Impact of Quality Management in the Swedish Construction Process

Anne Landin
To my sons

“Sunny” my sunshine Alexander
“Honey” my sweetness Johannes
“Lou Lou” my pleasure Julius

for being my great family
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Abstract

Background
During the past few years, extensive work has been done in order to develop quality system as an integral part of the process in the construction sector. The construction process is complex, since many different actors with different interests are involved.

The demand for quality assurance comes primarily from the central authorities via the client and quality systems should be applied in the whole chain of all actors involved in the process. The aim of this study was to investigate how the concept of quality management is adopted in the construction process and the impact it has.

Method
The work associated with quality was studied in several companies and these companies were chosen from different categories in order to cover the whole construction process. Companies representing clients, architectural/engineering-companies as well as different types of contractors were studied.

The main methods used in this thesis was collection of data by interviews and then sort these data into the same system as the ISO 9001 standard, and to use key-factors. By this method it was possible to search for patterns that could describe the general activities associated with quality management in the construction process.
Results
The results of these studies show that quality management appears to be considered primarily as a means of increasing effectiveness and enhancing competitive advantage. Beside this the outside demand from the customer requiring quality systems may be another force that initiate companies implementation of quality management.

It was shown that the most common way to initiate quality systems was by inspections, probably due to client requirements. Extensive systems for inspections were by most companies regarded as one of the major elements in the work associated with quality systems. These inspections were in many cases found to be rather meaningless because the companies had problems in finding resources for this type of work.

However, over time, it was found that the degree of acceptance to the use of the ISO 9001 standard gradually increased. The various parts of the ISO 9001 standard were by the companies not regarded as equally important and were therefore not used to the same extent. Some requirements of the standard tended to be confused with one another or to be misinterpreted.

In conclusion, quality systems based on the ISO 9001 standard in the construction sector is used with varying degree and the acceptance of the standard is increasing. The connection between the integration of these quality systems in the process and the use of this as a base for innovation and learning in the further development of the construction sector is neglected and has to be considered in the future.
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1 Introduction

This thesis is concerned with work on quality systems in the Swedish construction sector. The aim is to examine and analyze the implementation of a new management strategy into the construction process and to identify the positive measurable impacts of it.

In this chapter, I will describe the background of the studies in this thesis. The term “quality” often causes confusion and therefore I would like to start with a clarifying discussion about quality and why it is interesting in the Swedish construction industry. Some of the special circumstances in the Swedish construction industry are also discussed.

1.1 Background

Quality has become an increasingly important means of competition on the world market and has become a strategic weapon in the fight for market shares and improved profitability (Bergman & Klefsjö, 1994). During the past few years, work on quality management within the building sector has developed considerably. Many companies have gone to great effort to introduce the use of a quality system as an integral part of construction management. Several companies in the construction sector have chosen to structure their quality systems in accordance with the standards contained in the ISO 9000 series. Since 1995, authorities in Sweden have required that companies in the construction sector that bear responsibility for a construction
project have certain knowledge of ISO 9001. This has contributed to companies in that sector being concerned with the use of a quality system generally. The law concerning public competition for contractors, together with membership of the EU, has also contributed to companies preparing themselves for competition within a larger market than heretofore, a market in which customers may increasingly require suppliers to employ a quality system. Clients are demanding quality, consultants are preaching it, and construction firms are still struggling with it.

Historically, construction is an industry reluctant to change, but is now trying to catch up with the Total Quality Management revolution that has already transformed many other businesses (Schriener, 1995). The construction industry has made little progress in reducing the cost of building houses or improving their quality, while the quality and reliability of products produced by manufacturing industries have increased steadily. The cost of building houses today is little different, in real terms, from what it was two generations ago, and defects occur just as often as they ever did (Miles, 1996). This struggle with the concept of quality in the construction process is the background of this thesis.

What is quality?
In an ordinary dictionary the word “quality” is described as: Degree of excellence, the relative nature or kind of a thing; type; brand

and a “quality product” is described as: a superior article, a high-class article

These definitions indicate that quality is connected with type and excellence. In popular usage the word “quality” often means different things to different people. These different usages create considerable confusion and misunderstanding. Two such usages are “conformance to requirements” (Crosby, 1979) and “degree of excellence”. The first leads
people to argue that “quality costs less” and the second, conversely, implies that “quality costs more”. In this thesis the word “quality” is used in accordance with the standard of “ISO 8402 Quality management and quality assurance – Vocabulary” because this is the only definition that is internationally accepted and it is also the definition that is used when quality systems are adopted. In this international standard quality is defined as:

The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs.

The Swedish Construction Sector
The context in this thesis is the Swedish construction sector and as there are some special aspects that should be considered when trying to understand the research area the construction sector in Sweden is described here in general. Construction is one of Sweden's largest industries and contributes significantly to national prosperity. The following facts have been taken from the Swedish Institute (SI Home Page, 1999). During 1997, actual construction work employed about 220,000 people. Roughly the same number worked in related fields such as production and shipment of building materials, consulting and property management. The construction industry thus provided jobs, directly or indirectly, for some 450,000 people. This represented about one ninth of the Swedish labour force. The sizes of the different construction areas in Sweden are illustrated in Table 1.
### Total construction in Sweden, (1997)

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renovation, repairs and maintenance</td>
<td>53%</td>
</tr>
<tr>
<td>New dwellings</td>
<td>6%</td>
</tr>
<tr>
<td>Other types of buildings</td>
<td>18%</td>
</tr>
<tr>
<td>Industrial facilities</td>
<td>5%</td>
</tr>
<tr>
<td>Civil engineering projects</td>
<td>19%</td>
</tr>
</tbody>
</table>

Table 1. Sizes of the different construction areas in Sweden.

During the 1960s and the early 1970s, the construction industry enjoyed a boom, the main reasons for this rapid expansion were the demand created by urbanization, a widespread desire for improved housing standards, and the preferential treatment given to housing construction on the capital market. In this era of construction history many defects occurred because of the high tempo at construction sites.

During the latter half of the 1970s and the early 1980s the construction industry decreased successively in size. However, in the mid-80s the demand for dwelling units started to grow and during the latter half of the 1980s, construction increased considerably, reaching a peak in 1990.

The number of civil engineering projects has also declined during the last decade. Over the past twenty years investments have tailed off, one consequence of which has been a deterioration in the road and rail networks. In 1991, there was a downturn in industry, and the total construction volume fell by nearly 25% up until 1994. Most construction materials used in Swedish projects are supplied by domestic manufacturers and about 25% is imported. The wages of building workers are regulated by collectively negotiated wage scales which apply to the whole country. On average, 60% of all work is carried out at piece rates by teams of between five and 25 workers. Average hourly earnings are somewhat higher than in other industries.

### The Effects of the Climate

Because of the relatively long and cold winter in Sweden, it has been found economical to invest in the special facilities...
needed to ensure the required building quality even under conditions of cold, snow and darkness. Steam is used to rid moulds and reinforcements of snow. Concrete is delivered warm to the site with additives which accelerate hardening. Window openings are covered, the newly-cast concrete is insulated, and driers are used to attain the required hardening temperature for the concrete.

Techniques at the Construction Site
Over the years, techniques for the construction of buildings have become increasingly mechanized, and cranes, hoists, pumps, air compressors, high-pressure steam generators, hand-held power tools and other labour-saving devices have become standard equipment at every building site.

Prefabricated units are being used to a greater extent although prefabrication could be used considerably more (Söderberg, 1996). Installation of prefabricated units at the building site requires no more than simple assembly work. Stairways, refuse chutes, kitchen fittings, walls and floors can be taken from ready-made stocks, and large, “tailor-made” framing members are often produced in factories owned by the contractors. Virtually all conventional materials now come as prefabs, in the form of reinforced brick slabs, reconstituted wood, prestressed concrete, etc. Specially prepared steel is increasingly used in reinforcement.

Manpower is also used more efficiently. Since 1960, the working time per cubic metre of building volume has been reduced by more than 30%. Developments on the materials side have proceeded along several fronts: improved quality; a broader range of products; growing emphasis on synthetics; greater consideration for the environmental setting of materials; and more comprehensive, uniform specifications with standardized testing methods to facilitate choice of the right material at the right place.

Technological advances have also surged ahead in civil engineering. Mechanization is proceeding apace, and has become especially pronounced in earth excavation and road building.
1.2 Problem Statement
The research problem in this thesis is to analyze the construction sector’s activities regarding quality by using existing management models. The area examined and the theoretical base for the thesis consist of the theory of quality management, particularly the part of quality management concerning quality systems and the standard ISO 9001, see Figure 1. The empirical area is the construction process in Sweden. Since substantive theory is grounded in research on one particular substantive area it might be taken to apply only to that specific area. The term grounded is borrowed from Glaser and Strauss’ terminology and implies studies that are empirically based instead of being purely theoretically deduced studies. A theory at such conceptual level may, however, have important general implications and relevance (Glaser & Strauss, 1967).

Figure 1. The area examined in the thesis.

The area examined in the thesis is a problem-oriented field and it has been examined from four different aspects over time. The first aspect studied was early work on quality
among specialist contractors, and the second was implemented work following the standard of ISO 9001. Articles III and IV focused on the construction process and the implemented work on quality according to the standard, as well as the impact of quality management in general.

1.3 Structure and Purposes
The present publication summarizes a number of years of studies related to activities associated with quality management in the Swedish construction sector. This thesis includes a summary, and four articles appended in full. The structure of the summary is briefly described below:

Thesis Structure

Summary

Introduction
As a general background to the thesis the concept of Quality is explained and the Swedish Construction Sector is briefly described. The area examined and the problem are presented, as well as the theoretical basis of the thesis.

The overall purpose of the study is described. The research problem is presented together with the aim of the studies.

Research Approach
In this chapter, the methodology used for this type of research is discussed on an overall level with connections to the methods used in the four articles. The methods used and the research approach are discussed because different kinds of methods have been used and there are some difficulties related to these kinds of studies when quantitative methods are insufficient for the purpose.

Quality Management
In this chapter, the area of quality management is discussed from different points of view. The terms
Quality Management and Total Quality Management are used as starting points for the discussion.

Construction Process
Here, a short description of the Swedish construction process is given and some visions of the future process are presented. The construction process is described with regard to the special phenomenon that has to be considered when trying to implement quality management in such a process.

Quality Management in the Construction Process
In this chapter, quality management in the construction process is elucidated in connection with the research results from an international perspective.

Conclusions
The conclusions from the research projects are discussed and these are used to generate new problem statements that would be relevant in future research.

References

Articles
This thesis is based on the following articles, which will be referred to in the text by their Roman numerals:


IV Landin A, Nilsson C-H, Does Quality Systems Really Make a Difference, Building Research and Information, accepted for publication, 2000

In article II Mats Persson, M. Sc., Construction Management, Lund Institute of Technology, Lund University, contributed to the interviews and the analysis of the data.
In article IV C-H Nilsson, PhD, Assistant Professor, Institute of Economic Research, Lund University contributed to the analysis of the data and the use of the balanced scorecard.

All of the articles focus on quality management systems within the construction process. The overall purpose of this study was to investigate how the concept of quality management is adopted in the construction process and the impact it has. The studies in the separate articles (I-IV) of this thesis were carried out with the following specific aims:

I To describe the work that has been done to introduce quality management among specialist contractors in Sweden,

II To examine two categories of specialist contractors and the introduction of quality systems by them,

III To analyse how the ISO 9000 framework could be employed in the Swedish building process,

IV To ascertain whether companies in the Swedish construction process measure the impact of a quality system and, if so, whether the balanced scorecard is a useful technique as a measure of performance.
2 Research Approach

“Methodology is a difficult subject. There is no easy way out.” (Bjerke, 1981)

The purpose of this chapter is to present the research design and the methodological considerations of the studies included in this thesis.

2.1 Methods

A research method is a tool used to search for and gain new knowledge. In a research context there are many tools to choose between, and all of them have their advantages and disadvantages. During the research for this thesis, I have used different methodological approaches. The overall purpose of the studies is to investigate how the concept of quality management is being adopted in the Swedish construction process and the impact it is having. It is important to take the holistic point of view in these types of studies because an understanding of the quality implementation in each company has to be gained. Quality management is a rather new activity in the construction process, and all the companies studied had their own specific way of treating the implementation of the system because the requirements in the standard are expressed from a general point of view.

The systems approach proved to be useful when trying to describe the activities associated with quality in the construction process because this area of research is a problem-oriented field. An analytical approach requires an existing theory and the aim is to verify or falsify hypothesis
that does not contribute to the understanding of the studied phenomenon. The systems approach tries to explain the parts from the whole. The scientific intentions when using the systems approach can be divided into:

- describing
- determining connections
- forecasting
- guiding

The systems approach is common within business management research. It is necessary to use more qualitative than quantitative techniques to interact and try to understand instead of a passive study of reality. It is also important to adopt a holistic point of view instead of an atomistic one (Bjerke, 1981). The aim was to describe and examine an unknown research area and therefore an explorative approach was useful. The purpose of an explorative study is to explore an area which is new or unknown. An explorative survey can be carried out to generate interesting problems for future research, as well as an introduction to a survey can be made to test some chosen hypotheses. The aim of an explorative study is not to collect a specific kind of data for generalisation. The purpose is to collect as much information as possible within a certain problem area to gain an understanding.

The techniques most useful in explorative studies are interviews and observations (Patel, 1987). Case studies are often regarded as explorative (Patel, 1987) and a case studies approach is especially appropriate in new topic areas (Eisenhardt, 1989). The implementation of quality systems in the construction process is such an area. The methodological considerations of the studies in this thesis have a great deal in common with the research approach in case studies. It is typical for case studies to combine data collection from different sources such as interviews, questionnaires and observations. The collected data can be qualitative or quantitative or a combination of both. A case study is an empirical enquiry that investigates a contemporary phenomenon within its context (Yin, 1994).
Case studies can be used to accomplish various aims (Eisenhardt, 1989):
1. To provide a description,
2. To test a theory,
3. To generate a theory.

In this thesis case studies have been used to provide descriptions and to generate a theory. Theory-building research starts as close as possible to the ideal of no theory under consideration and no hypotheses to test because predetermined theoretical perspectives may bias and limit the findings. For instance, in article I, the quality activities of specialist contractors is described. This is done without any fixed paradigm in advance.

The selection of cases to study is, of course, important in case studies. How the cases are selected depends on the specific research question. Cases may be selected at random, although this is neither necessary nor preferable, but there is one advantage and that is that multiple cases allow findings to be replicated. Cases can also be chosen to replicate previous cases or extend emergent theory. Finally, cases may be chosen to suit theoretical categories. In the four studies, I have selected the companies in accordance with the three aspects mentioned above.

2.2 Data

When data are to be collected for research purposes, there are two main methodological approaches to choose between: qualitative methods and quantitative methods. The choice depends on the type of problem to be investigated. It would have been preferable to collect quantitative data that could show measurable results of the impact of quality management. However, the aim of the study was also to examine and describe the problem area within the chosen categories, which is better done with the help of qualitative data. All the studies described in this thesis show that the companies were unable to present any quantitative data, which is an interesting result in itself. The studies that were
performed were not predetermined to be qualitative because the objective was to explain the implementation of quality management in the construction sector by using existing management theories. It was, of course, tempting to try to measure the impact of introducing quality management but initially it was necessary to explain what the work on quality consisted of to gain an understanding of the area.

Qualitative studies primarily have the aim of gaining an understanding and not the ambition to test the general validity of a theory. The central mission is to gain a deep understanding of the complex problem area that is being studied by the collection of data. The central issue is, rather, to gain a deeper understanding of the problem being studied through the collection of data while, at the same time providing better conditions with which to describe the whole context in which the problem is found. Quantitative methods are more formalised and structured, and the methods are characterised by the scientist. The data of interest are predefined based on the problem chosen for study, and this dictated which answers were conceivable. This is necessary in order to be able to carry out a formal analysis and to put the results obtained to the test. Statistical methods play a central role in the analysis of the quantitative information.

2.3 The Research Process in this Thesis

Literature has been examined to gain a deeper insight into the area of research. It is important to discuss similar results because it gives a stronger validity to the findings and it makes it possible to reach a higher conceptual level.

The research design employed in this thesis can be illustrated as an amount of qualitative data from a number of explorative case studies on which a holistic point of view has been used when describing the results by the systems approach, see Figure 2.
The construction process is a complex process in which many different actors are involved. The demand for quality assurance comes primarily from the central authorities via the client. These demands are then transmitted by the customer-supplier chain to all of the actors involved. The subcontractors find themselves at the end of the chain, see Figure 3, and this was the reason for choosing this group of contractors for the first investigation (Article I). The companies were selected so that they covered a wide spectrum of specialist contractors who normally work as subcontractors during the production stage. In each category the companies were selected at random. This method provided a description of the work associated with quality management at the end of the chain in the construction process.
The requirement for quality assurance starts with the authorities and is transmitted through the process to the sub-contractors.

The term “specialist contractor”, traditionally referred to in Sweden as a “sub-contractor”, was used to denote a contractor who is not a building or construction contractor. Although it is often a building contractor who engages a specialist contractor for a job, in which case the term “sub-contractor” is appropriate enough in referring to the latter, this need not be the case. The interviews were carried out by telephone and they took about an hour each. In the interviews, I asked for a detailed description of the quality demands from clients or others and the work done to implement quality management. The rest of the interview was open, in the sense that I tried to discover the attitude to, and aims of, quality management. Documents related to quality management were also studied when possible. The result was a description of specialist contractors’ approach to quality management in Sweden (Article I).
The next study (Article II) was based on the results of the first in that I continued to investigate those categories of subcontractors which had come furthest in their quality systems. The sectors chosen were electrical contractors, and contractors for plumbing, heating and ventilation. Three companies were chosen from each of these two categories, from among the companies that had participated in the first study. The data collected from each company were more accurately defined and directed towards the systematics employed in the ISO 9001 standard. In order to obtain greater validity in the analysis, I worked together with a colleague, as this gives more shades of meaning and points of view on the same data. With the aid of the structure in ISO 9001, it was possible to set up profiles for the companies and see a general pattern. The method of data collection encouraged the company to provide quantitative data, but it was found here, as in the first study, that quality systems had not been implemented such that it was possible to trace their effects.

In article II rating variables were used. Rating variables tend to be subjective but can still provide much information. If we find the rating variables to be moving in a positive direction with time, we can conclude that there has been a positive change. The measurements will be meaningful only if made over a relatively long period of time. It takes a large number of ratings to compensate for individual variations in the assignment of quantitative scores to qualitative factors. Because design projects take many months, it will take time to obtain enough ratings from enough different customers to evaluate trends. Also, quality systems change with time, and there is thus no point in “taking a photograph” with a long exposure time as changes will have taken place before the exposure is complete.

