired, pieces are stored by Pienning and later on, reused for something else. Repaired products, are delivered directly from Service Centre to Logistics, where they pack and ship them.
External Failure Costs Q-SC

Once the standard process has been described, the quality costs with regard to the Service Centre department are estimated. First of all, it is necessary to decide the cost assignment from the total department cost to the strictly cost of quality. Table 7.26 presents the department costs during the first quarter of 2008.
<table>
<thead>
<tr>
<th>Type of cost</th>
<th>Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amortizations</td>
<td>3.109,31</td>
</tr>
<tr>
<td>Consumptions</td>
<td>40.252,21</td>
</tr>
<tr>
<td>Labour</td>
<td>114.390,00</td>
</tr>
<tr>
<td>Travel costs</td>
<td>3.309,48</td>
</tr>
<tr>
<td>External service</td>
<td>3.561,80</td>
</tr>
<tr>
<td>Overheads</td>
<td>4.368,04</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>168.990,82</strong></td>
</tr>
</tbody>
</table>


The assumed assignment base is the total number of returns, so that, the proportion of recognized claims over total returns, represents the proportion of the complaint costs in the Service Centre. Calculations follow in the next table:

<table>
<thead>
<tr>
<th>Returns</th>
<th>Type of claim [%]</th>
<th>Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total returns</td>
<td>981</td>
<td>168.990,82</td>
</tr>
<tr>
<td>Recognized claims</td>
<td>177</td>
<td>30.490,70</td>
</tr>
<tr>
<td>TECH</td>
<td>105</td>
<td>10,70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18.087,70</td>
</tr>
<tr>
<td>SALES</td>
<td>46</td>
<td>4.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.924,14</td>
</tr>
<tr>
<td>LOGI</td>
<td>26</td>
<td>2.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.478,86</td>
</tr>
</tbody>
</table>

Table 7.27. SC department cost assignment

In addition to the department costs, the costs of all returned products that have been stored should also be taken into account, and a credit memo has been written, i.e. it is the cost of not selling what has been produced, and the costs of all new deliveries due to international claims.

<table>
<thead>
<tr>
<th></th>
<th>Total Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-repaired (Tech)</td>
<td>29.184,00</td>
</tr>
<tr>
<td>Stored Products (Sales &amp; Logi)</td>
<td>11.393,45</td>
</tr>
<tr>
<td>New deliveries (export)</td>
<td>4.781,98</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>45.359,43</strong></td>
</tr>
</tbody>
</table>

Table 7.28. Non sold-products and new deliveries
Logistic external failure costs

As observed in the charts above, packing and transport costs are significant in order to manage customer claims. Next are summarized the most important logistic costs:

| Cost description     | Cost/unit  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>National Transport cost</td>
<td>5.00</td>
</tr>
<tr>
<td>Packing cost</td>
<td>10.00</td>
</tr>
<tr>
<td>Piening Service</td>
<td>1.50</td>
</tr>
<tr>
<td>Storage cost</td>
<td>1.87</td>
</tr>
</tbody>
</table>

Table 7.29. Logistic costs

Note that, in order to approach transport costs, it is more accurate to evaluate the number of returned shipments instead of every single returned good. Customers return more than one product in a shipment very often. Transport cost depends on the weight of the shipment; hence, an average price for all shipments was necessary. Likewise, an average packing cost has been taken despite having a wide range of sizes. The average values are based on the experience of the logistic manager and have been contrasted with old data.

The price for the Pienning service and the price for the storage are established and well known. Moreover it is important to distinguish whether it is a national claim, or an international claim, because the transport costs are, obviously, not the same (Table 7.30).

<table>
<thead>
<tr>
<th></th>
<th>TECH</th>
<th>SALE</th>
<th>LOGI</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Returns (shipments)</td>
<td>86</td>
<td>37</td>
<td>24</td>
<td>147</td>
</tr>
<tr>
<td>National</td>
<td>80</td>
<td>36</td>
<td>20</td>
<td>136</td>
</tr>
<tr>
<td>Export</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 7.30. National and exported returns

Table 7.31 presents the calculations for the total logistic cost. The following assumptions have been taken:

- ‘Delivery to VOGEL’ and ‘delivery to customer’ are transport costs only for national shipments.
- Logistics and sales complaints incur twice the cost of Pienning service (see Figure 7.7)
• Packing costs are considered for each returned good.
• Exports costs are just a rough estimation. It has been really difficult to extract the real cost due to the different possible scenarios. Costs depend on: the country, the export taxes, the weight, kind of shipment e.g express transport,....etc.

<table>
<thead>
<tr>
<th></th>
<th>Technical [€]</th>
<th>Sale [€]</th>
<th>Logistic [€]</th>
<th>Total [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery to VOGEL</td>
<td>400</td>
<td>180</td>
<td>100</td>
<td>680</td>
</tr>
<tr>
<td>Planning service</td>
<td>129</td>
<td>111</td>
<td>240</td>
<td>480</td>
</tr>
<tr>
<td>Storage</td>
<td>0</td>
<td>69,19</td>
<td>44,88</td>
<td>114</td>
</tr>
<tr>
<td>Packing</td>
<td>1.050,00</td>
<td>460</td>
<td>260</td>
<td>1.770</td>
</tr>
<tr>
<td>Delivery to customer</td>
<td>400</td>
<td>180</td>
<td>100</td>
<td>680</td>
</tr>
<tr>
<td>Export costs</td>
<td>350</td>
<td>175</td>
<td>175</td>
<td>700</td>
</tr>
<tr>
<td>Total</td>
<td>2.329</td>
<td>1.175,19</td>
<td>919,88</td>
<td>4.424</td>
</tr>
</tbody>
</table>

Table 7.31. Logistic external failure costs

**Total external failure costs**

To end up, external failure costs are mainly incurred by the Service Centre department and the Logistics. However, other unit costs like Sales, or QA-Internal, or the QA-Supplier or even the assembly, could be included. The reason why these are not included is the difficulty to get to know exactly the degree of participation.