This was one of the reasons for keeping the survey short. None of the studies has, for example, followed a project from start to finish because I wanted to avoid respondents who simply gave the same answer in different ways, and the aim was not to produce statistical data correlated to certain
projects. I expected, and received, answers showing insight and some critical thoughts from the respondents.

In the ensuing studies (Articles III and IV) three companies were chosen from each category in order to cover the whole construction process, see Figure 4. Twelve companies with well-established quality systems were studied. In Articles III and IV the companies selected were ones which two experts, Lars Björkman and Lars Ranhem, deemed to be at the forefront of developments. Both have a thorough knowledge of the Swedish building industry and extensive contacts within it. The companies were selected so as to encompass various quality systems used within the construction process, and the companies were judged to be at the forefront of quality management with considerable and long experience of the Swedish construction industry. We looked for people who welcomed change, had a history of success, and were open to training in personal skills. The criteria for the selection of the companies was:
- they must have had a quality system in place for at least three years,
- the quality system should be adopted to the standard of ISO 9000,
- they should have a genuine interest in quality issues, as evidenced by, e.g. active participation in conferences or debates,
- they should be able to produce a quality plan for a project.

Three team members, with widely varying experience of the construction industry, carried out interviews to collect data via the questionnaires. All three of the team members were present at each interview. The project was limited to companies in Sweden within the construction sector, and among the companies, three clients, three architectural/engineering businesses, and six contractors were represented, see Figure 4.

Complementary insight between team members add to the richness of the data and the convergence of observations.
from multiple investigators enhances confidence in the findings (Eisenhardt, 1989).

![Diagram of Construction process]

The interviews with open questions provided qualitative data because the respondents could not provide any quantitative data. It appeared that the implementation of quality management in the construction process was not organized in a way that allowed quantitative measurements, which was confirmed later in the research process. In Article II the cases were selected from categories chosen to gain a deeper understanding of the systematic work involved in quality management. The companies were not selected at random because it was important to choose companies that used as much as possible of the system defined in ISO 9001. Finally, in Articles III and IV categories were selected so as to cover the construction process and the companies were selected so that they fulfilled the required demands.

Analyzing the data is the most difficult part of the process. It is important to be familiar with each case and the detailed protocols from each case are valuable in gaining an understanding. The difficulty is that there is such a great volume of data that it is difficult to sort it out in a way that is easy to follow. The method used most in this thesis is to sort data into the same system as ISO 9001 and to use key factors. The aim of this method was to search for patterns that could describe the activities associated with quality.
management in the construction process in a general way, and to make it possible to develop theory for research in the area.
3 Quality Management

In this chapter the area of quality management is penetrated. The terms “Quality Management” and “Total Quality Management” will be used as starting points for the presentation. Thereafter, attention will be focused on the ISO 9001 standard, which is an international standard for quality systems. Finally, the issue of audits will be discussed.

3.1 Quality Management and Terms Related to it

“Quality management” includes both “quality control” and “quality assurance”, as well as the additional concepts of “quality policy”, “quality planning” and “quality improvement”. “Quality management” operates throughout the quality system (ISO 8402). Total quality management (TQM) is a term often used by researchers and it will therefore be discussed here as it is closely related to quality management. TQM has become one of the buzzwords of the 1990s. It is a term that has been used so widely that it means different things to different people. Focusing on customer expectations and needs is a key element of TQM. The theory that "if the customer is happy, your business will prosper", has been around for a long time. It has been applied with a large measure of success to many, diverse organizations (McKim, 1995). Quality management involves a continuous search for ways to prevent defects by “doing the job right”. Quality management is concerned with preventing problems by creating the attitudes and environment that make
prevention possible. One of management's likely questions is, "Can we afford the cost of TQM?". The answer is that it is not quality that is expensive, but rather non-conformance to quality. The cost of quality becomes very reasonable when compared with the cost of not achieving quality.

Unfortunately, people are familiar with the cost of not achieving quality and accept it, so there may be some resistance to the new, readily identifiable cost of TQM. The management must have a long-term commitment to quality assurance and continued improvement if any gain is to be made.

Applying TQM often requires new perspectives on existing practices. Normal contractual relationships between clients, contractors, sub-contractors, and suppliers, regardless of the industry, often create an adversarial atmosphere in the work environment. Traditional working relationships promote attitudes such as, "I will only do exactly what the contract says", and "I will get away with whatever I can", between partners (McKim, 1995). In TQM, business relationships are a series of transactions between customers and suppliers. A customer takes a product from a supplier, performs some value-added function to the product, and then provides the transformed product to another customer, thereby becoming a supplier. All organizations are thus both suppliers and customers. From a TQM viewpoint, this is a series of supplier/customer transactions in which the customer of one transaction becomes the supplier of the next transaction. If all suppliers are "keeping their customers happy" the process is successful. A study of the effectiveness of some TQM principles when applied to a sub-contractor in North America showed a strong correlation between profitability and satisfaction, and between schedule and quality (McKim, 1995). TQM assumes that continuous process improvement leads to continual customer satisfaction, which in turn leads to a more productive and profitable organization. To measure the success of the theory as applied to the test projects, several quantifiable measurements were made, including customer satisfaction, adherence to schedule, the number of construction defects,
and project profitability. In ISO 8402 the term “quality improvement” is defined as:

Actions taken throughout the organization to increase the effectiveness and efficiency of activities and processes in order to provide added benefits to both the organization and its customers.

Some applications of TQM to the construction industry have adapted the "plan-do-check-action" cycle, also called the improvement cycle, developed by Japanese industrial engineers (Deming, 1982), see Figure 5. Many practices cover the "plan" step and the "do" step, but few address the "check" step. The purpose of the check step is to "check the effects of implementation", which should provide information for the "action" (or correlation) step.

Figure 5. The improvement cycle.

When implementing a system in a company, such as a quality system, the improvement cycle is very important because the quality system is just a systematic approach to
describing the work associated with quality management. The ambition of most companies is to become more efficient, which requires improvements.

3.2 The ISO 9001 Standard

The term “quality system” is defined (ISO 8402) as:

Organizational structure, procedures, processes and resources needed to implement quality management.

According to ISO 9001, the scope of the standard is that it specifies quality system requirements for use where a supplier’s capability to design and supply a conforming product needs to be demonstrated. The model for quality assurance in ISO 9001 is structured into scope, normative reference, definitions, quality system requirements. The quality system requirements in are further divided into 20 sections:

1. Management responsibility
2. Quality system
3. Contract review
4. Design control
5. Document and data control
6. Purchasing
7. Control of customer supplied product
8. Product identification and traceability
9. Process control
10. Inspection and testing
11. Control of inspection, measuring and test equipment
12. Inspection and test status
13. Control of nonconforming product
14. Corrective and preventive action

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A quality system is a tool for steering and improving the quality of the company's products. In the ISO standard it is required that the system should be well documented, which provides a basis for the quality audit of the company. Systematic quality control requires appropriate routines and, in this respect, the ISO 9001 standard serves an important role.

In the ISO 9001 standard the process is in focus. The International Standards of the ISO 9000 family reflect the concept that all work involves a process (ISO 9000-1:1994), having, like any process, both inputs and outputs, see Figure 6.

The process itself is a transformation that adds value. Given the complexity of most organizations, it is important for quality management purposes to highlight the major processes, to simplify the processes to a certain degree, and to assign priorities. Figure 7 shows a supplier's supply chain relationship to a sub-supplier and to a customer.
A great deal of criticism has been aimed at the standard for quality systems and, therefore, management must interpret ISO 9000 to meet the company’s needs, which is a delicate task. Some researchers claim that ISO 9000 increases cost and reduces quality, instead of the other way around. It has become obvious to many people that current compliance-based quality assurance programmes are very costly and provide questionable benefits in terms of improved reliability and safety. The cost-benefit ratio appears to be unacceptably high, and sometimes reduced safety results because of the concentration on documentation. One serious problem associated with the document is that ISO 9000 is not focused on the control of product quality (Reedy, 1994) leading to disastrous financial consequences and little, if any, improvement in quality and safety.

Criticism on the standard is sometimes very harsh, Reedy (1994) claims for example that:

- ISO 9000 has the potential to destroy our competitive position in the international marketplace if not properly modified and implemented.
- The ISO 9000 program can work effectively only when the top executive responsible for engineering or production takes full responsibility for interpretation and implementation of the quality assurance program.
- The best way to verify product conformance is to check the product, not the paper.
- ISO 9000 was not written as a standard for controlling product quality. Programs based on these types of requirements are ineffective for ensuring product quality and are extremely expensive.
The same type of criticism was voiced in the Nordic countries. For instance, in Norway one opinion raised was that quality systems in general require too much, and too costly, documentation, as evidenced by experience from the off-shore oil industry (Sjöholt, 1990).

Although a great deal of criticism has been levelled against the standard, it is important to remember that these disadvantages are not necessarily connected to the standard itself, but rather to the interpretation and use of the standard.

3.3 Audits of a Quality System
According to the ISO 8402 standard, Quality Management and Quality Assurance – Vocabulary, the term "Quality Audit" is defined as:

Systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

Knowledge about the true results of a quality system is particularly important when new quality programmes are to be implemented (Samuels, 1994). This independent review provides management with information about how well the overall system is working and clues for adjustment of the process. The objectives of construction industry audits can be summarized as follows (Samuels, 1994):

• To optimize the performance of the quality system
• To follow up on the appropriateness of organizational planning
• To monitor effectiveness of policy and procedure applications
• To recommend and implement system improvements
• To provide consistency among inspectors and projects
- To analyze effectiveness of standard designs and specifications
- To analyze and improve constructability of project documents
- To provide information for life-cycle facility management
- To determine training needs.

The aim of the audit is to improve the system and to provide comprehensive, rather than day-to-day, control. However, some project-specific recommendations or general recommendations can be implemented immediately. When significant project-specific non-conformities or defects are discovered by the audit, corrections should be made. The construction quality facilities audit is unique and quite different from a financial audit, but it can be contrasted with the financial audit to enhance the understanding of the process (Samuels, 1994).

The audit can provide information and assistance in the positive control of the quality management system. System flaws can be detected and corrected almost immediately, with the result that non-conformities in the facilities can be eliminated during construction. The alternative to detecting system flaws in real time by auditing is to wait and see how the facility performs over time. It is not efficient to wait until a facility performs poorly, exhibits high maintenance costs, or fails due to overstress to determine if the quality management system is operating effectively.

Quality audits performed on facilities under construction are a viable way to analyze and correct the performance of construction management systems. By focusing on the process, the facilities audit complements participative management programmes such as TQM. Continual changes are made to the administrative and quality management processes in large organizations by the many different roles in the organization. The overall results of the individual changes are difficult to predict accurately. Procedures for conducting audits of construction systems are relatively new, but audit procedures covering quality plans for individual projects as well as quality systems for companies have been
practised for some time. Some information relevant for the development of new construction procedures can be gained from quality practices in manufacturing, from financial procedures, and from management system practices. These must be carefully applied, considering the unique needs of the construction and engineering disciplines (Samuels, 1994).

In the ISO 9001 standard internal audits are required, but if a company wants to have the quality system approved by a third party an external audit must be performed. Accredited certification bodies carry out these external audits. The estimated cost of the ISO 9000 certification is about US $ 50,000 (Reedy, 1994). However, the total company costs may be closer to US $ 100,000 to US $ 150,000. In addition, the yearly maintenance cost will be US $ 15,000 to US $ 25,000. This is the cost of obtaining and maintaining registration, not of programme implementation. In this work, an estimated cost of about US $1000 per employee was used (Article IV). A detailed comparison of the provisions under each of the requirements in ISO 9001 with those in NQA-1 and Appendix B shows that the provisions are nearly identical. Fortunately, this allows us to identify the problems that have occurred in the nuclear, military and aerospace industries. These problems illustrate the problems likely to occur with use of ISO 9000. The main problem with these quality assurance programmes is the manner in which the requirements are implemented. Reedy described the following example:

ISO 9001, 4.11 Control of inspection, measuring, and test equipment.
Quality assurance auditors have interpreted this provision to require calibration of wooden and metal rulers. The engineer should identify which measuring equipment requires calibration and the associated tolerances, not inspectors or auditors.

A similar situation occurred in Denmark, where one of the large contractors who was in a process of certification experienced a situation where the quality auditor required routines for the calibration of rulers. The certification process
continued later with another certification body who had better knowledge of the construction process and the tolerances these companies have to deal with. 

In Sweden, there is a public authority, the Swedish Board for Accreditation and Conformity Assessment, Swedac, which is the national accreditation body. Swedac is responsible for developing conformity assessment systems that comply with the principles applied within the European Union and internationally. Manufacture and trade are becoming increasingly international and there must be a system for checking whether products and processes comply with the requirements (Swedac, 2000).

The use of international standards provides a common basis for assessment, and if countries are to be able to accept each other’s assessment, through e.g certification, the competence of the bodies that perform these assessments must be approved in accordance with international standard. Accreditation is important for creating confidence between countries and the situations mentioned above can help to develop the use of standards for quality systems in new areas, such as the construction industry.
4 The Construction Process

The construction process is as old as mankind itself and it is a fascinating process going on all over the world. In this chapter, the definition of the process that I have used in the studies and the development of the process that could be expected in Sweden will be described.

4.1 Defining the Construction Process

Construction cannot be categorized as being strictly either a service or a manufacturing industry (Kubal, 1996), therefore the construction industry must combine quality concepts from both the service and manufacturing industries. The process itself is a transformation that adds value. Given the complexity of most organizations, it is important for quality management purposes to highlight, simplify and assign priorities to the major processes. The long-term performance of any building and its ability to satisfy clients' requirements depend both on decisions made by its designers and on the care taken and skill possessed by the workers at the construction site (Cheetham, 1993). The construction process is conceived, in this study, as encompassing all stages from the briefing to the commissioning stage, as is illustrated in Figure 8.
The construction process is a complex process. Many different parties, with varying knowledge and business interests, have to co-ordinate their activities in such a way that a building is completed at the right time, with the right quality and at the right price. The product determination (design) is normally carried out far from the actual location of the construction site. The use of the building cannot be tested on full scale until the building is finished, when the possibility of making changes is exceedingly small.

One attribute, which is typical for the construction industry, is the ability to work in projects. In this respect, the construction industry is far ahead of other industries. Builders are used to starting from scratch with new conditions in every project and producing a finished product within a fairly short time. Many activities and actors have to be co-ordinated in a restricted time, in a small space and under various climate conditions. The possibility of influencing the final quality of the product is very small for those who are late in joining the race.

Regarding the construction process and its participants, it is obvious that there is a state of conflict between many
4.2 The Improvement of the Construction Process in Sweden

In a paper presented at the CIB W65 Conference in Glasgow, "How Can IT Affect the Construction Process?", Jan Söderberg presented an analysis of the Swedish construction process together with some suggestions for improvement. This is an account of the results of the analysis (Söderberg, 1996):

The Good Sides
- Project work - daily routine for builders,
- Delegation to the workforce - a tradition which is being reinforced,
- Good training,
- The Swedish reliability,
- A new way of thinking about the market has started,

The Less Good sides
- Relay race with poor passing of the baton,
- Opponents instead of team members in the building process,
- Clients versus contractors,
- Building contractors versus sub-contractors,
- Architects versus contractors,
- Building managers versus architects,
- Contractors versus building managers and construction management,
- Education in schools of architecture versus education in civil engineering colleges,
- Too little analysis at an early stage,
- Insufficient financial control during the design stage,
Impact of Quality Management in the Swedish Construction Process

- No bills of quantities in the documentation for invitations to tender,
- Almost no architects on the building site,
- Lack of feedback of experiences,
- Insufficient and unclear information to the user,
- A low degree of prefabrication,
- The production planning which disappeared, ("in the head of a site manager")
- The lack of computer support,
- A wages systems that does not work,
- Materials distribution that does not work,
- Financial follow-up of the building project - difficult to make it work,
- Quality management - just a file?
- Installations in buildings - a neglected science,
- Hardly any women in the building process,
- Resistance to improvements,

The analysis was conducted with the following suggestions for improvements to the construction process:
- Improve collaboration - reduce antagonism,
- Integrate various interested parties into the process at an earlier stage,
- Improve the individual's motivation to do a good job,
- Control the economy for the building project from start to finish. Let the quantities be estimated successively and use these for the purchasing of contracts,
- Let the economic control also contain assessments of annual costs,
- Integrate quality management as a natural and dominating part of the planning - or rather the whole process,
- Plan the production of the building project already at the design stage. Let this planning contain schedules, an arrangement plan for the building site, materials administration and machine plan,
- Give the designers an opportunity to make use of previous experience,
• Create information for decisions which can be understood by all the people concerned,
• Create a design process which facilitates the use of alternative thinking to the greatest possible extent, i.e. one in which changes in the documentation of the building can be made quickly and simply without any mistakes appearing in various parts of the project, for example, in installations,
• Let information technology into the construction process,
• Plan the management of the construction process already during the planning stage,
• Create new forms of co-operation and contracting,
• Let women into the building process,
• Increase the degree of prefabrication,

The main proposal is to develop the use of information technology in the design process in order to obtain better decision support, but it can also be observed that quality management should have a more dominating role in the construction process in the future. Quality management is not just a tool to be used in certain situations, rather it is a way of thinking, which should influence the whole construction process.

Quality management must consequently be integrated into the creation of a more effective construction sector. Fragmentation of the construction sector is not only a Swedish problem. In an announcement from the EU Commission, in November 1997, The Competitiveness of the Building Branch, this issue is treated as a general obstacle to the development of the construction sector. Four options for the development of the construction sector have been presented:

1. Measures encouraging quality
   By encouraging the use of quality systems adapted to the size of the company, by choosing quality by using life-cycle economy and by stimulating the introduction of better management methods, etc.
2. Measures encouraging competition
By improving and consolidating legislation which hinders the inner market from functioning by e.g. introducing the Product Directive, and by strengthening the legal conditions for public procurement which increases the quality and the competitiveness by e.g. opening the possibility of combined public and private investments, etc.

3 Measures encouraging training
By increasing investments in training on all levels and by improving the working conditions in order to raise productivity, etc.

4 Measures encouraging research
By making investments to strengthen and give new directions for the research and development of new technologies and processes in order to improve the capacity of innovations and give the construction sector better opportunities to adjust to new demands. Another important element is the dissemination of research results.