The total external failure cost adds up to 80,274,13€ during the first quarter of 2008, the following table splits this cost up into the costs explained before.
Quality and non-Quality Costs.
Study case in Willy Vogel AG.

<table>
<thead>
<tr>
<th>Cost unit</th>
<th>Cost description</th>
<th>External Failure Cost [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-SC</td>
<td>Department cost</td>
<td>30,490.70</td>
</tr>
<tr>
<td></td>
<td>Technical</td>
<td>18,087.70</td>
</tr>
<tr>
<td></td>
<td>Sales</td>
<td>7,924.14</td>
</tr>
<tr>
<td></td>
<td>Logistics</td>
<td>4,478.86</td>
</tr>
<tr>
<td></td>
<td><strong>Product costs</strong></td>
<td><strong>45,359.43</strong></td>
</tr>
<tr>
<td></td>
<td>Non-repaired (Tech)</td>
<td>29,184.00</td>
</tr>
<tr>
<td></td>
<td>Stored Products (Sales &amp; Logi)</td>
<td>11,393.45</td>
</tr>
<tr>
<td></td>
<td>New deliveries (export)</td>
<td>4,781.98</td>
</tr>
<tr>
<td>Logistics</td>
<td>Logistic cost</td>
<td><strong>4,424.00</strong></td>
</tr>
<tr>
<td></td>
<td>Technical</td>
<td>2,329.00</td>
</tr>
<tr>
<td></td>
<td>Sales</td>
<td>1,175.19</td>
</tr>
<tr>
<td></td>
<td>Logistics</td>
<td>919.88</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>80,274.13</strong></td>
</tr>
</tbody>
</table>

Table 7.32. Total external failure cost, first quarter 2008.

7.2.6. Hidden costs

In chapter 4.3, the importance of hidden costs and the difficulty to measure them has been mentioned. The fact that these costs cannot be underestimated has been highlighted, and it is intended to approximate the cost of unsatisfied customers as an example of intangible cost.

Customer surveys are used worldwide and it is becoming an important tool for the quality organizations in order to evaluate the product's quality through the customers' perspective. The costs resulting from unsatisfied customers can only be estimated as profits not earned in the future. Nevertheless, it cannot be a precise estimation because it is rather complicated to predict customers' behaviour.

Since 2006, VOGEL runs a customer survey every year, which consists of 4 different questionnaires in different areas. Last year there were 524 questionnaires evaluated with approx. 8000 individual responses. In an scale from 1 to 5, where 1 means 'very satisfied' and 5 means 'very unsatisfied', VOGEL had an average value of 3.97. As a result of the question that asked if they would recommend VOGEL to a colleague, the result was:
• 79.25 % answered ‘yes’
• 18.71 % answered ‘probably yes’
• 1.02 % answered ‘probably not’
• 1.02 % answered ‘not’

The 2.04 % of customers that would probably or surely not recommend VOGEL to a colleague are more likely to switch to competitors. For this reason, it has been estimated the loss of revenue due to the possibility of loosing these customers. The presented data corresponds to the survey performed in 2007. At the end of 2008 the results from the data collected trough this year will be presented.

Next is the turnover from most of the customers that were not satisfied with the provided product or service in the last 4 years (Table 7.33). Due to the fact that VOGEL is not interested in publishing detailed data, the name of the customers is avoided:

<table>
<thead>
<tr>
<th>Turnover</th>
<th>Turnover</th>
<th>Turnover</th>
<th>Turnover</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>2006</td>
<td>2005</td>
<td>2004</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>72.265,18</td>
<td>104.526</td>
<td>46.317,37</td>
<td>43.856,64</td>
</tr>
<tr>
<td>D</td>
<td>193.000</td>
<td>196.000</td>
<td>200.000</td>
<td>197.000</td>
</tr>
<tr>
<td>E</td>
<td>1.237,58</td>
<td>664,62</td>
<td>1.124,5</td>
<td>1.043,21</td>
</tr>
<tr>
<td>Total</td>
<td>2.990.012,04</td>
<td>3.293.866,73</td>
<td>1.320.100,33</td>
<td>1.281.933,33</td>
</tr>
</tbody>
</table>

Table 7.33. Unsatisfied customers' turnover 2007

As far as the data is available, the average turnover between 2004 and 2007 of the customers that were unsatisfied with the provided quality, adds up to approximately 2,3 million Euros. If the risk of not purchasing again is considered, it is estimated that VOGEL will not earn approximately the average turnover during the next year. A rough estimation of the loss of turnover for the first quarter of 2008 is,

\[
\frac{2.318.728,11 \text{ €}}{4} = 580.182,0269 \text{ €/quarter}
\]

Assuming an average margin of profit of 18 percent for all products sold by VOGEL,

\[
580.182,0269 \text{ €} \times 0,18 = 104.432,7648 \text{ €/quarter}
\]
7.3. Results Analysis

7.3.1. Presentation of total cost of Quality

7.3.1.1. General Results

It is observed that the total cost of quality in the VOGEL company, excluding hidden costs, during the first quarter of 2008 adds up to 691,980.72 €.

Costs from the quality organization have been relatively easy to determine. In the previous chapter every cost category has been discussed and evaluated. For all quality units, the department cost has been split up into the different categories. Note that, for instance, in the case of QA-Supplier, the internal failure cost is a cost of labour. Therefore, it has been subtracted from the total labour expense, reducing equally both appraisal and prevention costs. The same kind of calculation has been carried out in order to estimate the prevention and internal failure cost for the QA-Internal.