From the above it is obvious that a quality system is one of the most important tools in making the construction process more effective. The importance of the quality system is clearly illustrated in a research project carried out in Göteborg. Some different building projects were studied (Josephsson, 1994) and the faults noted were estimated in terms of cost and time. At the same time, the origin of the faults was examined in order to find out which participant was to blame for the faults. The results of the study showed that the faults cost an average of 4.4% of the production cost. At the same time, the faults consumed 7.1% of the working time or 34 minutes of the working day for one person.

The underlying reasons for the faults were examined in order to find the participants responsible. Almost 80% was found to depend on a lack of engagement and insufficient knowledge. Faults caused by insufficient knowledge were traced mainly to the designers, 44%, then to the building site management, 34%, and least to the workers, 12%.
Regarding faults caused by a lack of engagement, the workers were responsible for most faults, 70%, compared with the designers, 35% and the building site management, 42%. This study shows that it is necessary to combine an effective quality system with increased information/training and measures to improve the engagement of various parties in the construction process. The importance of carrying out careful analysis in the early stages of the construction process before too much has been paid by the client, is often pointed out. This provides considerable opportunity to influence the final result, with regard to both quality and economy. Inadequate feedback in the construction process is often discussed. It is often said that those in the construction industry are especially conservative and resistant to change. One explanation of this could be that it is a very fast process, involving many participants, who feel that it is "safer to do it the old way". New technical solutions have often led to problems, e.g. "unhealthy buildings". But resistance to change is often associated with organisational change, e.g. the delegating of decision making to the workers (Söderberg, 1996). However, an organization in the construction process is, by its very nature, multi-site, its activity being so diversified and carried out in far-flung locations, therefore it is extremely useful to have a common system which every party is to follow (Tyler, 1993).

4.3 Some Visions of the Construction Process

The trend of the future is, according to Kubal, long-term partnering relationships. Just as single-project partnering is giving way to long-term, multiple-project relationships, so too is the way of doing business as design and construction processes become increasingly computerized. In the not too distant future, long-term project partners will communicate via networked systems, enabling simultaneous access to project documents and information, and the ability to modify shared files with simultaneous input by networked participants. This computer-aided partnering (CAP)
approach will open up new paradigms for advancing quality management processes (Kubal, 1996).

Sub-contractors could turn construction contracting upside down if they become integrally networked with contractors and design teams. Together, they could form strategic alliances to change the direction of the construction industry. The benefits of upside-down contracting that place a greater dependence on sub-contractors for process improvement include the following (Kubal, 1996):
- Cost reduction through sub-contractors' input during design and preconstruction
- Faster response time to innovations
- Superior quality improvements
- Reduced schedules
- Improved communications
- Improved networking and alliances.

The demand for this form of partnering has never been greater, as more and more clients utilize the same successful building team, project after project. Progressive companies in the construction industry know this, and are moving beyond single-project partnering to the formation of higher levels of effective strategic alliances. Alliances that include major sub-contractors and suppliers will be important for the success of firms that implement these higher levels of partnering. A successfully completed project can lay the foundation for the ongoing development of partnering relationships. This form of partnering can be used to achieve success between both internal customers and external customers - for example, between a sub-contractor and a general contractor (internal) and a contractor and an architect (external). These relationships endure partly because they are based on an atmosphere of trust and open communication, a basic requirement in any partnering programme. Such relationships go beyond first level partnering by providing a win-win situation for all parties involved (Kubal, 1996).
These higher levels of partnering are becoming a major influence in the construction industry's improvement of both product and process quality. For example, Otis Elevators has already taken a major step forward in the partnering process by providing a direct link to the design team's computer-aided design (CAD) system. This link allows a designer to create a customized elevator system, using manufacturer-available quality systems and design details that ensure the subsequent successful installation of Otis' product in field construction, well before the manufacturing process has begun.

Implementation of these higher levels of partnering may lead to strategic alliances. Strategic alliances are more formal agreements than partnering in which the team members agree to strategically share corporate abilities and information to better serve their customers to meet the challenges of the virtual age. There is no doubt that virtual construction is fast becoming a reality in all industries. The move towards virtual construction is being led by the industry's more progressive professional firms, including design teams, real-estate firms and construction organizations (Kubal, 1996). In the next decade, CAP will become the integral component of effective TQM programmes in the design and construction fields.

According to another researcher, Federle (1993), roles in the construction industry are about to change. Training should make middle management aware that their roles are changing; i.e. managers will no longer act as problem solvers. Instead, they will become coaches and mentors. They will work with others as examiners of processes, seeking improvement. Examples of recommendations expressed by others, inside and outside the construction industry, are:

- Stress the importance of management involvement and commitment, the need for training, starting at the top, the need for team-based structured process improvement, a database to support that effort, the establishment of client and employee surveys, and a system to recognize those who contribute to the improvement effort (Federle, 1993). These are examples of how the construction process could be
changed in the future. All of them contain a philosophy that supports systematic efforts to maintain and improve quality.
5 Quality Management in the Construction Process

The chance of success is greater if TQM is viewed as a true strategy for change, and not as something to be done to keep up appearances, or in an effort to achieve short-term objectives (Burati, 1993).

"Both the construction and design industries are way behind the curve on quality management from what they should be." (Schriener, 1995)

In this chapter, the construction process is discussed from a quality management point of view. The discussion is focused on some examples of measurements that could be used in the construction process.

5.1 The Construction Process – Service or Manufacturing?

The definitions and practices of quality technique are appropriate for use in the construction industry, but some special considerations must be dealt with when quality management is to be implemented. Quality programmes in construction must combine quality concepts from both the service and manufacturing industries, since a construction project is a product delivered through the provision of
services and a physical product (buildings, roads, etc.). Although ISO 9000 was developed for manufacturing industry, comparisons can be made between the processes used in connection with industrial design and factory production, and those used to produce buildings. The construction industry differs, however, from the manufacturing industry in that the constructions it creates are more individual, each being found in a unique location, a much lower degree of repetition (Cheetham, 1993). TQM programs that have been developed for other industries do not fare well when implemented in the construction sector (Cheetham, 1993); they have proven to be inadequate for achieving long-term success in improving the overall product quality, for example, the finished building. TQM will not be successful in the construction industry until it can be implemented in a team spirit with a direct invitation to participate from the bottom up.

The legal framework involved, which determines the relationships between the parties, particularly between the client and the producer of the product, is more complex in the construction industry than in the manufacturing industry.

Both manufacturing and engineering and construction are complex processes; however, the difference lies in the end products. In engineering and construction, the product is produced after the process is completed and ceases to exist. The product in engineering and construction is the actual facility, building, or other work. Any hopes of improving that particular engineering and construction process by measuring the quality of the product is theoretically not possible; however, may be used on future engineering and construction processes (Hart 1992).

5.2 Measurements
Earlier research shows, as Cheetham (1993) has indicated, that quality systems in the construction industry perform two valuable functions. The first is by their very existence, to raise the level of quality awareness throughout the company.
This, in turn, can favourably influence attitudes towards quality on the part of the employees. The second function is to enable certification; a certified system being a tool enabling a company to compete in an increasingly quality-conscious market. In an example from the United States, an engineering consultant was studied (Caldwell, 1994). The driving force behind a quality culture was commercial and the parallel belief was that in a service organization quality is meeting the needs of the client. The implementation of TQM values, principles and procedures yielded many benefits, including more satisfied clients, greater market share, increased revenue and high staff morale. Traditional quality measuring tools are effective means of improving performance in architectural engineering and construction projects. Their use and application require careful thought and consideration. There are many factors that affect how such quality measurement tools should be used (Hart, 1992).

Many construction firms question whether the benefits of TQM outweigh the cost. Other firms claim to have found the key to success and are now seeing measurable improvements in every aspect of their business.

Certainly, there are ways of preventing or minimizing quality concerns or problems. The industry has numerous methodologies to provide solutions. We know, generally speaking, that it is more effective to enforce vendor surveillance at the supplier than to wait until the material or component arrives at the construction site. We also know that it is more effective to apply in process welding inspection than to wait until the weld has been formed and finally inspect and test the weld. In order to systematically solve and answer the use of quality tools, one has to understand the functional relationships between engineering and construction workflow activities. One has to compare to a common base or a common unit of measurement. The most straightforward measure to use in this industry is in economical terms. Quality cost analysis may be a method that effectively understands these functional relationships.

Large American design firms that employ total quality management programmes have professional liability costs
that are nearly one-third lower than similar organizations without them (Schachner, 1996). A survey of 200 architectural and engineering firms also found that those with full risk management and legal staff have professional liability costs 23% lower than those that do not. Other ways of reducing losses include using alternative dispute resolution methods and entering into a construction contract that requires the service buyer to share the responsibility for preventing losses (Schachner, 1996). It was also found that total professional liability cost for firms without total quality programmes averaged 1.16% of revenues compared with 0.8% for those with them. Measurement and numerical quantification are essential parts of the management of quality. Wherever possible, numbers should be used to evaluate each part of the process. Every evaluation has areas in which performance could be improved. Other measures of quality that are monitored are the number of days ahead of schedule, dollars below budget, time or money required for rework, number of client meetings, number of deliverables on or ahead of schedule, and number of quality improvement initiatives completed per quarter and their cost savings. Project-specific quality measures and quality assurance manuals are compiled to comply with project and client needs. The benefits of TQM are quantifiable - some known, others, as yet, unidentified (Caldwell, 1994).

Currently in the design and construction industry, there are many different tools for measuring the performance of quality; technical drawing errors discovered during the checking process, too much slump concrete as it is discharged from the truck, partition walls out of alignment, undersized air handlers, lack of fusion welds in structural steel, etc. It is important to measure different kinds of defects and to investigate why these defects occur. A Swedish study (Josephson, 1994) confirmed that the main source of defects was a lack of individual motivation and conflicts between members of an organisation. A study at Texas A&M University (Culp, 1993) identified the following five factors which determine how a customer evaluates service quality:

- Reliability
Customer satisfaction is the key variable; however, other variables can be tracked on individual projects to provide valuable feedback. Although the team for each project must select the appropriate variables carefully, there are several general measurements that can be used to measure the overall impact of the TQM process on a firm (Culp, 1993):

Relatively short-term measurements:
- Number of scheduled milestones missed
- Amount of staff overtime
- Cost of drawing/specification rework after final check
- Number of inconsistencies between drawings and specifications
- Number of errors per drawing
- Hours and/or cost per drawing
- Ratio of project engineering/architecture cost to budgeted amount
- Submittal review time
- Response time to contractor requests for information
- Number of typographical errors per page on final resumes, reports, and specifications.

Relatively long-term measurements:
- Turnover rate of technical staff
- Claims, settlement, and litigation expense
- Success rate for proposals submitted
- Project budget overruns - frequency and amount
- Ratio of project overrun costs to total project cost
- Cost of marketing as a percentage of total fees
- Number of times a document is changed after it has been issued
- Number of formal reviews conducted on time
- Number of contractor requests for information
- Change orders, expressed as percentage of project construction cost
• Ratio of final construction cost to estimated construction cost
• Client perception of project quality, consultant responsiveness, etc.

Culp's research shows that it is possible to find different types of variables which indicate how successful a TQM programme has been.

5.3 An International Outlook

The implementation of TQM is not something specific to the Swedish construction industry; it is rather a global question concerning many countries of the world. For example, regarding the Western world, in the USA there is great concern among construction professionals, researchers, and professional societies about the overall direction of the North American construction industry (Kinai, 1993) with respect to its unwillingness or inability to change.

Some researches fear that the North American construction industry could be left behind in the global marketplace unless the industry as a whole changes some fundamental aspects (McKim, 1995). If we instead turn our attention to the East, we find that Japan is one of the few countries in the world where the major construction companies are investing heavily in research and development.

Japanese firms do not evaluate every investment as a discrete and incremental addition to their business. Instead, they treat investment projects in R&D, the expansion of production capacity, and market development as integral parts of the overall businesses when global competitive positions need to be advanced. The lessons to be learned are that, once market share is firmly established, profit will follow (Haley, 1994). The desire to achieve high quality, which is found generally in Japanese society, adds to the success of the Japanese construction industry, as this desire is manifested on-site thorough quality control and accurate building. In the early 1970s, the industry introduced formal quality assurance programmes, known as total quality control systems. Workers work in quality circles with their colleagues.
to find improvements, and report back to the management with their ideas. Japan's culture is based on cooperation, whereas Western culture is based on competition (Haley, 1994) which could explain why better attitudes to solving problems are seen in Asia. In Japan, if a worker sees a problem he/she will take responsibility for sorting it out. In the West, the problem will either be ignored, or it will become a formal contractual issue. There is a deeply rooted cultural difference and Western companies cannot suddenly develop the Eastern culture in this respect. Government involvement is essential. It is necessary for Western companies to turn away from short-term thinking, and their obsession with maximizing the net worth of stockholder equity, and turn towards developing a partnership of labour, management and shareholders to maximize the firm's added value (Haley, 1994). In Sweden, the government requires that companies in the construction sector that bear responsibility for a construction project to be oriented in basic quality issues. According to Haley (1994) this government involvement should bring about a positive development in the construction process.
6 Conclusions

“H e who runs his company on visible figures alone will soon have neither company nor visible figures to work with.”
Dr Deming

In this closing chapter I will point out some of the results in the articles. The discussion is not limited to the results of each individual article, but also addresses the broader integrative results from the whole thesis. Finally, I will address some issues deemed to be interesting for future research.

6.1 Results and Discussion
The overall purpose of this study was to investigate how the concept of quality management has been adopted in the construction process. In all my studies on the Swedish construction sector, I have been struggling with the question of whether the implementation of a TQM programme has some measurable results, or not. It is a delicate question, because no company would admit that their efforts were not profitable but, at the same time, they are not able to show any measurable results of their quality programme. In Article IV, all the companies interviewed were convinced that their quality system paid off, but they could not give many examples that showed how much, in any terms. A number of conclusions can be drawn from the analysis. Although the sample is not designed to form the basis for significant statistical inference, the research projects reported have shown some general trends that cover the construction process only, and others covering a relatively long period of
time. The positive results are not quantifiable statistically, but have provided information and experience only because of the TQM activities. The conclusions can provide justification for management in companies in the building sector to make changes that would otherwise have been difficult to implement.

Quality management appears to be considered primarily as a means of increasing effectiveness and enhancing competitive advantage (Article III) but it appears that outside influences, such as a customer insisting on TQM, may be the force that the company needs to start work on quality management. Management must understand what is involved. To become a “quality organization” may require a complete change in corporate culture and organizational structure. Because of this, management must be dedicated to the change process. Dedication is required because this is a long process (Federle, 1993). It must be realized that the companies will be spending money to achieve results that may not be evident for a considerable time. The most common way of initiating quality management is by introducing inspections, and the reason for this was probably demands for inspections from clients (Article I). It appears that the extensive inspections required by a quality system were regarded as one of the major elements in the construction process (Article III). Unfortunately, this was found to be rather meaningless by specialist contractors who already had problems in finding resources for quality management.

In summary, the most frequently occurring problems for specialist contractors were:

- Different customers demanded different quality plans, and did not use quality terminology in the same way,
- Customers often want to control the specialist contractors’ quality management,
- It’s difficult for a contractor to assure the quality of his product unless everyone else does,
- The majority of the companies involved are small organizations who cannot find the resources necessary for quality systems.
When one considers the use of the ISO 9000 standard over time, it is found that the degree of acceptance gradually increases. At the time of the first study, it was found that the Swedish construction sector was divided into two camps: one that thought ISO 9000 could be implemented, and one that did not (Article I). This has since changed. There is no longer a debate in media about the possibility of using the standard or not, because companies are starting to be certified with regard to their quality systems, which proves that companies can structure their quality systems according to the requirements in the ISO 9001 standard (Article III). It seemed commonly to be the case that a quality system was created in a manner that suited the company, but when communicating with the customer the description of the system was transformed into the structure of ISO 9001. The major criticism directed at the standard was (Article III):

- It was difficult to understand,
- It increased bureaucracy,
- It neglected economic matters such as profitability.

When the first study was carried out it was at a time when particular emphasis had begun to be placed on the idea of quality.

The various sections of the ISO 9001 standard are not regarded as equally important and are thus not used to the same extent (Article II). “Contract review”, “design control” and “management responsibility” were judged to be most important. “Contract review was the paragraph which was assigned the highest level of importance while “design control” was the second. An explanation of this could be that both have concepts that are familiar to the construction sector. Considerable emphasis was placed on “management review”, which was deemed to be the third most important paragraph, but here there was also a strong desire for improvement. If we consider the least important paragraph instead, we find “statistical techniques”, where the respondents were in complete agreement, regarding this paragraph as the least important of all. This is hardly
surprising as this whole area is new to such companies and initial resistance is great. The next three least important paragraphs were judged to be “internal quality audits”, “training” and “servicing”. Internal quality audits could serve as a motor in quality management work leading to a climate of open debate and the will to take up difficult problems.

Training is essential in any company in a changing world, and servicing can be used as a tool with which to learn customers’ needs. If we consider the results of the final study (Article IV) we find that the “innovation and learning” perspective is neglected when using the balanced scorecard which corresponds to the results in Article III because the neglected paragraphs are important ones in an organization that is devoted to improvement and learning.

All the companies in the second study (Article II) were engaged in quality management, but none of them could provide any measure of the degree to which resources were invested in it, or what effect it had had on their activities. In article III none of the respondents presented any concrete measures that had been taken to determine the economic gain of quality management.

Some of the requirements of the ISO 9001 standard tended to be confused with one another or to be misinterpreted, and some of them appear to scarcely find application in the construction sector (Article III). The improved acceptance of the ISO 9001 standard is an important step towards the establishment of systematic quality control within the construction sector (Article III), even if the standard is not yet always implemented in the proper way. This suggests that there is no longer a need for a separate standard for quality systems for the construction industry, which some researchers (e.g. Cheetham, 1993) have suggested. However, the standards of ISO 9001 are not the only tool that can be used to control and improve the process in a company. The secret lies not in discovering one magic tool, but rather in learning which tools to use, how and when (Rigby, 1993).

The balanced scorecard is a useful tool as a measure of the performance of quality systems (Article IV). The most
interesting result when using the balanced scorecard was that it became very clear that there is a lack of balance between the four different perspectives. Companies in the construction industry must pay attention to the fact that the perspective of innovation and learning is neglected.