<table>
<thead>
<tr>
<th>Cost unit</th>
<th>Prevention [€]</th>
<th>Appraisal [€]</th>
<th>Internal Failure [€]</th>
<th>External Failure [€]</th>
<th>Total [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-Management</td>
<td>14.855,16</td>
<td></td>
<td></td>
<td></td>
<td>14.855,16</td>
</tr>
<tr>
<td>QA-Management</td>
<td>56.552,54</td>
<td></td>
<td></td>
<td></td>
<td>56.552,54</td>
</tr>
<tr>
<td>QA-Supplier</td>
<td>36.130,58</td>
<td>52.533,37</td>
<td>1.981,32</td>
<td></td>
<td>90.645,27</td>
</tr>
<tr>
<td>QA-Internal</td>
<td>2.077,75</td>
<td>108.981,79</td>
<td>816,70</td>
<td></td>
<td>111.876,24</td>
</tr>
<tr>
<td>Q-SC</td>
<td></td>
<td></td>
<td></td>
<td>75.850,13</td>
<td>75.850,13</td>
</tr>
<tr>
<td>Total Q</td>
<td>109616,03</td>
<td>161.515,16</td>
<td>2798,02</td>
<td>75850,13</td>
<td>349.779,34</td>
</tr>
</tbody>
</table>

Table 7.3.4. Quality cost summary report, VOGEL Q1 2008.
The total cost of quality assigned directly to the quality organization adds up to 349,779,34€, which represents 50,55 % over the total cost (Table 7.34). These are the so-called, standard costs. The other 49,45 %, i.e. 342,201,38€, which is absorbed by the other units, represents the uncovered costs.

7.3.1.2. Other estimations

As it was already commented, accuracy for these uncovered costs must be taken into account. Certainly, there is a margin of error, and without any doubt the results obtained are smaller than expected. As VOGEL Berlin produces a wide variety of products, it is very difficult to standardise means of cost calculation. In addition, data is sometimes somehow hidden, so that makes it even more difficult to reach the real value. As a result, some estimations explain part of the cost and the rest remain hidden. Next, is an attempt to approximate potential costs by considering other scenarios in the manufacturing, in the assembly and in the logistics, that could increase the total cost of quality:

Manufacturing

The scrap analysis in the plant has not been accurate enough to present a precise result from its cost. Neither the amount nor the value is exact. So far, only measured data has been presented. Next, it is intended to evaluate some observations that might lead to different scenarios:

1) From the sample taken during 21.05.08-04.06.08, it was observed that 18 parts per day were scrapped due to machine adjustments. Considering the muster representative for the 20% of the plant, a rough calculation would lead us to the following result:

\[
\begin{align*}
18 \text{ parts/day} \times 13 \text{ weeks} \times 5 \text{ days/week} &= 1170 \text{ parts} \\
1170 \text{ part} \times 7.16 \text{ €/part} &= 8375.12 \text{ €} \\
8375.12 \times 5 &= 41.876.36 \text{ €}
\end{align*}
\]

Total scrap in plant= 82,206,51€+41,876,36€=124.082,86€

\[\text{See B.1 in the Appendix}\]
2) Based on some employee’s feelings, the amount of the real scrap would be around twice the estimated value. That would lead to the following result:

\[ 82.206.51 \times 2 = 164.413,02 \text{ } \€ \]

If the cost of adjusting machines is added then,

\[ \text{Total scrap} = 164.413,02 \text{ } \€ + 41,876,36 \text{ } \€ = 206,289,37 \text{ } \€ \]

3) The third estimation would refer to the evaluation of the scrap. The value used so far (7,16 \text{ } \€/part) could be too high since it represents the average added value per part at the end of the manufacturing. If it is taken into account the fact that parts are scrapped along the manufacturing chain, the added value may vary. A possible arbitrary measure could be to count only 80% of the value.

Summarizing, the potential increase of cost would be:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Scrap value 100% [\€]</th>
<th>Increase [%]</th>
<th>Scrap value 80% [\€]</th>
<th>Increase [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>124.082,86</td>
<td>150,94</td>
<td>99.266,29</td>
<td>120,75</td>
</tr>
<tr>
<td>2)</td>
<td>206.289,37</td>
<td>250,94</td>
<td>165.031,50</td>
<td>200,75</td>
</tr>
</tbody>
</table>

Table 7.35. Possible scenarios regarding scraps in plant

As it is shown on Table 7.35, the scrap value could be definitely higher than expected. It is estimated that the current value could increase between 120-250%. As it is a significant margin of error, it can only be understood as a warning message, in order to pay more attention to this field.

Assembly

Cost of the test activity in the assembly could also differ from the calculated value. The used base calculation is labour hours. In the internal information software, it is stated that 23% of the total time is due to test activity, whereas, with regard to the manager’s opinion, this time could be around 33%⁹. Then, from the department cost, the appraisal cost would be,

\[ 0,33 \times 1.031.029,44 \text{ } \€ = 335.865,65 \text{ } \€ \]

⁹ See B.2 in the Appendix
and the increase,
\[
\Delta = \frac{335.865.65}{236.804.09} \cdot 100 = 141.63\%
\]

**Logistics**

Logistics costs are quite accurate despite the given general assumptions. The only point to highlight is the fact that exceptions such as special deliveries, express shipments, taxes, etc can boost the cost of transport and they have not been added.

Finally, the total cost of quality changes if the facts above described are given. The increase of cost when considering the most extreme case (double scrap amount at the highest value),

\[
\begin{align*}
\Delta \text{ scrap value} &= 206.289.37 - 82.206.51 = 124.082.86 \text{ €} \\
\Delta \text{ assembly cost} &= 335.865.65 - 236.804.09 = 98.823.44 \text{ €}
\end{align*}
\]

The total cost of quality would increase up to,

\[
\text{Total Cost of Quality} = 696.683.32 + 222.906.33 = 919.589.62 \text{ €}
\]

### 7.3.1.3. Hidden costs

The estimation of hidden costs based on the loss of profits due to unsatisfied customers, is approximately 104,432,764€. As it is a loss of profit, it is preferred to be accounted separately from the total cost of quality.

Nevertheless, in comparison with the estimated quality costs, the cost of customer dissatisfaction would be around 33% of the total cost of quality. In other words, it could increase the total cost of quality by 33%. Thus, customer dissatisfaction cannot be underestimated; it is a potential risk.

On the other hand, the estimated loss of profit comes from unsatisfied customers that may not buy again, but it would also be interesting to evaluate the number of potential customers that VOGEL could loose due to loss of image.
7.3.2. Cost distribution

The analysed data shows that cost of conformance is around 74% of total cost of quality, whereas failure costs represent only 26% (Table 7.36). According to the theoretical models, this distribution suggests that VOGEL runs a mature quality system, since conformance costs are much higher than non-conformance costs.

Following the classical view of cost distribution, VOGEL might be placed in the perfectionism area, where the total cost of quality would have already exceeded an optimum level. However, if cost categories are individually analyzed, a particular cost distribution is observed, which would not agree on the common theoretical distribution. Appraisal costs are, definitely, the largest category of expenditure (57,56%), and represent almost all conformance cost. Furthermore, almost 60% of the total appraisal cost is due to the test activity in the assembly (236.804,09 €/quarter).

<table>
<thead>
<tr>
<th>Cost [€]</th>
<th>Distribution [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conformance</td>
<td>511.252,30 74,06</td>
</tr>
<tr>
<td>Prevention</td>
<td>112.933,05 16,21</td>
</tr>
<tr>
<td>Appraisal</td>
<td>403.021,85 57,85</td>
</tr>
<tr>
<td>Non-Conformance</td>
<td>180.728,42 25,94</td>
</tr>
<tr>
<td>Internal</td>
<td>100.454,22 14,42</td>
</tr>
<tr>
<td>External</td>
<td>80.274,20 11,52</td>
</tr>
<tr>
<td>Total</td>
<td>691.980,72 100</td>
</tr>
</tbody>
</table>

Table 7.36. Quality cost distribution VOGEL 1°Q 2008

Actually, in mature quality systems most of their conformance cost is due to prevention activities, whereas this survey shows that VOGEL is focused on appraisal activities rather than in preventive actions.

On the other hand, despite the fact that failure costs are small compared to conformance costs, is it worthy to say that internal an external failure costs are similar. Again, referring to the theory, external failure cost in a mature quality system is much smaller than the internal failure ones.
Nevertheless, if previous considerations about possible scenarios are taken into account—increase of scrap cost and increase of appraisal cost in the assembly—, cost distribution may change. Note that, internal failure cost increases significantly up to 24 percent, although the difference between conformance and non-conformance costs is still important. It is worth to highlight the fact that appraisal cost would still remain over 50% of the total cost of quality.

<table>
<thead>
<tr>
<th></th>
<th>Cost [€]</th>
<th>Distribution [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conformance</td>
<td>614.778,34</td>
<td>66.85</td>
</tr>
<tr>
<td>Prevention</td>
<td>112.933,05</td>
<td>12.28</td>
</tr>
<tr>
<td>Appraisal</td>
<td>501.845,29</td>
<td>54.57</td>
</tr>
<tr>
<td>Non-Conformance</td>
<td>304.811,28</td>
<td>33.15</td>
</tr>
<tr>
<td>Internal</td>
<td>224.537,08</td>
<td>24.42</td>
</tr>
<tr>
<td>External</td>
<td>80.274,20</td>
<td>8.73</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>919.589,62</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 7.37. Possible quality cost distribution, 1st Q 2008.

To sum up, VOGEL’s general cost of quality distribution is likely to be characteristic of a mature quality system, which has an important expenditure in conformance costs and failure costs have been already reduced. Still, appraisal costs are much higher than prevention costs, which might not be that common for a mature quality system. Investments in order to conform to quality standards are an attempt to drive failure costs to minimum levels.

In case variations of cost calculation are included, the general picture remain almost the same but the internal failure costs become more than 24 percent of total cost, which might be determining to implement future measures in order to decrease them.

7.3.3. Evaluation of quality costs

Finally, and as a result of the previous analysis, it is possible to determine with certainty which expenditures should receive the highest priority for action by reporting the percentage over net sales. So next, for a turnover of 30,9 million € for the Berlin facility during the first quarter of 2008, quality cost are find to be:
Quality and non-Quality Costs.
Study case in Willy Vogel AG.

<table>
<thead>
<tr>
<th></th>
<th>Percentage over Sales (standard)</th>
<th>Percentage over Sales (possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevention</td>
<td>0,37</td>
<td>0,37</td>
</tr>
<tr>
<td>Appraisal</td>
<td>1,30</td>
<td>1,62</td>
</tr>
<tr>
<td>Internal Failure</td>
<td>0,33</td>
<td>0,73</td>
</tr>
<tr>
<td>External Failure</td>
<td>0,26</td>
<td>0,26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,25</strong></td>
<td><strong>2,98</strong></td>
</tr>
</tbody>
</table>

Table 7.38. Percentage over Sales, 1st Q 2008.

Note that the first column shows the percentage over sales using the documented data, whereas the second column pretends to make an approach to the possible scenarios previously described.

Appraisal costs are definitely the biggest cost contributor to the total cost of quality, followed by prevention cost, whereas the external failure category presents the lowest value. As analysed before, the elements that contribute to the appraisal cost are: the test activity carried out by the QA-Supplier and the QA-Intern department, and the test activity in the assembly. It is important to highlight that only the test activity in the assembly accounts for 60 percent of total appraisal costs.

Concerning the internal failure costs, the Pareto distribution (see Figure 7.9) shows that more than 80% of the total internal failure cost is due to the scrap production.
Percentage of net sales increases from 2.25% up to 2.98% when including rough estimations of possible scrap and appraisal value. Then, the index may vary 0.72 percent with regard to the standard calculation. In this case internal failure costs are the second largest expenditure.

Finally, it is important to keep in mind and not to underestimate the so mentioned cost of unsatisfied clients. In chapter 7.2.6, it has been intended to estimate the loss of turnover due to clients that would not buy VOGEL’s products again or would not recommend VOGEL like a business partner. However, estimations of these costs are uncertain, since customer behaviour is something difficult to prevent. One of the main goals of the quality organization in Willy Vogel AG is to deliver non-defective products and to reach the maximum customer satisfaction. Therefore, any effort towards prevention of poor quality is justified in order to avoid huge losses due to unsatisfied customers.
8. FUTURE DIRECTIONS

8.1. Improvement opportunities

Next, the three issues are discussed and deeply analysed in order to present possible measures for the improvement. This study pretends to point out the biggest problem areas based on the previous obtained results, so that, some future directions can be suggested. However, the study does not provide concrete surveys that justify or prove the suggested measures.