6.2 Future Research
In the long run, use of a quality system within the construction sector would be more effective if concrete and generally applicable measurements were to be introduced. The difficulties in measuring and following up the results of a project in such a way that these are comparable over time may, in part, be solved by the very act of recognizing such difficulties. There is a need for the development of practices for the performance of construction quality management system audits. And there is also a need to develop knowledge about the cost of quality in the engineering and construction industry. One failing in many TQM efforts is the lack of clearly defined measurable goals that are aligned with the firm's overall strategic objectives. By merely adopting techniques used in manufacturing applications, measurements of quality management efforts may not reflect the success of the programme. Measuring the elements that constitute the essence of a successful construction process is a challenge. Because the ultimate measure of quality is a satisfied customer, it is critical to recognize the factors that influence the customer's rating of the service or product provided and how these factors differ from those in the manufacturing industry.
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8 Appended articles


IV Landin A, Nilsson C-H, Does Quality Systems Really Make a Difference, Building Research and Information, accepted for publication, 2000
Specialist Contractors Approach to Quality Management in Sweden

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Abstract
In Sweden there is a growing interest for quality management in the building process. This paper maps out and describes development work done so far concerning quality management among the specialist contractors. The term "specialist contractor" refers to all contractors involved in the building process, apart from the building contractor. This review among Swedish specialist contractors was done to obtain an approximate picture of the progress toward quality work. Those specialist contractors, whom I have interviewed, work traditionally as sub-contractors. I think that one senses a certain despondency; it seems as if there is something paradoxical in having both a quality system and being a sub-contractor. Inspection of own work during the production phase is the most common way of initiating quality management. The contractors usually call this quality assurance but I think quality inspection is a more adequate term because they are not dealing with questions of quality assurance or quality management at all. The case is often that the sub-contractor has not prepared the contract documentation himself, and therefore cannot be responsible for the function. The consequence can be big problems later, if functional problems arise and responsibility has to be sorted out. I think that this kind of problem should inspire a quality management approach, and it does in some cases, but the majority of the companies seem to see this as far too big a task; for which they have neither the time, nor the resources to take on. Quality work tends to be ambitious in the beginning, and it often starts with inspection of own work. Too much inspection of own work
Article I

is considered meaningless by the staff and it is therefore extremely important to make efforts to find the critical targets for inspection.

Introduction

There is a growing interest for quality management in the Swedish building sector. This is probably partly because of the increasing demand from the clients for quality assurance. Another reason is the high failure cost which motivates contractors to protect themselves by introducing quality management. This research project describes the development work which has been done to introduce quality management among specialist contractors in Sweden.

Method

The term "specialist contractor" refers to all contractors who are involved in the construction process, apart from the building contractor. Since many quality-related terms are used in the wrong sense in the building sector, the term "quality work" is used generally to describe all work affecting quality carried out in an organisation.

This review of the quality work among Swedish specialist contractors was done to obtain an approximate picture of how far it has progressed in different trades, and whether the scatter within and among the trades is large or small. Table 1 illustrates the result. The presentation is not comprehensive.

Table 1 Some of the distinctive features for the different specialist contractors.

<table>
<thead>
<tr>
<th>Category</th>
<th>Quality System</th>
<th>Interest</th>
<th>Cause of interest</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating and Plumbing</td>
<td>9001 exists</td>
<td>fluctuating</td>
<td>requirements from clients</td>
<td>too extensive demands</td>
</tr>
<tr>
<td>Ventilation</td>
<td>9001 exists</td>
<td>fluctuating a lot</td>
<td>feeling of meaninglessness</td>
<td>lack of teamwork</td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>Inspection of own work</td>
<td>poor</td>
<td>too many rules and regulations</td>
<td>too many rules and regulations</td>
</tr>
<tr>
<td>Electrical</td>
<td>9001, model from trade association</td>
<td>great</td>
<td>requirements from clients and from their own trade association</td>
<td>consider the entire function</td>
</tr>
<tr>
<td>Lifts</td>
<td>9001, Juran, Crosby</td>
<td>great</td>
<td>competition</td>
<td>high costs for guarantee work</td>
</tr>
<tr>
<td>Painting</td>
<td>9001-2 exists</td>
<td>fluctuating a lot</td>
<td>requirements from clients</td>
<td>unsatisfied as &quot;customers&quot;</td>
</tr>
</tbody>
</table>
Flooring

<table>
<thead>
<tr>
<th></th>
<th>Self inspection rules from trade association</th>
<th>poor</th>
<th>damages caused by moisture</th>
<th>unsatisfied as &quot;customers&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metalwork</td>
<td>QA-model from trade association</td>
<td>great</td>
<td>standpoint from their own trade association</td>
<td>difficult to get fully qualified employees</td>
</tr>
</tbody>
</table>

About a dozen organisations from each group of contractors was selected for interviews. The companies were selected at random, and the interviews are made with either the head of the firm or the person who is managing the quality work. In those cases when specialist contractors are organised in an association, I made interviews with persons involved in the quality work for the association.

The interviews are made by telephone, and they took about an hour each. In the interviews I asked for a detailed description of the quality demands from clients or others and the work done to implement quality management. The rest of the interview was open, in the sense that I tried to figure out the attitude to and aims of quality management. I could often get a copy of the quality manual or other important quality documents to study before or after the interview.

The description that follows is extracted from the interviews, and the opinions represented were given by the persons interviewed.

**Electrical Contractors**

The electrical contractors in Sweden are organised in The Swedish Electrical Contractors Association which has done a lot of work with questions concerning quality management for electrical contractors. The Swedish Electrical Contractors Association have developed a general quality system based on ISO 9001, because in the future there will probably be a demand, and it will be too expensive for all the small companies to develop a new system of their own. The building contractors have taken the opposite stand, which I find very interesting. They want to use the quality work as a weapon for competition and do not want to collaborate at all in these matters. Electrical contractors can use two basic documents: a guidance note and a quality document. The individual company can develop and implement their own quality system on the basis of the documents from The Swedish Electrical Contractors Association. No detailed directives are given in the documentation because the quality work must be guided by the
Article I

company's objectives and conditions. The intention is that all electrical contractors should be able to provide a uniform specification to their clients.

Heating and Plumbing

Most of the heating engineers and plumbers are well informed about the quality concept, and they want to introduce it "as soon as they get the time." The quality assurance most demanded by the clients is self-inspection of the contractors own work. Contractors worry that this form of quality work will destroy the motivation of the workmen because it is perceived as meaningless. Quality work must definitely not be seen as something unnecessary and meaningless. There are pipe installing contractors who have already established quality systems, for example those who have been involved in the Norwegian off-shore market. They have been forced to build their quality system in accordance with the Norwegian standard NS 5801-3. These contractors are not the usual heating engineers and plumbers but those who work with gas pipes and hydraulics. There is no doubt among these organisations that quality assurance pays off. Sometimes clients choose heating and plumbing contractors because of the quality system of the company. The Swedish Association of Plumbing, Heating and Ventilation Contractors has developed a general quality system, based on ISO 9001 which the associated companies can use.

Ventilation

Among the ventilation contractors the level of ambition varies a lot. What is common in this trade seems to be that the members put great emphasis on pride in their workmanship. Some of the companies have established quality systems that satisfy ISO 9001. Rumours that more than 80% of all ventilation systems do not function as intended does not appear to concern many. Most maintain that they enter the process so late that they have no chance to influence the design of the ventilation systems. Therefore they have got accustomed to installing systems which they know will not work properly. Co-ordination is a big problem for ventilation contractors, and they would like to have co-ordination consultants. A number of building contractors demand self-inspection from the ventilation contractors.
Metalwork

Metalwork is one of the most craft-oriented activities at a building site and requires a lot of knowledge and skill of the operatives. It is difficult to get good metalworkers today, and new employees need a long apprenticeship. Metalwork contractors do not have many customers who demand quality assurance, but they think that demands will come, and therefore they want to be one step ahead of the customers. Employers Association of the Swedish Plate works has prepared two quality handbooks, one for building metalwork and one for ventilation. The quality handbooks give very clear directives and apply in the first instance to the "average firm" which consists of five employees plus a leader who is also a metalworker. They have chosen not to apply the quality system to any standard in the ISO 9000-series, because this was found difficult and theoretical.

Air Conditioning

The air conditioning contractors do not appear to be interested in quality management. Due to a new law about limitation of freon emissions, most air conditioning contractors attended a course in inspection of own work. This means that all air conditioning contractors must have an authorisation of competence. This cool attitude towards quality management is probably a consequence of new regulations.

Lifts

It seems as if the large international organisations within the lift trade are interested in quality management. The motivation is partly a desire to be able to compete internationally, because many countries demand quality assurance according to established standards and partly the high guarantee costs. The lift contractors claim that they cannot do things precisely correct from the beginning, and this is the explanation to the high guarantee costs. They know where the fault is, once it has arisen but cannot avoid it from the start. Another consequence of this is that the commissioning periods are longer than necessary, which costs money and erodes the client's confidence in the contractor.
Painting

Painting contractors have not paid much attention to quality management. Most of the painting contractors do not know what quality assurance is. The companies are often very small, and there is not any need for a formal quality system. Sometimes, if the client wants it, they use self-inspection sheets in the production stage. There are exceptions however. Some painting contractors work very seriously with quality management. One of their greatest problems is to make the client understand that if he wants the painter to deliver a "quality assured product," he must first make sure that the painter also receives a "quality assured product." The core in all quality work is to satisfy the customer's need. The customer is always the one who has to take over and carry out the next step in the process. This means, for example, that the painter is customer to the carpenter, because the carpenter delivers the surface to the painter when he puts up the plasterboard. This is an unusual way of thinking at a building site. There are painting companies who implement quality systems in accordance with ISO 9001 and ISO 9002.

Flooring

The insurance companies high costs for moisture damage in Sweden have resulted in a program for preventing water damages. The flooring trade must take its share of the responsibility for minimising the damage in wet rooms. "The Flooring Trade's Wet Room Inspection", GVK, was introduced in 1988. All serious flooring companies can join GVK, and those who have trained their personnel shall be able to demonstrate this through a GVK-authorisation. Random inspections of the work are carried out continuously at every company and the authorisation can be withdrawn in cases of repeated notifications. How does it work in reality? GVK functions very poorly, claim a number of floor layers, because they can not follow the recommendations. In many cases flooring cannot be laid in accordance with GVK, because the plumber and the building contractor do not make this possible. The reason that plumbers and building contractors do not meet the requirements is partly that they do not know them. The flooring contractors problems are in principle the same as those
of the painting contractors, namely that they are not given a quality assured product to quality assure.

**Common Tendencies in the Quality Work**

Inspection of own work during the production phase is the most common way of initiating quality management, and the contractors usually call this quality assurance, but I think quality inspection is a more adequate term, because they are not dealing with questions concerning quality assurance or quality management at all. The reason for this is probably that the customer imposes demands for quality inspection when they require quality assurance. Unfortunately some of the largest clients in Sweden impose a long list of demands for inspection. This list is found completely meaningless by the contractor, but he accepts it because he wants the job. The building sector in Sweden consists of two sides; one that thinks the series ISO 9000 is possible to use, and one that thinks it is impossible to use. I think that the companies which are most serious with their quality work align with ISO 9001 or ISO 9002 from the beginning and structure their quality system after the requirements in them.

**The Most Frequently Occurring Problems**

Those specialist contractors whom I interviewed work traditionally as sub-contractors. I think that they feel a certain despondency; it seems as if there is something paradoxical in both having a quality system and being a sub-contractor. Many maintain that it is not worthwhile to try to aim at good solutions, because they know that it will be too expensive, and even then they cannot count on getting the contract. There is no one who listens to the sub-contractors, and often they are brought into the building process too late to have a chance of influencing the choice of solutions. The case is often that the sub-contractor has not prepared the contract documentation himself, and therefore cannot be responsible for the function. The consequence can be big problems later if functional problems arise and responsibility has to be sorted out. I think that this kind of problem should inspire to a quality management approach, and it does in some cases, but the majority of the companies seem to see this as far too big a task, for which they have neither the time, nor the resources.
Specialist Contractors often think that their part in the building process is very important, but that it is impossible to implement ideas from quality management. On the other hand, they think that it is necessary that the building contractor implements quality management into his company. This is actually a great dilemma, because what these specialist contractors mean is that they have an overview of their own work, and that they can, within their framework, influence the work from beginning to end. A larger organisation which has divided the quality chain into many links has no chance of overseeing every part in the same way, and therefore needs a quality system. The question is then, how big and how complex should an organisation be to motivate a quality system? A great number of specialist contractors are borderline cases, which can be a problem when building contractors begin to demand quality assurance from all sub-contractors.

Quality work tends to be over ambitious in the beginning, and it often starts with inspection of own work. Too much self-inspection is considered meaningless, and it is therefore extremely important to make efforts to find the critical targets for inspection.

Credibility is an important component in quality work, which can be a problem for specialist contractors. A carpenter may confirm with his signature that a job has been done correctly, without wondering whether it is true or not. Another carpenter may check several times before he signs. It is tempting to believe that he who checks carefully before signing would be the most credible, but does he know exactly what a correct job looks like?

How is the problem dealt with by the specialist contractors? I think that the most important component in quality management is that the right person with the right competence work with the right things.

In summary, the most common problems for the specialist contractors are:

- Different customers demand different systems, and do not use the quality terminology in the same way.
- The customers want to control the specialist contractors' quality work.
- It is difficult for a contractor to quality assure his product unless all others do it.
- The majority is small organisations which cannot find resources for quality work.
References

Interviews with quality managers in individual companies and in organisations for specialist contractors.

Quality Handbooks from:
- The Swedish Association of Plumbing, Heating and Ventilation Contractors
- Employers Association of the Swedish Plate works
- The Swedish Electrical Contractors Association

Quality 9000 Access, Quality Forum, Sweden
Evaluation of Quality systems for specialist contractors
- electrical contractors and contractors for plumbing, heating and ventilation

by

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Abstract
Quality systems are being adopted by the Swedish building industry to an increasing degree. This paper examines two categories of specialist contractors - electrical contractors and plumbing, heating and ventilation contractors - and the introduction of quality systems there. The companies were assessed in terms of the ISO 9001 standard and the Crosby Quality Management Maturity Grid. The evaluation shows that much has been accomplished in efforts to ensure quality but that much is yet to be done. Considering the investment in resources which the introduction of a quality system represented for these firms, it is noteworthy that none of them measured the effects of quality control in a concrete way. A specific instrument, based on ISO 9001 and the Crosby Grid, is seen as applicable. The importance of developing the evaluation of quality systems further is emphasized, an approach which can be used both by suppliers and by customers.

Keywords
Building industry, Evaluation, ISO 9000, Management, Quality system, Specialist contractors

INTRODUCTION
The most basic conception of quality management is that one should do things right from the start, both in terms of product quality and of process quality. Within the building industry there have been problems in connection with both of these. Examples are the tremendous building projects during the 60s which were found later to have involved “doing the wrong things” and the dampness and mould problems to which attention was drawn during the 70s and 80s that were a consequence of having “done things wrong.”

It is usual nowadays for clients (the parties that commission building projects) to demand that the building contractors that are given a contract guarantee in some way the quality of their work. The demands the client makes can vary considerably, however, and be quite vague. This gives the contractor the opportunity to take the initiative and show what genuine quality of workmanship involves, yet it may also result in the contractor’s falling victim to the capriciousness of the client. The development of quality consciousness has been strongly supported by ISO, the International Organization for Standardization, which has formulated a set of standards concerning what a company’s quality system should encompass. The standards involved represent what is called the ISO 9000 series.

A survey of the quality of workmanship of specialist contractors in Sweden (Landin 1995) was carried out in 1988-89. That was at a time when particular emphasis had begun to be placed on the idea of quality, and a campaign for quality had been going on in various sectors of the economy for about a year. The results of the survey indicated that specialist contractors differed markedly in the quality of workmanship they provided. These results led, in turn, to a more thorough study being...
undertaken of electrical contractors and of contractors for plumbing, heating and ventilation. The term "specialist contractor", traditionally referred to in Sweden as a “subcontractor,” will be used here to denote a contractor who is not a building contractor. Although it is often a building contractor who engages a specialist contractor for a job, in which case the term “subcontractor” is appropriate enough in referring to the latter, this need not be the case. Specialist contractors are often small companies, yet this cannot be used as an excuse for poor workmanship in their dealings with the client. To achieve some general solution to quality problems here, the attempt has been made to work out basic principles for quality which apply to the whole sector rather than to a single company.

**METHOD**

The sectors chosen were electrical contractors and contractors for plumbing, heating and ventilation. This study sought answers to the following questions:

- How does the quality control system presently in use work?
- Is the effectiveness of the quality control system measured in such a way that one can see the consequences of it for the firm’s performance? What quality measures are employed?
- What parts of the quality control system appear most important in terms of their practical implications? How does a firm evaluate the various components of the quality control system?

The trade associations, the Swedish Electrical Contractors Association and the Swedish Association for Plumbing Heating and Ventilation Contractors were also investigated in terms of the informational support they provided their members on questions of quality.

Six firms altogether, three electrical contracting and three plumbing, heating and ventilation contracting firms, were selected for the major part of the investigation. They were all large southern Swedish firms working in the respective sector. All of these firms had shown a particular concern for questions of quality. The person in charge of quality control was interviewed and the handbooks on quality control used in the firm were studied. The vocabulary of ISO 8402 is used in this paper.

The interviews dealt with the following questions and assessment tasks:

A. Respondents placed the firm at the point which they adjudged most appropriate within Crosby’s “Quality management maturity grid” (Crosby 1979).

B. In the interview itself, the various standards that ISO 9001 encompasses were used in each of three different ways:

1. The twenty paragraphs of chapter 4, Quality system requirements, of ISO 9001 served as open questions, the respondents describing how each of the paragraphs was applied at their firm.
2. The respondents evaluated each of the paragraphs in terms both of its use within the firm and its importance for what the firm had to offer.
3. The respondents were to select the five paragraphs they considered to be most important and to rank order them, and were to do the same thing with the five paragraphs they considered to be the least important.
C. The respondents answered questions concerning what parameters they regarded as particularly relevant in assessing the quality of work within the firm and the firm’s performance generally.

RESULTS

A. Crosby’s "Quality Management Maturity Grid"
The initial task was to let the respondents assess in terms of Crosby’s grid the quality control measures in use. The results are summarized in Table 1.