Scrap in the manufacturing

As discussed in chapter 7.2.4, after a survey carried out during 21.05.2008-4.06.2008, it was checked that neither the amount of reported scrap, nor its value were reliable. That means, there is no established and accurate procedure to collect and control the scrap in the manufacturing. Scraps are only evaluated and reported by the QA-Internal when parts do not conform to quality standards in the final quality control and cannot be used again. All the scraps produced within the manufacturing are not properly controlled and reported, which is definitively the issue to be treated and considered.

The advantages of reporting scraps are well known. Knowing exactly the scraps that occur in the plant, it does not only give information about the wasted money, but also it is a tool to improve productivity in the manufacturing. It is about an economic and a technical analysis. Some of the reasons that may attract an organization to implement a scrap controlling program are:

- Gain of cost transparency and cost effectiveness
- Fast identification of hidden manufacturing problems such as defects from suppliers, decentralization of processes, upset of machines or human errors.
- Failure analysis as preventive measure
- Process optimization
- Better use of resources
As seen above, scrap analysis needs to go further than a simple economic study; it must lead to figure out the causes for it.

In the VOGEL Company this issue is not well covered. Next, there is a list of some of the facts that lead to state that scraps are not properly analysed:

- Notification of scrap is not compulsory i.e. not all the real scrap is notified. Only defects that are considered relevant are notified to the production manager.
- Responsibilities for this duty are not assigned so that, corrective and preventive actions cannot be managed.
- Information collected through the internal software is incomplete and not trustful at all. For instance, there is not any option that allows the user to figure out the cost of a certain scrap.
- Any other method to notify the scraps is not reliable e.g. flow of material, since a lot of incongruities in the internal software were found.

Altogether leads to the necessity to design a framework for the collection and control of the scraps. The estimations made so far, show that the scrap production might not be so worrying because, even in the worst case, the cost of scraps represents around 0.6 percent of the net sales. However, it is not pretended to focus only on the scrap amount and on the wasted money, which is also very important. Actually, what it is intended is to point out the importance of improving a procedure which is half implemented.

Once the actual system has been analysed and the strengths and weaknesses are clear, it is possible to set up some actions. There are three fields to confront:

1. Commitment of all implicated parties
2. Means of data collection
3. Control and monitoring of scraps

The first step, and maybe the most important one, is to motivate all the employees in the manufacturing in order to make them aware about the importance of reporting scraps.
In this case, every manager of every working place (drilling, turning and grinding) should inform the workers that reporting scraps is strictly obligatory, even if scraps are due to human errors or due to machine adjustment.

Secondly, employees should be able to notify the failures as easy as possible. Fortunately, the software SAP allows to insert all necessary information; there is even a classification of 4 different kinds of scrap. The only thing that should be additionally included is the cost of the scrap. It would be possible to determine automatically the added value of a certain part just before scraping it. Therefore, Controlling should be linked and involved in the setting of this framework.

Finally, data must be controlled and tracked. A department should be assigned to manage this duty e.g. production controlling. QA-Internal could assign a quality engineer to analyse periodically the scrap produced and to work together with production. It would very useful to set priorities for the failures, so that for certain failures a bench test could be possible. Often, failures go ahead because no failure analyses have been made and it could be avoided through scrap analysis.

Furthermore, productions planners could easily check the flow of manufactured parts. A frame by plus/minus 10 percent could be set up, so that every time this frame is exceeded production planners send a warning to the production and ask for explanations. This 10 percent represents the variation of parts due to human errors in the accounting of parts, or because the material received does not reach to produce what was planned and vice versa.

**Appraisal activity**

The appraisal cost represents about 57 percent of the total cost of quality and about 1,3 percent of the net sales. It is the largest cost expenditure, and its major contributor is the test activity in the assembly. VOGEL’s policy is to prove at 100 percent all final aggregates. Thus, 23 percent of the time in the assembly is spent on testing.

It is true that appraisal activity in the assembly is responsible for avoiding defective products that may arrive to the hands of customers. Two means of reducing appraisal costs are possible: on one hand, simply reduce test activity in the assembly, on the other hand, increase prevention activities in order to decrease the appraisal ones.
In case test activity is reduced, some advantages and disadvantages must be discussed. The main advantage would be, of course, that appraisal costs would decrease. The capacity of the assembling would increase since time destined for testing would be now used for assembling. At the same time it would be possible to deliver more products and to satisfy the required demand.

However, what it is difficult to decide is how much should the test activity decrease without affecting too much the number of customer complaints. Up to a certain point, this balance could be profitable i.e. a certain number of customer complaints could be acceptable if it helps to reduce significantly the appraisal cost. The danger of this measure is the potential hidden cost of damaging the company’s image. As it was already discussed, the loss of a customer could boost the cost of quality, and the little savings achieved so far would rapidly disappear. A further study is required to evaluate the feasibility of this option e.g. a cost-profit analysis or a simulation using statistical tools.

The second option is probably less risky and matches the normal trend of a mature quality system. It consists of investing in prevention rather than in appraisal. Prevention is always cheaper. As failures are revealed through appraisal actions or customer complaints, they are examined for root causes and eliminated through corrective actions.

**Improvement of the Accounting system**

Despite the fact that it was not the intention to cover any other issues not quality-related, it is considered interesting to suggest other means of cost collection. Although quality costs can be identified and collected within the framework of any financial accounting system, one accounting method is particularly compatible with quality cost methodology and objectives—namely, Activity-Based Costing (ABC).

During the realization of this project, many problems have been encountered in order to find costs that at the beginning seemed to be clear. The problem was to evaluate failure costs since most of them laid buried and had to be revealed. Sometimes it was simple and straightforward because, for example, QA departments represent directly cost of appraisal, prevention, internal failure and external failure. But in other cases, costs had to be estimated through rough estimations due to the difficulty to extract the data.
The aim of Activity-Based Costing is to improve cost effectiveness through a focus on key cost elements. Quality cost methodology seeks to assign quality-related costs to specific activities, products, processes, or departments, so that these costs can be targeted for reduction. The use of ABC techniques can make it easier to find and assign these costs.