Table 1 Summary of each firm’s assessment of itself in terms of Crosby’s “Quality Management Maturity Grid”

<table>
<thead>
<tr>
<th>Measurement Categories</th>
<th>ELA</th>
<th>ELB</th>
<th>ELC</th>
<th>PHVA</th>
<th>PHVB</th>
<th>PHVC</th>
<th>Aver.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management understanding and attitude</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4.0</td>
</tr>
<tr>
<td>Quality organization status</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3.2</td>
</tr>
<tr>
<td>Problem handling</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>Cost of quality as % of sales</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>2.2</td>
</tr>
<tr>
<td>Quality improvement actions</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Summation of company quality posture</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3.5</td>
<td>3</td>
<td>3.4</td>
</tr>
<tr>
<td>Average</td>
<td>3.4</td>
<td>2.3</td>
<td>3.2</td>
<td>4.2</td>
<td>3.5</td>
<td>3.7</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Note: Stages in Crosby’s system to which the numbers respondents selected correspond:
Stage 1. Uncertainty,
Stage 2. Awakening,
Stage 3. Enlightenment,
Stage 4. Wisdom,
Stage 5. Certainty.

From the summary of the results for Crosby’s maturity grid, one can see that the plumbing, heating and ventilation contractors assigned themselves higher numbers than the electrical contractors did. One of the electrical contractors assigned itself much lower numbers than the others.

One could speculate on whether the firms assigned themselves numbers of appropriate size. A firm that was in fact at Stage 3 (Enlightenment) might well consider itself to be at Stage 5 (Certainty). Probably anyone assessing his/her firm in terms of Crosby’s grid would need to have reached the stage of certainty (stage 5) in order to make a correct assessment.

B. Rank ordering of the different requirement paragraphs contained in ISO 9001 chapter 4.1

The firms were to rank order in terms of importance certain of the requirement paragraphs which ISO 9001 contains. The five most important and the five least important were to be selected for this purpose. These results are summarized in Table 2. Whereas all of the firms named the five paragraphs they considered most important, some of the firms failed to
indicate which paragraphs they regarded as least important. For this reason, negative values are lacking for some of the firms.

Table 2 Selection and assessment of the most and least important requirement paragraphs listed in Chapter 4.1 of SS-ISO 9001

<table>
<thead>
<tr>
<th>Requirement paragraph of SS-ISO 9001</th>
<th>ELA</th>
<th>ELB</th>
<th>ELC</th>
<th>PHVA</th>
<th>PHVB</th>
<th>PHVC</th>
<th>judged important</th>
<th>judged unimportant</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Management responsibility</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>4.2 Quality system</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>4.3 Contract review</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.4 Design control</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td></td>
<td>4</td>
<td>14</td>
<td></td>
<td></td>
</tr>
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<td>4.5 Document and data control</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>4</td>
<td></td>
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<tr>
<td>4.6 Purchasing</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.7 Control of customer-supplied product</td>
<td>4</td>
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<td>4.8 Product identification and traceability</td>
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<td>4.11 Control of inspection, measuring and test equipment</td>
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<td>1</td>
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<td>4.13 Control of nonconforming product</td>
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<td>1</td>
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</tr>
<tr>
<td>4.14 Corrective and preventive action</td>
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</tr>
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<td>4.16 Control of quality records</td>
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<td></td>
<td></td>
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<td>4.18 Training</td>
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<td>2</td>
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<td>5</td>
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<td></td>
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<tr>
<td>4.19 Servicing</td>
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<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.20 Statistical techniques</td>
<td>-5</td>
<td>-5</td>
<td>-4</td>
<td></td>
<td>3</td>
<td>-14</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Values of 1 – 5 designate the paragraphs viewed as most important, 5 being the one given the highest priority, whereas the negative values -1 – -5 designate the paragraphs seen as least important, -5 being that given the lowest priority.

In Table 2 one can also see in what rank order the firms placed the respective paragraphs. In Table 3 the firms are sorted accordingly.
Table 3  Relative weights assigned to the requirement paragraphs listed in Chapter 4 of SS-ISO 9001, on the basis of the ranks they were given.

<table>
<thead>
<tr>
<th>Requirement paragraph in SS-ISO 9001</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3 Contract review</td>
<td>20</td>
</tr>
<tr>
<td>4.4 Design control</td>
<td>14</td>
</tr>
<tr>
<td>4.1 Management responsibility</td>
<td>12</td>
</tr>
<tr>
<td>4.9 Process control</td>
<td>9</td>
</tr>
<tr>
<td>4.6 Purchasing</td>
<td>8</td>
</tr>
<tr>
<td>4.10 Inspection and testing</td>
<td>6</td>
</tr>
<tr>
<td>4.18 Training</td>
<td>5</td>
</tr>
<tr>
<td>4.2 Quality system</td>
<td>4</td>
</tr>
<tr>
<td>4.5 Document and data control</td>
<td>4</td>
</tr>
<tr>
<td>4.8 Product identification and traceability</td>
<td>3</td>
</tr>
<tr>
<td>4.13 Control of nonconforming product</td>
<td>2</td>
</tr>
<tr>
<td>4.19 Servicing</td>
<td>2</td>
</tr>
<tr>
<td>4.12 Inspection and test status</td>
<td>0</td>
</tr>
<tr>
<td>4.14 Corrective and preventive action</td>
<td>0</td>
</tr>
<tr>
<td>4.16 Control of quality records</td>
<td>0</td>
</tr>
<tr>
<td>4.17 Internal quality audits</td>
<td>-1</td>
</tr>
<tr>
<td>4.11 Control of inspection, measurement and test equipment</td>
<td>-2</td>
</tr>
<tr>
<td>4.15 Handling, storage, packaging, preservation and delivery</td>
<td>-2</td>
</tr>
<tr>
<td>4.7 Control of customer-supplied product</td>
<td>-9</td>
</tr>
<tr>
<td>4.20 Statistical techniques</td>
<td>-14</td>
</tr>
</tbody>
</table>

As is evident in the table, contract review, design control and management responsibility are judged to be the most important.

Three of the paragraphs were not mentioned by any of the firms. These are inspection and test status, corrective and preventive action and control of quality records.

As one can also see in the table, statistical techniques together with control of customer-supplied product are viewed as least important.

C. Adherence to and importance of ISO 9001

In the investigation, each firm representative who was interviewed was asked to indicate, for each of the ISO 9001 requirement paragraphs, to what extent it was adhered to and how important it was. To what degree a standard was adhered to was judged on a scale of Not at all – Partly – Completely, whereas its importance was judged on a Small – Moderate – Large scale (Sandholm 1988). The results are presented in Table 4.
Table 4 Adherence to and importance of the different SS-ISO 9001 paragraphs as judged by the firms.

<table>
<thead>
<tr>
<th>Requirement paragraph of Chapter 4 SS-ISO 9001</th>
<th>ELA Adherence</th>
<th>Importance</th>
<th>ELB Adherence</th>
<th>Importance</th>
<th>ELB Adherence</th>
<th>Importance</th>
<th>PHVA Adherence</th>
<th>Importance</th>
<th>PHVB Adherence</th>
<th>Importance</th>
<th>PHVC Adherence</th>
<th>Importance</th>
<th>SUM Adherence</th>
<th>Importance</th>
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<td>1</td>
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<td>1</td>
<td>1</td>
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<tr>
<td>4.2 Quality system</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>0</td>
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</tr>
<tr>
<td>4.3 Contract review</td>
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<td>1</td>
<td>1</td>
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<td>1</td>
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<td>4.5 Document and data control</td>
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<td>-1</td>
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<td>4.11 Control of inspection, measuring and test equipment</td>
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<td>-1</td>
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<td>-1</td>
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<td>11</td>
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<td>12</td>
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<tr>
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<td>3</td>
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<tr>
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<td>14</td>
<td>-2</td>
<td>1</td>
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</tr>
<tr>
<td>Note: Degree of adherence was assessed on a scale of Not at all - Partly - Completely and is reported in the table as -1 = Not at all, 0 = Partly, 1 = Completely. Importance was assessed on a scale of Low - Moderate - High and is reported in the table as -1 = Low, 0 = Moderate, 1 = High.</td>
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</tr>
</tbody>
</table>
These interview results, concerning the degree of adherence to and the importance of the various ISO 9001 requirement paragraphs, can be compared with the degree to which the one standard was given higher priority than another, as reported in Table 2. In the text that follows, the extent to which these assessments and priorities agree or disagree will be commented on. Also considered will be how agreement or disagreement between the two types of assessments should be interpreted. A standard that one considers to be of great importance ought logically to be adhered to either completely or to a high degree. Similarly, there should be little reason to adhere to a standard one regards as unimportant. If the two types of assessments fail to agree in this manner, this can be interpreted as a desire for change. Various combinations of the two types of assessments can be interpreted as follows:

<table>
<thead>
<tr>
<th>Adherence</th>
<th>Importance</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>High</td>
<td>There is a desire to improve the situation.</td>
</tr>
<tr>
<td>Completely</td>
<td>High</td>
<td>The situation is under control.</td>
</tr>
<tr>
<td>Completely</td>
<td>Low</td>
<td>There is the feeling that too much is done.</td>
</tr>
</tbody>
</table>

In terms of an interpretative model of this sort, it appears that the firms consider that improvements are needed in various areas, in particular in the areas of management responsibility and of design control.

In the following, the various requirement paragraphs contained in ISO 9001 are commented on one by one.

**Requirement paragraph 4.1 – Management responsibility**

All but one of the firms that took part in the study had a definite policy regarding quality at the firm.

Considerable emphasis was placed on “Management responsibility” (judged to be the 3rd most important paragraph of all), at the same time as the comparison of adjudged importance and adjudged use of it suggested there to be a wish for improvement. This can be based on the policy in this regard being positively formulated but its failing to reflect a total commitment to quality on the part of management.

**Requirement paragraph 4.2 – Quality system**

All of the firms in the study reported having a well-documented quality system. Even the firm that had no clear policy concerning quality had its quality handbook almost finished and appeared very ambitious regarding the quality of its work.

A certain basic importance was also attached to the quality system generally (seen as the 8th most important paragraph), at the same time as the comparison of assessed importance and assessed use suggests the firms to be satisfied with the situation as it is in that respect. That can reflect either the fact that work to develop a quality system had just been completed in the organization, so that the firms had no desire to work further with it at the moment, or very simply that the quality system in effect appeared sufficient.
Requirement paragraph 4.3 – Contract review
Contract review was the paragraph that was assigned the highest level of importance (highest of the 20). All the firms considered it to be highly important and all but one declared that it made use of this paragraph. The results suggest that those firms that did not use routines in connection with “contract review” wanted to achieve improvement in this respect. In the interviews, various of the firms declared that failure to attend to this paragraph could have serious economic consequences.

It is possible that considerable emphasis was placed on this paragraph because of its being customary in the building sector to draw up a contract. This particular paragraph was viewed as being concrete in character, in contrast to various other paragraphs that appeared to be more abstract and difficult to apply.

Requirement paragraph 4.4 – Design control
“Design control” was the paragraph judged to be of second highest importance (2nd of 20). Four of the firms considered it to be of considerable importance but only one of the firms declared that it used it. Here a desire for improvement is obvious. The comments that were made during the interview indicated that drawings and descriptions are often made under conditions of extreme time pressure and often contain many flaws and limitations which give rise to conflicts and require extra work.

Like contract review, design control seems to be a paragraph with which one is familiar within the building sector. In addition, there seems to be a general view that many of the problems that appear during the production phase could be avoided if greater resources were devoted to design. That may be an explanation for this paragraph being given such a high position in the hierarchy.

Requirement paragraph 4.5 – Document and data control
A certain weight was attached to “Document and data control” (viewed as 8th-9th most important of the 20). Three of the firms regarded it to be of considerable importance and one of them said that it utilized it. There was thus a certain desire for improvement.

Keeping track of drawings, of distribution lists concerning whom these have been made available to and of how they have been revised are familiar routines within the building sector. It is very obvious when these routines fail to function as they should and when the resources available for the handling of documents are too limited. This can be an explanation of its being regarded as important that this paragraph function properly but of its failing to receive a high priority.

Requirement paragraph 4.6 – Purchasing
“Purchasing” was considered important (the 5th of 20 in importance). Three of the firms declared that they used it and that it was of some importance. Thus, there were no signs of a desire for improvement here.

This paragraph can probably be expected to be given much higher priority in the future if greater attention is directed at matters of material administration and material cycles. Since no measures of the effects of the steps one takes are available, there is no way of determining what profits one achieves through carrying out one’s purchases in some other way.
Requirement paragraph 4.7 – Control of customer supplied product
“Control of customer supplied product” was regarded as being of little importance (19th of 20 in importance). Since the answers obtained point in different directions, no clear interpretation of them is possible. These differing answers can indicate that the question was understood differently in the various interviews. It is also possible that “Control of customer supplied product” occurs to varying degrees in different firms and that how they deal with it is thus not strictly comparable. No wish for improvement is evident.

Since this paragraph is not directly linked with matters of day-to-day experience for the contractors, it is hardly strange that it is given such low priority. In fact, it can be seen as best that efforts not be wasted on adhering to a paragraph that finds little application.

Requirement paragraph 4.8 – Product identification and traceability
“Product identification and traceability” was judged to be of intermediate importance (10th in importance of the 20). Two of the firms regarded themselves as making full use of this paragraph and of its being of considerable importance. Another two considered themselves to use it in part and it to be of certain importance. The remaining two firms indicated a desire for improvement in regard to the use of this paragraph.

Since it is in the administrative phase that this paragraph is of greatest importance and since links between design, production and administration are often far from perfect, it is hardly strange that “product identification and traceability” are judged to be of no more than intermediate importance.

Requirement paragraph 4.9 – Process control
“Process control” was regarded as important (the 4th in importance of the 20). Three of the firms adjudged it to be of considerable importance and one of the firms declared that they used it. A desire for improvement is thus evident.

The term “process” can be defined here as production at the place of work. It can be seen as positive that process control is given high but not the highest priority, since it is important that a firm not think only of that. There are many other activities that also need to function well if there are to be any orders at all.

Requirement paragraph 4.10 – Inspection and testing
“Inspection and testing” was considered to be of very definite importance (6th in importance of 20). The electrical contractors declared both that they used this paragraph and that it was of considerable importance, whereas the contractors for plumbing, heating and ventilation declared that they made only partial use of it, two of the latter firms regarding it to be of considerable importance. The two separate sectors may possibly have developed differently in terms of this paragraph. A definite desire for improvement is evident among the plumbing, heating and ventilation contractors.

“Inspection and testing” are well-known phenomena for all types of contractors and it is quite usual that these functions are shared by contractors, those commissioning a job and public authorities. An aim of
the current design and building laws is that control by public authorities be reduced and that the person or organization commissioning a job and the building contractor agree among themselves regarding responsibility for control. This means that the degree of control and the responsibility for it must be clearly specified in the quality plan. The desire for improvement that is evident presumably originates in the desire to find effective routines for how control should be dealt with in the quality plan.

Requirement paragraph 4.11 – Control of inspection, measuring and test equipment
“Control of inspection, measuring and test equipment” was judged to be of rather low importance (17th to 18th in importance of the 20). All of the electrical contractors considered this paragraph to be a very important one which they made complete use of. One of the plumbing, heating and ventilation contractors concurred with this view, whereas the others regarded this paragraph as being of only slight importance and declared that they made no use of it.

In the plumbing, heating and ventilation sector, it is usual enough that tasks of control and adjustment be assigned the subcontractor. That can explain the answers given to questions about this paragraph.

Requirement paragraph 4.12 – Inspection and test status
“Inspection and test status” was adjudged to have a certain importance (13th to 15th in importance among the 20). Since the degree of use and the importance assigned it varied greatly from firm to firm, no general tendency could be discerned.

It does not appear that much attention is directed at this paragraph. This can be due to its abstract character. In a factory, to be sure, that produces large numbers of identical parts or objects, it is obviously important that those which are accepted be marked or separated from the rest so as not to be confused with those that are rejects and are to be destroyed or modified. In the building sector, it is difficult to find direct parallels to this. The “inspection and test status” paragraph is relevant, however, within the framework of a quality plan. The point is that one should not risk either missing some control that should be carried out or the carrying out of repeated controls.

Requirement paragraph 4.13 – Control of nonconforming product
“Control of nonconforming product” was assigned certain importance (12th to 13th place among the 20). Views regarding the importance of this paragraph and its degree of application varied. Only one of the firms showed signs of a wish for improvement.

It can be regarded as unfortunate that “Control of nonconforming product” has such low priority. For one thing, it is not unusual for nonconformity of the product to be discovered while building is in progress, which can lead to controversies, repairs, alterations, extra work, and the like. For the other, nonconformity of the product can be very expensive and very demanding of resources. Thus, there is much to be gained by efforts to avoid such nonconformity.
Requirement paragraph 4.14 – Corrective and preventive action
“Corrective and preventive action” was adjudged to be of certain importance (13th to 15th in importance among the 20). Assessments of the paragraph’s importance and use varied from the one extreme to the other. The results for one of the firms can be interpreted as the feeling that too much was done already.

Being blind to the obvious and lacking sufficient feedback can be seen as possible explanations of “Corrective and preventive action” not being given higher priority. Committing small errors and making adjustments for them afterwards has become a part of day-to-day work. One thus readily fails to comprehend how much would be gained by finding routines that reduce the number of mistakes that need to be corrected for.

Requirement paragraph 4.15 – Handling, storage, packaging, preservation and delivery
“Handling, storage, packaging, preservation and delivery” were assigned little importance (17th to 18th among the 20). Two of the firms regarded this paragraph as highly important and use of it to be complete, whereas two of the firms considered it to be of little importance and to not be used by them at all. Among the remaining firms, no desire for improvement is evident.

As was already mentioned (in connection with 4.6 “Purchasing”), consideration of material cycles can contribute to an emphasis on matters of material administration. This involves thinking ahead and exercising greater care regarding material so that waste and unmarketability are avoided. An example of such waste is that of electrical installations that are not sufficiently well defined at the production stage, so that one does not know exactly where each electric outlet is to be placed in a given room. The result can be that far too much electrical wiring is drawn through the walls simply to be sure that it will suffice for every corner of a room. The wages of those installing material or equipment tend to be based on how much material or equipment is to be installed, which does not encourage the effective use of it.

A possible explanation of the low priority given this paragraph is that more thorough planning is experienced as both dull and work-intensive and that one scarcely can conceive of having the system of remuneration changed.

Requirement paragraph 4.16 – Control of quality records
“Control of quality records” is assigned a certain importance (13th to 15th among the 20). Two of the firms regarded this paragraph as being of extreme importance and its use to be complete. One of the remaining firms indicated the wish for improvement, whereas two others showed just the opposite.

The introduction of quality records is a relatively new phenomenon within the building sector and some time will be required before keeping such records become a part of day-to-day work.

Requirement paragraph 4.17 – Internal quality audits
“Internal quality audits” is viewed as not being of much importance (the 16th in importance of the 20). None of the firms claimed they utilized this paragraph. One of the firms assigned high importance and two of the firms certain importance to it. This is the paragraph for which the wish for improvement is greatest.
Internal quality audits can serve as a motor in quality control work, preventing both stagnation and unwanted detours in directions that are irrelevant for a firm’s work. It is unfortunate that use is not made of this paragraph, but that can depend upon firms’ not being accustomed to availing themselves of it. If internal quality audits are to contribute to the work of a firm, it is essential that there be a climate of open debate and a will to take up difficult problems.

Requirement paragraph 4.18 – Training
“Training” was assessed as being of definite importance (7th in importance of the 20). Four of the firms regarded its importance as being considerable and its use within the firm as being complete. The importance of this paragraph thus seemed to be an obvious one to the firms.

Changes in laws and regulations, the increasing complexity of construction systems and the increasing need of new forms of installations contribute to the importance of a firm’s keeping itself up-to-date regarding new developments.

Requirement paragraph 4.19 – Servicing
“Servicing” is assigned a certain importance (11th to 12th in importance among the 20). Three of the firms considered this paragraph to have a high level of importance and that they made complete use of it. The remaining firms gave mixed answers. None of the firms viewed servicing to be without importance or declared themselves to make no use of it.

Requirement paragraph 4.20 – Statistical techniques
The firms were in complete agreement regarding “statistical techniques”, viewing this paragraph to be the least important of all (20th in importance among the 20 paragraphs). Each of the firms considered this paragraph to be of little importance and none of the firms felt they used it.

There is an abundance of statistical techniques which, if dealt with in a creative way, could be utilized by a contractor. However, this whole area is new to such firms and the initial resistance is large.

D. Analysis
Although many specialist contractors have the desire to conform with the requirement paragraphs of ISO 9001, they frequently fail to understand what the various paragraphs mean and how one best can work for their realization.

The firms that were interviewed ranked the 20 different requirement paragraphs in terms of the extent to which they utilized them and the importance they adjudged them to have. The results are summarized in table 5.

That table shows the degree of priority the different paragraphs are assigned and whether a desire for improvement is found (a desire for improvement can be so interpreted that a given paragraph is considered important, for example, but that the use to which it is put is very limited). Contract review, Design control, Management responsibility and Process control were the paragraphs that were considered most important and for which an improvement was also desired. The requirement paragraph Handling, storage, packaging, preservation and delivery was far down on the list, being assigned little importance, the view being that too much was
done with respect to it already. One of the most noteworthy and paradoxical results was that Internal quality audits was given low priority, despite a strong desire for improvement in regard to it.

**Table 5** Ranking of the various SS-ISO 9001 requirement paragraphs.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Requirement paragraph</th>
<th>Desire for improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.3 Contract review</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>4.4 Design control</td>
<td>+++</td>
</tr>
<tr>
<td>3</td>
<td>4.1 Management responsibility</td>
<td>+++</td>
</tr>
<tr>
<td>4</td>
<td>4.9 Process control</td>
<td>++</td>
</tr>
<tr>
<td>5</td>
<td>4.6 Purchasing</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>4.10 Inspection and testing</td>
<td>++</td>
</tr>
<tr>
<td>7</td>
<td>4.18 Training</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>4.2 Quality system</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>4.5 Document and data control</td>
<td>++</td>
</tr>
<tr>
<td>10</td>
<td>4.8 Product identification and traceability</td>
<td>++</td>
</tr>
<tr>
<td>11</td>
<td>4.13 Control of nonconforming product</td>
<td>+</td>
</tr>
<tr>
<td>12</td>
<td>4.19 Servicing</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>4.12 Inspection and test status</td>
<td>+</td>
</tr>
<tr>
<td>14</td>
<td>4.14 Corrective and preventive action</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>4.16 Control of quality records</td>
<td>-</td>
</tr>
<tr>
<td>16</td>
<td>4.17 Internal quality audits</td>
<td>+++++</td>
</tr>
<tr>
<td>17</td>
<td>4.11 Control of inspection, measurement and test equipment</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>4.15 Handling, storage, packaging, preservation and delivery</td>
<td>-</td>
</tr>
<tr>
<td>19</td>
<td>4.7 Control of customer-supplied product</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>4.20 Statistical techniques</td>
<td>0</td>
</tr>
</tbody>
</table>

Most of the specialist contractors concentrated their efforts on specific projects in which they were engaged. This seems natural enough since, in the building sector, firms are accustomed to being engaged in specific projects. They seldom conceive of their work as a continuous process but regard it as consisting of a series of separate projects. This may be the reason why they appear to have failed in achieving four of the particularly important requirement paragraphs of quality:

- Management responsibility (ISO 9001 4.1)
- Internal quality audits (ISO 9001 4.17)
- Statistical techniques (ISO 9001 4.20)
- Corrective and preventive action (ISO 9001 4.14)

Without attending to the latter paragraphs, it is not possible to maintain adequate quality control. An advantage in working in terms of separate projects, as one does within the building sector, is that this provides one greater freedom of movement in being able to try out different methods.
and discover better solutions to problems, since a project represents a clearly demarcated set of activities.

The danger in linking quality control work to a specific project is that this can lead to a firm’s neglecting those aspects of its activities which, although not linked to a particular project, are nevertheless very important for the work of the firm. Examples of this are such functions as those of administration, accounting, management, organizational development, marketing and storage or maintenance of stock.

There is a tendency to regard quality control as a checklist for internal control. The ideas connected with quality control influence work at a construction site far too seldom. If one is to work with quality control in a true sense, it does not suffice to simply do good work; one must also know why.

The study shows that marked changes have occurred since a system of quality control was first introduced at the level of the separate firm. The different requirement paragraphs concerning quality vary in the importance they are assigned and they are taken up with varying degrees of thoroughness, some of them not being dealt with at all.

**DISCUSSION**

Although all of the firms were engaged in quality control work, none of them could provide any measure of the degree to which resources were invested in quality control or of what effect it had on their activities.

It appeared that the plumbing, heating and ventilation contractors considered their quality control work to have advanced further than was the case for the electrical contractors. Yet when one examines to what extent the various quality paragraphs were utilized, the opposite picture emerges, the electrical contractors seeming to make use of a larger number of these paragraphs than the plumbing, heating and ventilation contractors did.

For the construction industry in Sweden, the present study appears to be particularly relevant in the following ways: a) it casts light on the degree to which quality work functions in the parts of the building sector examined; b) it indicates that no internal evaluation of the effectiveness of the existing quality systems was carried out there; and c) it suggests a relatively simple approach to evaluating such a system, both on an internal and an external basis. The method can be used internally by the person or department responsible for quality within the firm with the aim of discerning trends and focusing efforts at the goals for quality work that have been established. A purchaser can also use the method so as to compare the quality work of different suppliers with some desired profile or norm.

Public and private clients in Sweden demand of a planning or construction firm that it provide documented evidence of its commitment to quality, this being required by the Swedish Law (Plan- och Bygglagen 1987). As a consequence, companies that implements a quality system will have a better long-term competitiveness. ISO 9001 provides the framework for developing such a quality system. The developing of client expectation is not a typical Swedish phenomena, e.g in the United States there is a similar growing interest, (Hayden 1996).

In view of the considerable investment in resources which the introduction of a quality system represents for a firm, it is noteworthy that
the firms employ no concrete measures of the effects of quality control work.

The research project was financed by The Swedish Council for Building Research and a full report is available in Swedish (Landin & Persson 1995)

REFERENCES


Plan- och Bygglagen, 1987:10 (Swedish law regulating construction activities)

ISO 9001 Within the Swedish Construction Process

Anne Landin, M.Sc

Abstract

This study analysed how the ISO 9000 framework could be employed in the construction process. Interviews were conducted at twelve companies in Sweden that utilized the quality system standard ISO 9001.

Many of the concepts contained in the quality system standard were experienced as being too abstract and too difficult to comprehend. Frequently quality management was considered as serving the function of improving the company’s competitiveness and allowing the company to be more efficient. It appeared difficult, however, in view of the many stages the construction process encompasses and the diverging interests represented, to meet the needs of the construction sector by the use of ISO 9001 alone. Some of the paragraphs it contains also tended to be confused with one another and to be misinterpreted. Others, although useful elsewhere, appeared scarcely to find application in the construction sector. Developments in the area appear to be going in the direction away from using large bureaucratic inspection systems and quality handbooks aimed at impressing customers and towards employing more diversified systems. Certification was found to be a matter of concern to all of the companies investigated.

Keywords:
Quality Management, Construction, Certification, ISO 9000
Introduction

During the past few years many companies in the construction sector have made great efforts to introduce a quality system as an integral part of construction management. Many of these systems are structured in accordance with the standards contained in the ISO 9000-series. Since 1995, authorities in Sweden have demanded under building law that companies in the construction sector which have responsibility for a construction project have a certain knowledge of ISO 9001. This has contributed to companies in this sector becoming involved with the use of quality systems in general. The law concerning public competition for contractors, together with membership in the EU, also have contributed to companies preparing themselves for competition within a larger market than heretofore, a market in which customers may increasingly require suppliers to employ a quality system.

However, organization in the construction process is by its very nature multi-site, the scale of operations being extremely diverse. With activity being so diversified and carried out at far-flung locations, it is extremely useful to have a common system which every party is to follow (Tyler, 1993).

Construction cannot be categorized as being strictly either a service or a manufacturing industry (Kubal, 1996) therefore the construction industry needs to blend quality concepts from both the service and manufacturing industries.

The process itself is a transformation that adds value. Given the complexity of most organizations, it is important for quality management purposes to highlight, simplify and assign priorities to the major processes. The long-term performance of any building and its ability to satisfy clients' requirements depend both on decisions made by its designers and on the care taken and skill possessed by the workers at the construction site (Cheetham, 1993).

The International Standards of the ISO 9000 family reflect the concept that all work can be viewed as processes (ISO 9000-1:1994), thus having, like any process, both inputs and outputs.

The construction process is conceived, in this study, as encompassing all stages from the briefing to the commissioning stage, as can be seen in figure 1.
The aim of the present study is to analyse how the ISO 9000 framework can be employed in the construction process. The major question examined here is whether the inherent structure of ISO 9001 is compatible with the construction process.

**Method**

In the present study, interview data from a total of 27 respondents from 12 companies within the construction sector were collected during the fall of 1994. An interview guide was employed (appendix 1); one based on an interpretation of the ISO 9001 standard for the construction sector in Sweden (SIS Quality Forum, 1990).

The companies were selected so as to comprise various quality systems used within the construction process. Two consultants who were members of the research project group, Lars Björkman and Lars Ranhem, both with a thorough knowledge of the Swedish construction industry and extensive contacts within it, selected the companies judged to be at the forefront of quality assurance implementation (appendix 2).

Interviews were conducted with leaders and employees of the various companies. A qualitative approach was employed to identify those aspects of quality management, which are of central importance and in order to gain insight into problems related to use of the standard within the construction sector.
The respondents answered the open questions on the basis of their own experience. Accordingly, the data represent a broad spectrum of different views. The basic matters treated the following:
- Their experience of quality management at the company they represented
- Their experience of quality management stemming from projects in which they had been engaged
- Their experience of quality management based on their contacts with other companies.

The approach was to ask open questions that respondents were to answer by discussing the topics they considered most relevant. During each interview, a protocol was kept, aimed at capturing the most salient details, views and nuances. On the average an interview took about three hours. The interview material that appeared particularly representative and pertinent was then selected for further analysis. Such an approach, although permitting no quantitative conclusions to be drawn, can provide an understanding in depth, or a pre-understanding (Holme, 1991), of a given area. According to Bjerke (1981), a systems approach is more appropriate than an analytical approach for the investigation of self-organizing systems. Inter alia, it is desirable to use qualitative techniques to a greater extent than quantitative ones, to interact with the participants and to endeavour to understand them instead of carrying out simply a passive study of reality. Thus a holistic approach rather than an atomistic one is taken (Bjerke, 1981). This has the advantage of allowing an assessment to be made of the situation as a whole and an understanding of it to be gained from both a systems perspective and the perspective of the various actors involved (Holme, 1991), the resulting analysis being of hermeneutic character (Ödman, 1979).

So as to summarize the data, they were classified in various categories, each representing some set of views or observations pertaining to a particular topic in the field of quality management.
Empirical Findings
The empirical findings of the study are analysed level by level depending on where the quality work is done in a company, see figure 2.

![Figure 2. Different levels of the quality work.](image)

The data are not sorted on the basis of the interest group a respondent belonged to, because there were no signs that advocating one approach or another depended on this. One could well imagine, for example, that contractors would wish to create as little documentation as possible whereas clients would want very thorough documentation, but this was found not to be the case. An explanation of this may be that the demand for information varies with the personal style of decision-making (Driver and Brousseau, 1993) but not with profession. Another explanation may be that the respondents answered the questions on the basis of their total experience of work in the construction industry, not on their current role in a company.

Quality Management
Quality management appears to be primarily considered as a means of increasing effectiveness and enhancing competitive advantage. The empirical material contains a variety of views regarding the extent to which co-operation should take place within the construction sector and the extent to which the routines employed should be kept secret. The aspects of quality management considered particularly important were the
responsibility, which the company management assumed, and the involvement of employees.

Considerable time appears to have been needed within the construction industry for knowledge of quality management to be spread, a matter which is a problem in large organizations generally (Federle, 1993). Several respondents commented on the need for companies within the construction sector to change their approach to quality management.

Although the respondents appeared to comprehend the importance of quality management, none of them presented any concrete measures that had been taken to determine the economic gains. The examples given to show the advantages of quality management concerned temporal gains achieved by starting such work early in a project, increasing the possibilities of attaining a high degree of effectiveness. Some of the companies also had specific quality goals that were regularly assessed. Signs of advances in quality management can be seen in changes in the companies’ conception of the possibility to supply a zero-defect product. The heads of some companies had also begun requiring the use of certain evaluations to assess how far and to what extent quality management had been implemented. Although this can be seen as positive for the development of quality management, the measures mentioned by the respondents concerned mistakes discovered when a construction project had been completed. This is a matter of only limited interest, since a construction project represents a long process, in the course of which many mistakes can be made before the completion of the product.

**Quality System**

The respondents indicated that, previously the extensive inspection work required by a quality system was regarded as one of its major elements and drawbacks. It appeared that now, however, the quality system was regarded as more of a help than a burden, the emphasis on the need of inspection in the maintenance of quality having been reduced. Some of the respondents argued specifically that maintaining quality is not a matter of inspections. The companies seemed to endeavour to minimize inspections and to carry these out as early as possible in the construction process.

All the companies participating in the investigation utilized the quality system standards of the ISO 9000 series. These provide a common language that all the parties involved in a construction project can use to communicate both with each other and between different stages of the construction process. The quality system adopted appeared to be largely based on what already functioned well, such as a system for construction co-ordination. The standard is often experienced as being difficult to
understand, many of the companies had decided to create their own quality manual, structured not according to the standard, but according to principles that seemed better adapted to the tasks with which the company was faced. This supports the view that the construction process is in need of a quality standard of its own (Cheetham, 1993).

It seemed commonly to be the case that a quality system was created in a manner that fitted the particular activities in which the company was engaged, but that in communicating with customers the description of the system was transformed so that it conformed with ISO 9001. The major criticisms directed at the quality system standard were that:
- it was difficult to understand,
- it increased bureaucracy,
- it neglected economic matters such as profitability.

In Sweden, the fear that quality management would lead to extensive bureaucracy may well have hindered its development, particularly since the neighbouring country of Norway has had considerable problems with its increasing and very costly bureaucracy (Hansen, 1994). In this study respondents appeared often to regard handbooks of quality management as being too comprehensive. A less complicated approach to dealing with questions of quality management was sought after. In the view of one of the respondents, the fear of increasing bureaucracy can be largely dismissed if one takes into account the reduction in paperwork that the implementation of a quality system brings about.

Some respondents advocated a maximizing of information, while others advocated a minimizing of it (Driver and Brousseau, 1993). Thorough documentation was seen as giving the impression of high reliability. Concise documentation was regarded as being easier to handle but requiring special care in the selection of information.

The standard was created to be applied to all types of activities. This makes it somewhat abstract and inaccessible. One aim of the standard is to be applicable to contract situations in which a customer wants assurance that the supplying party will provide a product that satisfies the quality requirements of the standard (ISO 9001:1994). Thus, though the standard makes no reference to profitability, productivity, quality and profitability are linked in a very natural way. Productivity alone, for example, is meaningless if no account is taken of quality or of profit; this became evident in Japan, where productiveness was overemphasized and the value of a product to the customer tended to be neglected (Edvardsson, 1991). In a business, on the other hand, the danger of neglecting profitability is small. The official quality manual has become increasingly brief and concise. According to various
respondents who were sceptical about the use of the quality manual as an aid to the marketing of a product, the target group of the manual is not the customer but persons within the company who make direct use of it in their work.

**ISO 9001 versus the construction process**

A large part of the requirements stipulated in the ISO 9001 standard were found to be utilized in some form or other, albeit not all of them. There has been an obvious and positive change in the approach taken to quality systems. The major emphasis is no longer on inspection activities (such as in ISO 9001 4.10 Inspection and Testing). Rather, increasing use is made of the breadth inherent in the paragraphs on requirements.

The interview data showed the standard is not understood in the same way by all respondents, despite each of their companies being at the forefront in the use of quality management. Some of the requirements in the standard tended to be confused with one another or to be misinterpreted, as shown in figure 3.