8.2. Quality cost program implementation

The survey has provided a general view of the quality and non-quality costs in the company VOGEL. Main quality costs have been identified, measured and also improvement opportunities have been suggested. Then, the next step is to set up a framework for the collection and control of quality costs, so that more than a static study, it can turn into a dynamic study. It is believed that using the existent tools within the company, the implementation of a quality cost program will not require much investment, but time and interest. Lector may think that time costs money, and that is right, however the investment is only at the beginning of the implementation, whereas the benefits are not restricted at any period of time.

The implementation of a quality cost program can be carried out in 4 stages:
1-Management presentation.
2-Quality cost education.
3-Internal procedure.
4-Quality cost collection and Analysis

1-Management presentation

Before undertaking any attempt to implement a quality cost program, management must be convinced of the value of the program and the use for which the system is intended. The implementation of the program requires an advocate and champion within the company. By VOGEL it is suggested that this person could be someone from the finance department, supported by the Quality Assurance and the Quality Management. It is very important to verify with factual costs that the quality program
can be beneficial to the company in order to attract management’s attention and interest. To accomplish this purpose this survey can be presented as an estimation of major costs and justification of the effort to implement the program.

2-Quality cost education

Once main quality costs have been identified, key members of each department, involved in the accounting of quality costs, should be educated in the concepts of a quality cost system. Every department should be given the opportunity to review the entire program as planned and see exactly where they fit. As they come to recognize the contributions or participation that will be expected of them, they can begin to evaluate the program’s benefits and impact on their individual departments. Department’s representatives should be encouraged to make suggestions from their expert point of view, and should be asked to list all those tasks or activities performed by their departments that can be considered quality costs.

Based on the survey, the following departments could be engaged to do so: manufacturing, assembly, purchasing, logistics, sales and even R&D, although for this study it has not been considered. Obviously, the accounting department must be strongly involved; otherwise the quality cost program cannot be successful.

3-Internal procedure.

The internal quality cost procedure is necessary to describe each element of quality cost to be used and to define how and when the actual cost data are to be estimated or collected, and assembled. Figure 8.1 describes the information flow among the different departments involved in the collection of quality costs according to the estimations done in the previous chapters.
Basically, different units involved in the accounting of quality costs collect the data and report it to the quality organization. As shown in the chart, every unit of the Quality Assurance is responsible for a certain area.

For example, the manufacturing and the assembly units are directly linked to the QA-Internal. That means, every scrap and rework must be collected by these two units and reported to the QA-Internal. Employees from QA-Internal should be able to check scraps and reworks through the internal software program (SAP). At the same time the QA-Internal must define and control the appraisal and preventive measures carried out in both assembly and manufacturing.

The purchasing department works together with the QA-Supplier unit since it is responsible for dealing with suppliers. As they are in charge of processing material rejections, they are able to report quality-related costs. This unit should estimate the cost of each rejected material in terms of logistic expenses and time expenses.

The logistics unit should be linked to the purchasing department, so that they provide them with all transport and packing cost due to defective purchased material.
In addition, logistics should also be responsible for reporting to QA-Service Centre all logistics costs due to customers’ complaints. This step requires special attention since, so far, there is not any procedure focused on reporting logistics costs.

Finally, the sales department should also be networked to the QA-Service Centre unit. As they are also responsible for dealing with customers, they should report the time wasted dealing with unsatisfied customers.

The three quality units must be networked and should check and contrast the collected data in order to avoid repeated costs. Therefore it is important to put all the information in common and to report it to the quality management. For sure, during the implementation of a quality cost program unexpected costs may arise and a new working procedure might be required.

4-Quality cost collection and Analysis

The internal quality costs procedure includes a complete system of costs elements, generated as discussed in section 2. These cost elements should be coded in a way that the costs of prevention, appraisal and internal and external failures could be easily distinguished and sorted.

As it was already mentioned in this survey, costs elements could be introduced by using the internal information program (SAP). For example, most of the failure notifications, created by the QA-Internal or the QA-Supplier, include already an option that enables the notification of costs such as: scrap, rework, transport, and pack. The problem is that this information is not further analysed, so that nobody reports it if it is not required.

It is suggested that the IT department develops a tool within the SAP in order to systematically collect properly the quality costs. Every cost element that appears in the different SAP transactions can be easily coded with the proper cost category. For instance, and following the definitions from chapter 7, all costs reported by purchasing, should be coded as internal failure costs. This way costs can be introduced without worrying about the cost category.
In case of logistics, it might be a little more complicated since they have to report to the Service Centre and to Purchasing, and sometimes even to Sales (in case of exports failures). For this reason it is important that these units pay special attention to the costs incurred in the logistics, and have to be responsible to fit them in their proper category i.e. purchase into internal failure, service centre and sales into external failure.

Moreover for the Service Centre an interface in the SAP should be developed in order to track quality costs for the claimed products. Internal logistic costs, external logistic costs and cost of repairs, should be altogether estimated.

Collection of quality cost labour becomes relatively easy with a system such as the one described. However, since labour costs in the quality organization can belong to more than a cost category, it is required to classify the employees according to their quality-related activity. In addition every quality department should be aware of their own expenditure.

With the system of collecting costs implemented, data can be analysed over a sufficient period of time, in conjunction with basic quality measurement data, to determine and verify current opportunities. The data is used to develop individual trend charts to describe the initial opportunity, the targets for improvement, and the actual process against the targets.

8.3. Use of quality cost

Next an example of the use of quality costs is given. It is intended to evaluate the supplier quality costs in order to rate supplier quality performance and compare it with the results obtained from the traditional rating systems based on quality tools e.g. use of ppm.