<table>
<thead>
<tr>
<th>ISO 9001 Quality System Requirements</th>
<th>Common confusions of ISO 9001 in the Construction Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Responsibility</td>
<td>4.1</td>
</tr>
<tr>
<td>Quality system</td>
<td>4.2</td>
</tr>
<tr>
<td>Contract Review</td>
<td>4.3</td>
</tr>
<tr>
<td>Design Control</td>
<td>4.4</td>
</tr>
<tr>
<td>Document and Data Control</td>
<td>4.5</td>
</tr>
<tr>
<td>Purchasing</td>
<td>4.6</td>
</tr>
<tr>
<td>Control of Customer-supplied Product</td>
<td>4.7</td>
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<tr>
<td>Product Identification and Traceability</td>
<td>4.8</td>
</tr>
<tr>
<td>Process Control</td>
<td>4.9</td>
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<tr>
<td>Inspection and Testing</td>
<td>4.10</td>
</tr>
<tr>
<td>Control of Inspection, Measuring and Test Equipment</td>
<td>4.11</td>
</tr>
<tr>
<td>Inspection and Test Status</td>
<td>4.12</td>
</tr>
<tr>
<td>Control of Non-conforming Product</td>
<td>4.13</td>
</tr>
<tr>
<td>Corrective and Preventive Action</td>
<td>4.14</td>
</tr>
<tr>
<td>Handling, Storage, Packaging,</td>
<td>4.15</td>
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<tr>
<td>Preservation and Delivery</td>
<td></td>
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<tr>
<td>Control of Quality Records</td>
<td>4.16</td>
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<tr>
<td>Internal Quality Audits</td>
<td>4.17</td>
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<tr>
<td>Training</td>
<td>4.18</td>
</tr>
<tr>
<td>Servicing</td>
<td>4.19</td>
</tr>
<tr>
<td>Statistical Techniques</td>
<td>4.20</td>
</tr>
</tbody>
</table>

Figure 3. The twenty requirement paragraphs tend to be easily confused with one another and to be misinterpreted.
In addition, some of the requirements, although useful elsewhere, appear to scarcely find application in the construction sector.

**Contract review (4.3) and Purchasing (4.6)**

Some of the companies tended to confuse the two requirements, paragraphs 4.3 and 4.6. Some actually considered them to be identical. Whereas 4.3 concerns contracts made between a company and a given customer, 4.6 concerns contracts made between a company and a particular supplier. One of the companies chose to insert its own purchasing routines into paragraph 4.3 of ISO 9001, which is clearly wrong. Others responded to the question of what routines they follow in drawing up contracts by indicating those routines that apply to contracts with their own suppliers. As defined in the standard, the supplier is the organization that provides the customer with a product, ISO 9001 dealing with the relationship between the customer and the supplier. One can easily misinterpret the standard to mean that a building contractor could view a company as its supplier rather than as a subcontractor, it is according to the standards.

A building contractor with a quality system is a supplier since it is subject to the standard. Figure 4 indicates how the standard is meant to be interpreted. The statement that a building contractor cannot be a supplier is thus false, despite respondents frequently asserting this to be the case.

![Figure 4. Distinction between "ISO 9001 4.3 Contract Review" and "ISO 9001 4.6 Purchasing" for a particular supplier (ISO 8402:1994).](image)

**Design Control (4.4) and process control (4.9)**

Some of the respondents claimed that the design stage is dealt with in paragraph 4.4, irrespective of whether the company involved is an A/E-firm or a contractor. Other respondents claimed that the "design process" of an A/E-firm is dealt with in paragraph 4.9.
No concrete examples were given of how a company tended to control activities such as design and project planning. This may be due to the 20 paragraphs regulating the quality system requirement being viewed as located on a time axis and project planning as something that occurs earlier (in connection with ISO 9001 4.4), 4.9 being regarded as pertaining to what happens at the construction site.

**Document and Data Control (4.5) & Control of Quality Record (4.16)**

The respondents did not clearly distinguish between the requirements in 4.5 and 4.16. An explanation may lie in the fact that the text of the standard leaves considerable leeway regarding the interpretation of the requirement.

**Control of Customer-Supplied Product (4.7)**

Within the construction industry, situations such as the following can arise, in which a customer supplies a product:
- when the client purchases materials or objects for installation from one company and then purchases the service of the installation from another company (Landin and Persson, 1998).
- when a repair and rebuilding contractor supplies parts of what becomes the final product.
- when, during the contracting period, some portion of what the contractor supplies is provided by the client.

Although such situations are usual in the construction sector, they appear either to be of low priority or not to be understood properly, since none of the respondents addressed them.

**Product Identification and Traceability (4.8)**

None of the companies that participated were able to present any good examples of routines concerned with the identification and traceability of their products. The examples respondents described concerned the traceability of built-in materials such as asbestos, casein and padding materials.

Questions of the traceability of programming or planning were not discussed at all by the respondents.

**Control of Inspection, Measuring and Test Equipment (4.11)**

None of the firms were able to provide any good examples of how measuring equipment was handled.

**Control of Nonconforming Product (4.13) & Corrective Action (4.14)**

It became evident that some misunderstanding existed regarding what was intended by the paragraphs 4.13 and 4.14. Routines
regarding how mistakes are to be corrected were even considered by some of the companies to be dealt with in paragraph 4.9 "Process Control". Although a company can decide to design its quality system in some other way than that described in the standard, this does not change the content and structure of the requirement paragraphs. Also, although some respondents declared that a first-time client is unconcerned about the supplier's making use of earlier experience, a first-time client can indeed go to great pains to ensure that the supplier's routines for taking advantage of earlier experience function well. A supplier who has managed to properly utilize experience gained from earlier projects can be expected to perform well in producing the product for the first-time customer.

Handling, Storage, Packaging, Preservation and Delivery (4.15)
A frequent misinterpretation of this paragraph by respondents was to erroneously assume that paragraph 4.15 is not applicable to the construction sector. Although many contractors had logistics handbooks containing routines for handling construction materials, they often chose to treat such routines as belonging to paragraph 4.9 "Process Control". This is not in agreement with the content of 4.15.

Internal Quality Audits (4.17)
Internal quality audits appear to be assigned surprisingly great importance within the construction sector. Not all of the companies that considered internal quality audits to be important carried them out, but all of them planned to do so.

Statistical Techniques (4.20)
Although statistical methods are clearly used within the building sector, such as in connection with testing structural concrete and measuring moisture, the routines developed for such methods were found often to be dealt with under 4.10 "Inspection and Testing".

Quality Plans
The concept of a quality plan is new in the construction sector and rather difficult for those involved to comprehend, thus leading to considerable confusion. Such a plan is often mistakenly thought of as a project plan or an inspection plan (Sjøholt, 1995). An investigation carried out in 10 European countries indicated that there was considerable variation in the content of quality plans. The greatest differences concerned the question of whether the origin of the demand for the quality plans was internal or external to the company. In the latter case, economic
aspects were included (Sjøholt, 1995). The results obtained in the present investigation point to a similar conclusion.

In the construction sector, quality management is often focused on a particular project and thus on a quality plan. This has definite consequences for the quality system. Quality plans have become the instrument most widely employed. At the same time, there is a tendency for emphasis to be shifted from quality plans to the quality system. Customers tend not to be interested in highly detailed quality plans. Contractors also tend to prefer having set routines that apply in a very general way to various activities encountered repeatedly, in project after project. As a result, quality plans for the individual project tend to become increasingly brief, reducing bureaucracy and placing greater demands on the company’s quality system. In the construction sector, quality plans are negotiated for each project separately and are highly dependent upon who the client is, the type of negotiations involved, the type of project, etc.

In the view of the companies themselves, the quality systems of the A/E-firms involved in a project are generally not developed in as much detail as those of contractors. The use of quality plans in connection with projects has contributed to A/E-firms becoming increasingly concerned with quality management.

All the parties involved tend to have a positive view of quality plans and to consider them to be an excellent instrument for improving profitability and effectiveness. A particularly problematic aspect, however, is that of their legal status. No one knows with certainty what legal implications quality plans have. This can result in problems later. In Singapore for example, the question of whether quality assurance should be incorporated into building contracts generally is in need of clarification (Peng, 1994). Quality plans should be brief and concise, dealing only with routines specific to the project in question. The fact that they tend to be increasingly concise appears to be due to:

1. quality systems becoming increasingly effective, dealing with general activities of relevance to all projects.
2. the overambitious, highly detailed quality plans employed earlier leading to the demand for brief and concise quality plans.

There is a certain fear that there is a trend towards the development of fixed and easily accessible quality plans that any company, whether serious or not, can make use of. This is often experienced as being a threat to those companies that work for quality in a serious way, since customers are not able then to distinguish serious suppliers from those who simply copy fixed quality plans.
Relations to other organisations

The respondents showed a somewhat dubious attitude towards their customers, perceiving customers that posed unexpected demands as uncomfortable, rather than taking advantage of the opportunity this provided for improvement. Customer satisfaction is perhaps the concept most basic to efforts of ensuring quality. All changes and improvements in an organization that occur systematically have customer satisfaction as their ultimate goal (Edvardsson, 1991). This is because a satisfied customer returns, with continued profit-making as a result. Nevertheless, there is the tendency within the construction sector to try to manipulate the customer into expressing the needs and desires the supplier wants to satisfy. The greater the number and intensity of the special demands customers express, the more this can lead to the suppliers improving, but only if the supplier responds to the demands.

Views varied considerably regarding the competence of customers in the requirements they placed on contractors’ quality systems. Some respondents complained about the incompetence of many clients. They felt that clients were often unaware of the requirements they should or did in fact place on the supplier, that some of them required too much and others too little, and that they tended not to follow up these requirements. Other respondents felt that clients tended to improve in these respects as quality systems improved.

Various respondents claimed that one positive effect of the failure of clients to follow up on the demands they made was that contractors and A/E-firms have become more independent in their quality management. They had been forced to create their own quality routines in line with this, by the work they normally carried out, albeit without attending to the desires of clients. Conflicts of interest in quality routines could be clearly detected, as remarks of various respondents indicated. For example, if contractors considered clients to be incompetent and consultants not to know what went on at a construction site, this made it difficult for quality routines to be implemented properly. Since quality systems aim at contributing to a better understanding of such conflicts, being able to discuss sensitive questions of this sort more openly can be seen as a sign of progress.

The European construction industry is fragmented and there appear to be many barriers to development, particularly that of a conservatism based on parties tending to rigidly defend their own positions (Henricson, 1994), a view that respondents in the present investigation supported.

Another view of respondents was that, whereas effectiveness in other sectors had increased, enabling clients to purchase a better product at a lower price, the construction sector was
selling the same sort of product as earlier at a higher price. This finding is supported by an American investigation of changes in productivity between 1969 and 1993 (Teicholz, 1994). In this study it was found that, whereas the manufacturing industry had increased in productivity, there had been a decrease in productivity in the construction of apartment houses. This suggests that the phenomenon is not unique to the Swedish construction industry.

According to the respondents, the extent to which quality management has progressed varies considerably within the construction sector. In some companies, quality management had developed gradually, whereas in others an ambitiously conceived quality system had been established within a short period of time. In still others, clients were misled by a quality system being marketed that did not really exist. Even in those companies in which the most serious efforts had been made to establish a quality system, quality management had not yet become fully integrated within the company as a whole. Although the essence of quality management is not the filling in of forms, many persons appeared to experience this as being the case. Concerning the general quality standards that have been formulated, there was wide acceptance of the view that companies that employ these standards tend to have more reliable quality systems than companies that do not.

The most serious criticism directed at consultants was that they appeared unable either to define the task they were to carry out or to provide a definite price estimate. Although it may be difficult to determine at an early stage what scope a consultancy task will have, it seems reasonable to assume that the more a quality system is developed, the better a consultant will be able to accurately assess the task as a whole.

Some companies that were in the role of customers were dissatisfied with their suppliers. In the efforts to control the latter, they had developed a system for assessing and controlling the quality of the work suppliers performed (ISO 9001 4.6).

**Certification**

Each of the respondents had something definite to say about certification. Some of them felt that it was good for the construction sector and others that it was bad. One got the impression that rumours abound within the construction sector concerning that the certification procedure is a fraud. Such a sceptical view can be a healthy sign as long as it does not result in certification being rejected on false premises.

A view frequently expressed was that it is a mistake that it is the system and not the product that is certified. The ISO standards in the ISO 9000 series are intended as a complement to the
technical requirements that customers place on a product by demanding quality of the process that leads to the finished product. Although a logical consequence of the critical view just cited might be thought to be that of ISO 9000 standards not being seen as desirable, each of the companies that participated wanted to employ the standards. In summary, one could conclude that companies in the construction sector have begun to apply these standards and that quality management has developed rapidly during the past few years, but that the sector is not yet ready to implement certification.

Discussion
Companies within the building sector have obviously made great efforts to introduce quality systems that can be regarded as integral parts of the overall system of control of the construction work they undertake. The broad acceptance of the standard ISO 9001 is an important step toward the establishment of systematic quality control within the construction sector. Many of these companies also have quality systems that are structured in accordance with the ISO 9001 standard. All the companies participating in the study invested considerable resources in implementing quality systems. Each of them had taken a positive attitude to the use of the standard. Although they did not employ the ISO 9001 standard in all situations, there appeared to be a general belief on their part that the ISO 9001 standard could provide a common language for use at all stages of a construction process.

Quality systems and quality plans
Managers in the construction sector seem to prefer to consider the activities pursued to consist of separate projects rather than of a single process which produces completed projects of various types. Whereas in the first case great importance is attached to the quality plan, in the latter case current activities of all sorts are dealt with by the quality system, quality plans being drawn up only under relatively unusual circumstances. Although a certain reluctance to structure a company’s quality system in accordance with ISO 9001 was evident, all respondents agreed that it was important to have a common structuring of quality systems in contacts with clients. The most common approach appeared to be to develop some system that seemed to fit the activities in which the company was engaged and then, when communicating with clients, to speak in terms of ISO 9001.
All the parties participating expressed a positive attitude to the use of a quality plan, appearing to consider such a plan to be useful as a control instrument for achieving profitability and efficiency. What was seen as problematical was the question of the legal status of such a plan.

The respondents were uncertain about what legal implications a quality plan has and felt that such uncertainty could lead to problems later. In the construction sector, the quality management carried out within individual projects is often concentrated to quality plans.

There has been a tendency, however, for the role of a more general quality system to increase and that of a more specific quality plan for an individual project to decrease.

**Application of the paragraphs of requirement**

The reformulation of 4.5 in the revised set of standards from "Document control" to "Document and data control" may contribute to the utilization of information technology in the construction sector. Since much of the information available is stored in electronic media, there is good reason to ensure that it is presented in such a way that it is readily available and easy to handle. An example is to have a strategy for the relevant information technology (Landin, 1993).

For the construction process, with all of its varying steps and interests, interpreting ISO 9001 seems difficult at times. Some of the steps in the construction process are not clearly distinguishable from one another. Also, the contractual forms and the share of responsibility can vary. One consequence of this is the lively debate developed in Sweden concerning how "ISO 9001 4.4 Design Control" and "ISO 9001 4.9 Process Control" should be interpreted. My own view is that a company that wants to employ the standards of ISO 9001 should start by defining its own product, and consider it as the result of a process. When the product has thus been defined, one can go on to define the process. When a company has defined the process in hand, control of it should be carried out in a manner conforming to "4.9 Process Control".

The interviews dealt specifically with ISO 9001 since this is the most comprehensive quality system standard available. However, this does not mean that the products of a company that employs ISO 9001 necessarily achieves a higher level of process quality than one using ISO 9002 or ISO 9003. The standard appropriate for the activity in question should be used. It is also possible for a company to use different sets of standards, depending upon the type of activity involved. The results of the interviews indicated a preference for the use of ISO 9001, perhaps due to its being regarded as having the highest status. In time praxis will
undoubtedly determine what quality system standards are most appropriate for the construction sector.

Some of the paragraphs on the list (4.7, 4.8, 4.11, 4.12, 4.15, 4.19, and 4.20) are hardly used at all within the construction sector. Although there are routines applying to some of them, such routines are generally assigned to other paragraphs instead.

Even though a company employs ISO 9001, it need not make use of all the paragraphs it contains. Some may, in fact, not be applicable. For example, "ISO 9001 4.11 Control of Inspection, Measuring and Test Equipment" is not applicable to a company which does not have such equipment. For a company that has measuring and test equipment, however, it is wrong to interpret the standard as if one could just as well assign one's calibration routines for such equipment to some other paragraph simply because of the routines involved are possibly connected in some way with activities that are closely related to that paragraph. Such misinterpretations of the paragraphs could undermine confidence in the quality system, however satisfactory the routines available may be.

The requirement paragraphs are based on the idea of using an abstract model to give a concrete activity a certain structure. Willingness to think in these terms seems often to be lacking within the construction sector.

The fear which seems to exist, namely, that developments are going in the direction of ready-made and easily accessible plans that anyone can use, however superficially, does not seem justified. There are many small to medium-sized companies that work in a serious and efficient way but lack the resources needed to develop a structure for quality plans (Landin, 1995). The whole idea of a set of general standards for a quality system is to have a structured set of principles for the purpose of orientation, a set of principles which makes the company's competence and capabilities clear to the customer. Thus, a printed set of quality plans can be seen as an extended development in this same direction. Although this does not mean that all companies should attack their problems of quality in the same way, use of such a set of plans can lead to different companies reporting to customers and authorities in a similar way (Landin, 1995).

**Approval of quality systems**

Most companies within the construction sector in Sweden seem to want an approval of their quality system. There are exciting times ahead since it will surely be decided within the near future how the quality system standards should be interpreted and what additional standards will be called for. The strictness of the standards is also a matter that will probably be discussed at length.
Internal quality audits appear now to be assigned a surprisingly high degree of importance within the construction sector. This can be seen as a considerable step forward. Indeed, if one fails to assess the quality system that has been established, one is unable to say whether or not it functions well or where more resources may be needed. If this willingness to have quality audits holds and systematic audits gradually come to be carried out regularly, the result may well be as follows:

- that activities, which tend now to be placed in the wrong category within the quality system, will become properly classified
- that resources will be made available to develop those routines that are not at present up to par
- that a workable solution will be found, in connection with the requirement paragraphs, to distinguish between project design and production
- that it will be easier to distinguish between the quality system and a quality plan
- that one will be able more readily to assess the effects that a quality system has within a company.

This, in turn, should lead to positive developments in quality management within the construction industry.

There are certain problems of interpretation that represent difficulties in implementing ISO 9001 in companies involved in the construction process. This problem is not of such great proportions, however that it should give rise to the development of a special standard for the construction area. Future research should focus on how to create quality systems that work for all the varying steps in the construction process and to the satisfaction of all the interests involved.

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Appendix 1. Interview guide

1. Introduction, presentation of the project
2. The company’s views on quality management
   - within the quality control system
   - in projects and in quality control plans
   - in relation to customers and owners
   - in relation to contractors
   - in relation to suppliers
   - in market contacts and in bidding
   - in connection with certification
   Group A
   4.1 Management responsibility
   4.2 Quality System
   4.3 Contract Review
   4.17 Internal Quality Audits
   Group B
   4.4 Design Control
   4.9 Process Control
   4.10 Inspection and Testing
   Group C
   4.6 Purchasing
   4.13 Control of Non-conforming Product
   4.14 Corrective Action
   Group D
   Further sections in the standards
   Definitions
   Quality plans
4. Further views
Appendix 2. Companies interviewed

Clients:
- Swedish National Rail Administration
- Sweden Post Real Estate Company
- L M Ericsson Properties, Inc.
- Swedish National Road Administration

A/E-firms:
- Scandiaconsult
- EVR & Wahlings
- Construction Management, Tyréns
- HJS Architect Stockholm

Contractors:
- Siab
- Skanska
- Asea Brown Boveri (ventilation)
- Asea Brown Boveri (installations)
Landin A, Nilsson C-H, Does Quality Systems Really Make a Difference, Building Research and Information, accepted for publication, 2000
Do Quality Systems Really Make a Difference?

Anne Landin, M.Sc and Carl-Henric Nilsson, PhD

Abstract

The purpose of this study was to ascertain whether companies in the Swedish construction process measure the impact of a quality system and, if so, whether the balanced scorecard is a useful technique as a performance measure. The balanced scorecard requires each organization to look at itself from four different perspectives: the financial perspective, the customer perspective, the process perspective, and the innovation and learning perspective. In this study twelve studies were performed in companies with well-established quality systems. The results show two main things:
- The balanced scorecard can be used to measure the performance of quality systems in the construction process.
- The innovation and learning perspective is not used to its fully potential.

The balanced scorecard is an interesting tool as a performance measure for quality systems. In this study the balanced scorecard was very useful because it reveals the lack of balance between the four different perspectives in the construction industry.

Keywords:
Quality Management, Construction, Balanced scorecard, ISO 9000
Introduction

The use of ISO 9000 for Quality Management is spreading from the manufacturing industry to other sectors such as the construction sector. The overall purpose of introducing ISO 9000 in a company is to increase the performance of the organization. However, there is little evidence linking quality management investments to improvements in organizational performance. Another management tool aimed at controlling organizational performance is “the balanced scorecard”. Neither method is well understood in the construction industry, but may prove useful in managing such companies at the business unit level.

Research concerning control systems in the construction sector have been traditionally focused on the project level, thus omitting a comprehensive view of the company. This study addresses the issues at the company, or business unit, level. In this study, the impact of the implementation of ISO 9000 quality management systems in several companies in the construction sector was analysed with a balanced scorecard. The purpose of the study was to improve our understanding of the relationship between quality system implementation and organizational performance at the business unit level.

In ISO 9004-1:1994 "Quality Management and Quality System Elements - Part 1: Guidelines", which describes the basic goals in establishing a quality system, the following is stated (Chapter 6.1, Financial Considerations of Quality Systems):

It is important that the effectiveness of a quality system be measured in financial terms. The impact of an effective quality system upon the organization's profit and loss statement can be highly significant, particularly by improvement of operations, resulting in reduced losses due to error and by making a contribution to customer satisfaction.

Such measurement and reporting can provide a means for identifying inefficient activities, and initiating internal improvement activities.

By reporting quality system activities and effectiveness in financial terms, management will receive the results in a common business language from all departments.

Measuring the impact of a quality system solely from a financial perspective may not be sufficient. Traditional financial measures can give misleading signals, encouraging
companies to achieve short-term financial results at the expense of long-term objectives. In the manufacturing industry, these problems have been observed in the form of reduced investments and neglected maintenance. One solution to the problem during the second half of the 1990s has been the balanced scorecard (Kaplan and Norton, 1992).

The use of the balanced scorecard in business is well established in large and sophisticated firms. The use of scorecards in an organisation is strongly driven by a strategic view of the mission of the organisation and the vision of how this will be achieved. A good model of the business and the inter-relationships between different activities and functions is essential. The balanced scorecard is a management system which can bring about sustained profitability and breakthrough improvements in critical performance (Newing, 1994). The model integrates long-range strategic plans with short-term measurable objectives (Kaplan, 1994). The scorecard is not a replacement for financial measures, it provides a more comprehensive view of the company in which the financial perspective is one of four perspectives. The other perspectives are the customer perspective, based on the marketing strategy, the process perspective, based on the manufacturing strategy, and the innovation and learning perspective, which deals with the ability to cope with changing circumstances. Balancing the scorecard implies that these perspectives are afforded approximately equal importance. Furthermore, balancing is also pursued within each perspective. All perspectives consist of roughly three to five different measures, providing a nuanced picture of the company's performance but two to three measures per perspective may provide a more transparent tool for the organisation (Nilsson, 1997).

Theoretical Review

Quality systems such as ISO 9001 are gradually being implemented in the construction industry, but their purpose is not fully understood at any level of many companies in this sector. Other novel management systems such as “the balanced scorecard” are also not well understood. Therefore, a brief review of the underlying philosophies is presented.
Quality systems

All of the standards in the International Standards in the ISO 9000 family are generic and independent of any specific industry or economic sector. A quality system can focus on one or several of the following: the input to the process, the process itself, or the output. For instance, the quality of the fruit and vegetable stand in a supermarket is primarily dependent on the input, cold and fresh vegetables and fruits, while the quality of vegetables served with a meal at a restaurant is dependent on the input as well as the production process at the restaurant. Some car manufacturers during the 1970s and 1980s maintained a high quality by monitoring and checking each car before delivery. This output-focused quality system was deemed too costly, and an alternative is ISO 9000, which focuses on the production process. When ISO 9000 is implemented, it controls operations such that they run, not at a maximum quality level, but at a predefined, constant satisfactory level. While a constant level of quality is the essence of ISO 9000, it is also the major drawback which critics of the system call attention to, i.e. continuous improvements of the production processes are not encouraged. In the next version of ISO 9000, to be released in the year 2000 this “bug” should have been removed.

Collectively, the ISO 9000 standards provide guidance for quality management and quality assurance. An effective quality system should be designed to satisfy customer needs and expectations, while serving to protect the organization’s interests (ISO 9004-1:1994). A quality system is a tool for steering and improving the quality of the company’s products. Systematic work on quality improvements requires well-planned routines and, in this respect, the standards in the ISO 9000 family serve an important purpose.

The balanced scorecard

During the late 1980s, a group of managers of major American companies gathered together with Professor Kaplan from Harvard Business School and one of the managers was Norton from a consultancy firm. The objective was to answer the question: Are we managing our businesses with suitable tools for long-term prosperity? If not, how should such a tool operate? The answer to the second question is the balanced scorecard.
The balanced scorecard rests on two basic assumptions:
- Running a business is a complex task, so much so that one measure, e.g. return on capital, is not enough to guide anybody in the company. Several indicators are needed, preferably from several perspectives.
- Measuring something is a way of directing attention to it, or put more popularly; what you measure is what you get.

Implementation of the balanced scorecard starts with the company’s vision and strategy. Based on the vision and strategy, the same four questions are posed in turn, for each of the four perspectives: financial, customer, process and innovation and learning.

For the financial perspective the questions are:
- How will we appear as a company if we reach our financial goals?
- What are the key success factors for reaching our financial goals?
- What actions have to be taken in order to reach our financial goals?
- What is it critical to measure in order to reach our financial goals?

For each of the remaining perspective the word “financial” is substituted for in term: “customer”, “process” and “innovation and learning”.

The balanced scorecard is usually presented in the form of four boxes around a circle, see Figure 1. The perspectives are arranged in three horizontal layers, from top to bottom:
- The past: Financial perspective
- The present: Process and customer perspectives
- The future: Innovation and learning perspective
The balanced scorecard strategy and perspective causality.

These layers provide a balanced time horizon, some very short-sighted measures, such as financial measures, and some medium-term and long-term measures.

Furthermore, the perspectives are related in a logical manner, as indicated by the arrows. For example in order to achieve financially good results the customers have to be satisfied. How do we keep customers satisfied? The answer is: Through a well-organized internal process and by continuously learning more and upgrading the processes and innovating new products.

In general, the balanced scorecard has been recognised and met with enthusiasm in several industries. Since the mid-nineties, many of the larger corporations have implemented the balanced scorecard; Ericsson, Atlas Copco and Scandia, to mention a few. Many medium-sized and small companies are presently implementing balanced scorecards.

The primary criticism of the model so far is related to:
- the problems of coordinating information gathering with several IT systems within a company,
- grasping scorecards with many parameters (systems with 20 different measures),
- the four perspectives not being sufficient (common additional perspectives are the employee perspective and the environmental perspective).

Method
An investigation was carried out of the indicators used by twelve companies in Sweden to monitor the performance of their quality systems with the aim of determining how far these could be constituted as a balanced scorecard. The companies were selected so as to encompass various quality systems used within the construction process, and were judged to be at the forefront of quality assurance with considerable and long experience of the Swedish construction industry. The criteria for the selection of the companies was:
- they must have had a quality system in the company for at least three years,
- the quality system should be adopted to the quality standard of ISO 9000,
- they should have a genuine interest in quality issues, as evidenced by, e.g. active participation in conferences or debates.
- they should be able to show a quality plan for a project.

The project was limited to companies in Sweden within the construction sector, and among the companies, four clients, four architectural/engineering-businesses, and four contractors were represented. These categories were judged to represent the construction process, see Figure 2.

![Figure 2. The chosen categories cover the construction process.](image)

The numbers of employees and the sales volumes of the companies are listed in Table 1. Interview data were collected from 27 individuals during 1994. The respondents held positions in the companies such as CEO, regional manager or
quality manager. During each interview, notes were taken, so as to capture the most salient details, views and nuances. The material that appeared to be particularly representative and pertinent was then selected for further analysis.

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Table 1. The size of the companies included in the study

The study was not intended to provide answers such as: 27% of the companies did this or that. Such information is of little practical relevance (McCloskey, 1992). Instead, a qualitative methodological approach was considered more apt for this study. Although no quantitative conclusions can be drawn, a deeper understanding of the subject is obtained (Yin, 1981; Eisenhart, 1989). The data from the companies representing the various actors within the construction process were used as the basis for the interpretations arrived at. The interviews involved open questions concerning different aspects of the quality system (Landin, accepted for publication). A qualitative method was employed to classify the data and to gain insight into the problem, see Figure 3.
Figure 3. Methodology

Three investigators were present at each interview. The use of multiple investigators has two key advantages (Eisenhardt, 1989):

- They enhance the creative potential of the study because team members often have complementary insights which add to the richness of the data.
- The convergence of observations from multiple investigators enhances confidence in the findings.

First, the remarks made by the respondents concerning the effects of the quality system they employed and the measurements used, were identified, and listed. The data were divided into different categories depending on the subject. The interview data were then analysed and sorted into different categories or key factors several times until all of the data had been fitted into one of the categories. The key factors were

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settled when the content in each reached a balance. The results reported here represent a collective analysis of all cases organized according to the key factors emerging from the interviews. Each key factor was evaluated in terms of both its importance and its use in practice as indicated by the respondents. Finally, the key factors which emerged were fitted into the four traditional categories of a balanced scorecard.

**Empirical Findings**

The analysis of the results of the interviews at twelve different companies covering the whole construction process showed the companies to be strongly convinced that it was both beneficial and profitable to employ a quality system. Reasons of a logical character were commonly referred to in connection with quality techniques.

It was reasoned that taking the correct action from the beginning through conscious and effective planning, and putting this into practice through sound management, would result in lower costs than if erroneous actions had to be corrected. Although this line of reasoning is simple and obvious, and constitutes a strong argument for the use of a quality system, it is by no means certain that a quality system used in real life fulfils the purpose for which it was designed, especially if the effects are not examined properly, and if it fails to be linked with specific goals.

The danger was thus seen that the implementation of a quality system could involve the introduction of routines that had no positive effect on the organization and were simply a waste of time.

The result was nine key factors as follows:

- Time required for quality work
- Control of inspections
- Certification cost
- Customer satisfaction
- ISO 9000 certification
- Zero defects at delivery
- Competitiveness
- Efficiency
- Follow-up
The “time required for quality work” denotes the time spent by management and the employees on the quality system in the company. “Control of inspections” means that the inspections that should be made must be planned so that they are relevant and not too costly in each project. A certificate from a third party costs a certain sum of money, depending on different factors such as the size of the company and line of business, and this is included in the key factor “certification cost”. However, when a company introduces a quality system according to a standard, one of the goals can be to obtain third-party certification and this is covered in the key factor “ISO 9000 certification”.

The key factors were fitted into the different perspectives in the balanced scorecard and the results were as follows:

Financial perspective

Time required for quality work
All the companies set aside time for quality work. None of the companies measured the amount of time, but the data revealed the following. In one of the large companies, 4 or 5 people were engaged full time. In one of the medium-sized companies, higher management devoted some 30-40% of their time to quality work. In another of the medium-sized companies two people were engaged in quality matters full-time and every employee underwent a half-day training course in quality techniques. The time required for quality work was judged to be of great importance but was only partly measured.

Control of inspections
Inspections were not viewed as an effective approach to quality management. In seven of the companies, efforts were made to minimize inspections and to concentrate quality efforts to early stages of the process. It was felt that the inspections carried out should be as close as possible to the activity involved. These companies also stressed the point that quality assurance is not the same as making inspections. The respondents noted for example, “Inspections are costly” and “Checklists do not help”. Control of inspections was deemed to be of high importance but was not measured.
Certification cost
The direct costs referred to were those in connection with certification, i.e. the costs associated with engaging an accredited certification agency. The calculated cost varied between three of the companies from $US 100 to 1000 per employee. The rest of the companies merely stated that certification “is not inexpensive”. Eight of the twelve companies wanted to gain certification. The certification cost was judged to be highly important, but was only partly measured.

Customer perspective

Customer satisfaction
Although the interest in measuring customer satisfaction was evident in six of the twelve companies, only one of the companies made any genuine effort to actually measure it. Customer questionnaires were used and the results analysed with statistical models. Only a few of the companies had received demands from customers for quality assurance. Nevertheless, all the companies were convinced that the maintenance of a quality system was worthwhile. However, customer satisfaction was judged to be of moderate importance and was seldom measured.

ISO 9000 certification
Certification of the quality system was the goal of eight of the twelve companies. According to the respondents, a quality system should encompass the whole company, not simply a particular section, or a particular department. It appeared that repeated internal auditing of a quality system was something all the companies were basically in favour of. Some of the companies were, on the one hand, suspicious of the certification procedure but, on the other hand, thought that those of their suppliers that had a certificate were better than those who did not. ISO 9000 certification was judged to be highly important and was easily measured.

Zero defects at delivery
Four of the twelve companies had the goal of achieving zero defects. Actually, for one of the companies, this was the only goal mentioned. The reason that this key factor was mentioned could be that it is easy to measure, although none of the
companies could verify a trend towards fewer defects. Zero defects at delivery was judged to be of moderate importance and was seldom measured.

Process perspective

Competitiveness
There were high expectations that the implementation of a quality system would increase the company’s competitiveness. Although no one provided any concrete example of this, there was a strong belief in the relationship between quality systems and competitiveness. Respondents maintained, for example; “A quality system makes the product better and cheaper”, “A quality system generates more projects”, and “Quality assurance is a matter of survival”. Competitiveness was judged to be of great importance but was not measured.

Efficiency
Ten of the twelve companies regarded a quality system as being identical to a system aimed at attaining greater efficiency. Although the companies were convinced that work on quality led to an increase in efficiency, none of them had any definite concept of how great the gain was. There was also the fear that bureaucracy would increase and that the routines of a quality system were not completely realistic. Efficiency was judged to be of great importance but was not measured.

Follow-up
None of the companies could identify any concrete strategy for achieving positive effects in connection with quality work, although some of the companies expressed the opinion that follow-up of the effects of a quality system was important. One of the respondents said: “You would not put millions into a project (like a quality system) if you did not believed that you get them, and more, back”. The only concrete measures employed were the number of negative assessments found in the final inspection protocol and the time required for correcting errors. Follow-up was judged to be of moderate importance and was not measured.
Innovation and learning

There were no key factors that indicated that the companies found the organization and learning perspective important or that they tried to measure any key factors associated with it. This may partly be explained by the lack of requirement for systematic improvements in the standard.

When the key factors were fitted into the balanced scorecard the results showed the measures used in the different perspectives. Two main results could be identified.

- The balanced scorecard can be used to measure the performance of quality systems in the construction process.
- The innovation and learning perspective is not used in the Swedish construction process to the same extent as the others.
Figure 4. Balanced scorecard with the key factors identified in the study.

The results are illustrated in Figure 4. The figure also illustrates how important the key factors were judged to be, and to what extent they were measured.
Discussion and conclusions

The total effect of a quality system cannot be fully measured in practical or theoretical terms. This is, in part, due to the complexity of the matter and to continuous changes occurring in the environment. Caution is thus called for in interpreting the results. However, this does not amount to giving up, and declaring it impossible to evaluate the effects. Since it is important that all routines in the quality system that fail to contribute to quality improvement and efficiency be removed. A management control system such as a quality system is not static, but must be altered and remoulded continuously based on changes that occur in the situation in which the company finds itself. Accordingly, the weight placed on a specific measure may, and should, change over time.

The question for the researcher/company is whether the implementation of quality systems really makes a difference. While it is tempting to conclude that investments in quality systems increase organizational performance, there is little (if any) evidence that this is the case. Many of reports in the popular press, as well as in academic journals, are based on success stories. Failures are seldom reported, hence the average report is skewed towards too optimistic a point of view. Unfortunately, many investments in quality systems appear to be based more on blind faith than on facts.

The cost of quality has many definitions; one is the cost of quality management plus the cost of rework (Neese, 1991). The cost of rework has been investigated and found to be considerable in relation to the contract sum in the construction process (Josephsson, 1994). Surprisingly enough, the rework cost was not mentioned by the respondents as a way of measuring the cost of quality.

The Balanced scorecard is an interesting tool as a measure of the performance of quality systems. In this study, the balanced scorecard was very useful because it reveals a clear lack of balance between the four different perspectives. The companies in the construction industry must pay attention to the fact that the perspective of innovation and learning is not used to its full potential. A balance between the four perspectives is important, otherwise there is a risk that these companies will not be able to compete on the market in the long run. Among the other perspectives in the balanced scorecard, the financial perspective seems to be deemed the most important since all three key factors were judged to be highly
important. In spite of this the key factors were only partly measured, which is an interesting contradiction. Both the “process” and the “customer” perspectives seem to be of moderate importance to the companies.

The secret lies not in discovering one magic tool, but rather in learning which tools to use, how and when (Rigby, 1993). Most companies today operate in a turbulent environment with complex strategies that, though valid when they were launched, may lose their validity as business conditions change (Kaplan and Norton, 1996). Tools are only valuable if they improve results, and improved results will only occur when companies establish the capability to serve customer needs better than their competitors (Rigby, 1993). There is a need to develop knowledge through future research on the cost and benefits of quality systems in the engineering and construction industries.

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