8.3.1. Supplier rating program using quality costs

Supplier quality costs, if tracked, can be significant and can be good indicators of problem areas. It is true that supplier quality costs include prevention cost elements, such as the cost of supplier quality surveys; appraisal cost elements, such as the costs of receiving and source inspection and failure cost elements, such the cost of returning nonconforming purchased material or the cost of scrap and rework of supplier-caused non-conformances.
However, the presented supplier rating program is basically focused on the failure costs i.e. all costs incurred by VOGEL when suppliers fail to conform to quality.

The suggested supplier rating system assesses supplier quality performance for each supplier, using an index based on the following equation:

\[
QCS = \frac{\text{Supplier Quality Cost} + \text{Purchased Cost}}{\text{Purchased Cost}}
\]  

(Eq. 8.1)

The method of interpreting the quality cost performance index to assess each supplier, sets different levels of quality. A perfect supplier would not have quality costs so its index would be equal to 1.000. The actual assessment used for this survey is:

<table>
<thead>
<tr>
<th>Index (QCS)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000-1.009</td>
<td>Excellent (A)</td>
</tr>
<tr>
<td>1.010-1.039</td>
<td>Good (B)</td>
</tr>
<tr>
<td>1.040-1.069</td>
<td>Fair (C)</td>
</tr>
<tr>
<td>1.070-1.099</td>
<td>Poor (D)</td>
</tr>
<tr>
<td>1.100+</td>
<td>Corrective action required (E)</td>
</tr>
</tbody>
</table>

Table 8.1. Interpretation of index QCS

It is not pretended to include all quality costs because of the administrative problems involved. Thus, the most important costs are identified.

**Internal logistic cost.** These costs are the same as in chapter 7.2.5. They include the cost of delivery, in case of a customer claim, cost of stock and release from storehouse and the cost of packing. Costs vary depending on where the failure is identified – incoming goods, manufacturing, montage or customer-.
Internal logistic cost per delivery

<table>
<thead>
<tr>
<th></th>
<th>€/delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incoming goods</td>
<td>0</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>3,37</td>
</tr>
<tr>
<td>Assembly</td>
<td>3,37</td>
</tr>
<tr>
<td>Customer</td>
<td>21,5</td>
</tr>
</tbody>
</table>

Table 8.2. Internal logistic cost per delivery

From Table 8.2, note that defects detected in the incoming goods do not have any internal cost, whereas in the manufacturing and in the assembly material has already been stored and released from the storehouse at least once. The highest cost occurs when the defective material is found by the customer, then additional packing and transport cost must be estimated. All costs are estimated per delivery.

**Shipment cost.** Shipment costs include transport cost and packing cost when material must be sent back to the supplier. Although it is a cost that the supplier will afterwards pay for, as it is firstly incurred by VOGEL, it is accounted as expenditure. From Figure 7.6, transport cost and packing cost are estimated to be 15€/delivery.

**Complaint investigation.** The cost of complaint investigation is the time needed to process complaints, either from the factory i.e. internal complaints, or from customers. In case of internal complaints i.e. defects from the incoming goods, manufacturing and assembly, the QA-Supplier is in charge of reporting the complaint. This cost has been estimated in chapter 7.2.4, as a cost of 1981,32 €. If there were 134 complaints during the first quarter of 2008, then a rough estimation of the cost per complaint would be:

\[
\frac{1981,32}{134} = 14,79 \text{ €/complaint}
\]

In a likely manner, in case of external complaints, the QA-Service Centre is in charge of processing the complaint, although afterwards, as a supplier defect, the QA-Supplier will have to report it anyway. Then if the cost of technical complaints was 18.087,70€, and there were 105 complaints:

\[
\frac{18.087,70}{105} = 172,26 \text{ €/complaint}
\]
Cost of rejecting the purchased material. Because this company had estimated 51€ the cost of rejecting purchased material, this cost has been used for this study.

Cost of scraps and reworks. Defective products can be either reworked or scrapped. Normally, the best solution is to deliver the defective product back to the supplier, but when the schedule is tight it might be faster to rework it. It can also happen that the purchased material is not usable any more, and then it must be scrapped. If responsibilities are clear, the cost can be assigned to the supplier, if not VOGEL must pay for it. Due to the difficulty to figure it out, it has been considered a cost for the company.

Next figure shows the 8.3 suppliers, which have been evaluated, and the number of claims during the first quarter of 2008 spread on the place where the defect was found.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Incoming goods</th>
<th>Manufacturing</th>
<th>Assembly</th>
<th>Customer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stängerle</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Camozzi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nidec</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>DP pumps</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>HEW</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Preuss</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Bauer</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Steinco</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>WOO</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 8.3. Number and origin of claimed lots

Supplier quality costs can be estimated by estimating the cost of each rejected lot of material. A ranking of suppliers by quality cost performance index follows.

10 see chapter 7.2.5
Quality and non-Quality Costs.
Study case in Willy Vogel AG.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Supplier quality cost [€]</th>
<th>Purchased cost [€]</th>
<th>Index CQS</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stängle</td>
<td>868.69</td>
<td>101.261,83</td>
<td>1,009</td>
<td>A</td>
</tr>
<tr>
<td>Camozzi</td>
<td>0.00</td>
<td>146.002,64</td>
<td>1,000</td>
<td>A</td>
</tr>
<tr>
<td>Nidec</td>
<td>296,05</td>
<td>39.963,00</td>
<td>1,007</td>
<td>A</td>
</tr>
<tr>
<td>DP pumps</td>
<td>343,31</td>
<td>74.539,28</td>
<td>1,005</td>
<td>A</td>
</tr>
<tr>
<td>HEW</td>
<td>676,26</td>
<td>246.065,53</td>
<td>1,003</td>
<td>A</td>
</tr>
<tr>
<td>Preuss</td>
<td>414,04</td>
<td>116419,09</td>
<td>1,004</td>
<td>A</td>
</tr>
<tr>
<td>Bauer</td>
<td>323,14</td>
<td>80.669,37</td>
<td>1,004</td>
<td>A</td>
</tr>
<tr>
<td>Steinco</td>
<td>242,36</td>
<td>5268,14</td>
<td>1,046</td>
<td>C</td>
</tr>
<tr>
<td>WOONAM</td>
<td>703,35</td>
<td>51.575,69</td>
<td>1,014</td>
<td>B</td>
</tr>
</tbody>
</table>

Table 8.4. Example of supplier quality rating.

From the assessment, it is worth to highlight that almost all suppliers offer an excellent performance. The supplier ‘Steinco’ is the one who has been worst rated followed by WOONAM, and ‘Stängle’ is just on the limit to turn to ‘B’ class. These results would encourage the company to focus on the performance of Steinco, as well as to control WOONAM and Stängle.

8.3.2. Actual rating system

The VOGEL Company has developed a method to assess the supplier’s performance by analysing the number of complained lots with the total delivered lots. The formula used is:

\[
QZV = 100 - \left( \frac{X}{G} \cdot 100 \right)
\]  

(Eq. 8.2)

\(X=\) Claimed lots  
\(G=\) Delivered lots

According to the result obtained using Eq. 8.1, suppliers are classified into three quality levels:
A → 95<QZV<100 Excellent  
B → 90<QZV<95 Good  
C → QZV<90 Fair

Using this assessment the ranking of suppliers follows.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Delivered lots</th>
<th>Claimed lots</th>
<th>QZV</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stängle</td>
<td>282</td>
<td>8</td>
<td>97,16</td>
<td>A</td>
</tr>
<tr>
<td>Camozzi</td>
<td>43</td>
<td>0</td>
<td>100</td>
<td>A</td>
</tr>
<tr>
<td>Nidec</td>
<td>10</td>
<td>1</td>
<td>90</td>
<td>B</td>
</tr>
<tr>
<td>DP pumps</td>
<td>56</td>
<td>3</td>
<td>94,64</td>
<td>B</td>
</tr>
<tr>
<td>HEW</td>
<td>369</td>
<td>3</td>
<td>99,21</td>
<td>A</td>
</tr>
<tr>
<td>Preuss</td>
<td>227</td>
<td>5</td>
<td>97,79</td>
<td>A</td>
</tr>
<tr>
<td>Bauer</td>
<td>421</td>
<td>4</td>
<td>99,05</td>
<td>A</td>
</tr>
<tr>
<td>Steinco</td>
<td>31</td>
<td>3</td>
<td>90,32</td>
<td>B</td>
</tr>
<tr>
<td>WOONAM</td>
<td>56</td>
<td>3</td>
<td>94,6</td>
<td>B</td>
</tr>
</tbody>
</table>

Table 8.5. Assessment using index QZV

In this case all suppliers are placed between A and B, but there are two of them that are about to turn to C –Nidec and Steinco-. Nidec and DP-pumps appear to be worse rated than with the other system.

8.3.3. Comparison of both methods

If both rating systems are compared, the differences are not really significant. On one hand both models agree on having a high level of supplier performance. On the other hand, both of them agree on the fact that ‘Steinco’ and ‘WOONA’ have some difficulties with the quality of the deliveries.

The method already used by Willy Vogel AG is apparently stricter. The reason may be the criterion used to establish the quality levels. The three quality levels defined using the formula QVZ, are set under the experience that the company has, dealing with suppliers, whereas the criterion used to rate quality costs is rather arbitrary.
Both criterions can be adjusted according to the necessities of the company. Is it clear, though, that both systems are comparable and at the same time they can be complementary.

The main difference is the fact that using quality costs as rating parameters, gives more tools to the company to deal with suppliers. Money is a more understandable and powerful language when making business.
CONCLUSIONS

First of all, this study concludes that Willy Vogel AG has presented a low Total Cost of Quality during the first quarter of 2008 (2.5% over net sales) in comparison to recent benchmarks in the manufacturing sector. The long experience in quality management and quality assurance might explain this fact. On the other hand, it is important to take into account that comparisons with others might be meaningless since variations in the application of quality costs, in the business itself, in accounting systems, an in overall performance, make each company unique.

The survey has provided a general picture of the Cost of Quality, but also has identified two problem areas to focus on: a disproportioned expenditure for the appraisal activities and the scrap amount in the manufacturing.

According to the theoretical models, the distribution of the cost presented in Vogel, shows that the company runs a mature quality system where cost of conformance (74% of total COQ) is much higher than failure costs (26% of total COQ). Nevertheless, in mature quality systems most of their conformance cost is due to prevention activities, whereas Willy Vogel AG is focused on appraisal activities rather than in preventive actions. The appraisal cost is the largest cost expenditure, and its major contributor is the test activity in the assembly. Two means of cost reduction are suggested: either to reduce the test activity in the assembly ensuring that customer complaints do not increase, or investing in prevention activities in order to decrease the appraisal ones. Both measures need to be further developed and discussed in order to achieve a feasible solution.

The second issue pointed out in the survey is the scrap production in the manufacturing. It is observed and checked that the scrap amount is not properly controlled and reported. As a result, this study cannot provide a reliable value of the internal failure cost. Estimations of different scenarios regarding the scrap amount and its cost show that the Total Cost of Quality over net sales would not increase dramatically. However, although the final result is optimistic, it is absolutely required to cover this issue. By reporting and controlling properly the scrap production, the company gain cost transparency, improve productivity, use resources in a more responsible way and optimize processes.
Therefore, it is suggested a more efficient use of the internal software (SAP) for a detailed report of the scraps, more commitment in the production department, and new responsibilities to carry out this task are also suggested.

Moreover, the study emphasizes the importance of intangible costs i.e. hidden costs. It has been intended to estimate the loss of turnover due to the customer dissatisfaction. As a result, the classic model of optimum can be argued, since it assumes a certain level of defects to achieve the minimum level of quality cost, without considering the economic effect of hidden costs that may boost the total cost of quality.

To conclude, despite the fact that the quality organization covers almost all the issues that are identified and pointed out through the monetary language of a quality cost program, a quality cost analyse gives another perspective, helps to identify and confirm problem areas and highlights opportunities for cost improvement.
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