Title: Implementation of Quality Assurance in the Design Process

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Abstract: Explores the quality assurance programs in various design firms. Evaluates the advantages and disadvantages of implementing such programs. The results suggest that customer satisfaction and design error reductions were the greatest benefits.

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ENGINEERING AND TECHNOLOGY MANAGEMENT
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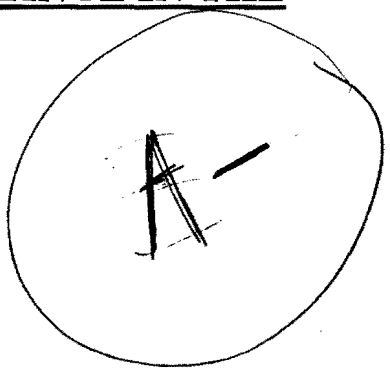
Term Project

IMPLEMENTATION OF QUALITY ASSURANCE IN THE DESIGN PROCESS



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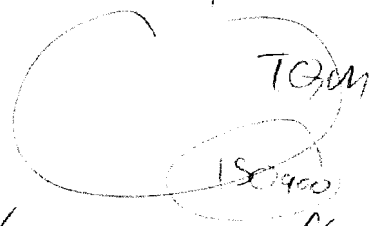
ABSTRACT

Increased competition and the need for agility has made it necessary for firms to not only provide quality products but also 'do it right' the first time. The goal is to eliminate the needs for costly re-designs, reworks and returned products. Design firms are no exception to this. This paper explores the various Quality Assurance programs that are in place at various design firms. The advantages and disadvantages of implementing such programs are evaluated both qualitatively and quantitatively. The paper also attempts to provide a general overview of the most commonly implemented Quality Assurance programs. The results suggest that customer satisfaction and design error reductions were the greatest benefits gained with the implementation of such programs. The results are based on a survey of ten medium to large size design firms located in various U.S cities. This paper also suggests further areas of study to explore the impact of Quality Assurance in the design process.

1. Respondents are generally consulting companies!

2. Quality Prgms & Methods have too many overlaps! Don't get this.



!?

Analyzing them as they had evolved and how they evolved would have been interesting

3. Limited Lit Search.

INTRODUCTION

In the competitive environment of the last decade, companies have strived to produce more and deliver the product to the marketplace at a faster pace. Firms often do not have the luxury of taking their time to deliver a quality product, whether the product is a manufactured item, a system of operation (such as a wireless telephone communications system), or an engineered design for a construction project. As a result, many "high technology" firms have engaged in a "fast track" process that parallels the design and construction process to speed up the completion of a fabrication facility, in order to commence fabrication and deliver the product sooner, hopefully before the competition.

In this fast-paced culture, deficiencies have been allowed to creep into the process. The engineering profession has recognized that the change in the traditional process has necessitated the need to focus on the delivered product. *Speed and quantity has not reduced the need for quality.*

Purpose and Goals

The purpose of this study is to review and analyze the implementation of a Quality Assurance Program as it pertains to the design process of an engineering firm. The specific goals are to determine:

- To what extent a Quality Assurance program is used by engineering firms.
- What programs are currently being used.
- What issues face these firms which can be addressed by a successful QA program.
- What degree of success occurred as a result of the program's implementation.

BACKGROUND

Rapidly advancing technology, increasing complexity of operations, and growing competition in the market place have made modern industry painfully aware of the necessity to provide, as economically as possible, products and services that satisfy customer requirements. Fortunately, quality assurance concepts and techniques have been evolving in a way that facilitates achieving these quality and cost objectives.

Traditionally, quality process was considered to be something that was done after, and apart from, the important work of engineering and manufacturing. The assurance of quality is in fact an important aspect of all activities that enter into the matching of customers' needs or desires with company-produced products and services. Quality assurance begins with the customers need. That must be effectively translated into design documents and manufacturing process.

Quality assurance is important to all kinds of organizations. To some degree it touches almost every employee, and it extends to suppliers and subcontractors. Yet every

company is a unique one, so each must develop and implement its own plan of quality assurance [6].

WHAT IS QUALITY?

Since quality is personal and subjective (as perceived by the user), what constitutes quality for one person may not be applicable to another person. Thus, the definition of quality must take the user into account [5]. Therefore, different definitions have been coined by different researchers and standards. Some of them as follows:

> "Fitness for purpose or use". (Juran)
>
> "The total composite product and service characteristics of marketing, engineering, manufacture and maintenance thorough which the product and service in use will meet the expectation by the customer." (Feigenbaum)
>
> "Conformance to requirements." (Crosby)
>
> "The totality of features and characteristics of a product or service that bear upon its ability to satisfy stated or implied needs." (ISO 8402) [7]

In this paper we will refer the following definition;
Quality is all the characteristics of a product or service which the user specifies or implies and which the user will readily accept at a price he or she is willing to pay [5].

DEFINITION OF QUALITY ASSURANCE

The decade of 1980's was a period of remarkable change and awareness of quality by consumers, industry and government. Consumer awareness, improvements in technology, inadequate managerial thinking, and economic impact on national competitiveness are the four significant influences that contributed to the awareness of quality in that decade [3]. Up until this decade American industries were suspicious that the potential benefits of quality management might not justify the associated costs and benefits. The 1980's brought enormous pressure on U.S. companies to produce their goods and services more cost effectively and at a higher quality [4]. The quality profession has responded to this challenge by shifting it's emphasis from audit and inspection to preventive methodologies. However, this shift is sufficient if the intent is not to create another discipline such as TQM or a quality engineering department. This is because quality is no longer a department, a discipline or a measure of compliance or conformance. It is a value no different from integrity and honesty [9].

Quality assurance refers to any action directed toward providing consumers with products (goods and services) of appropriate quality [3]. QA is defined as the total effort

involved in planning, organizing, directing, and controlling in a production system with the objective of providing the consumer with products of appropriate quality [3], [5]. Quality assurance goes back to the design of the product, where customer performance requirements must be realistically defined, taking into account both customer expectations and shop capabilities [6].
The development and implementation of a quality assurance program is of primary importance to the pursuit of product quality. The quality assurance program is the foundation on which quality-related activities are built. Therefore, all planned and systematic actions necessary to achieve the quality standards established for the goods service to be provided must be identified, described, and implemented [5].

Today many of the professionals are still stuck with the traditional approach of quality. However, in order to survive, businesses need to change their understanding of quality and make the transition from oversight to ownership [9].

Whereas both inspection and quality control concentrate their attention on the process of creating the product or service, quality assurance addresses the whole of the quality loop. It attempts to anticipate and prevent errors at all points in the organization which could have an impact on the quality of a complete and delivered package associated with the product or service [7].

QUALITY ASSURANCE PROGRAM

Developing a quality assurance program is the most critical step and the basic building block in the assurance of quality. It is a key element to attain and maintain the quality. The quality assurance program has been defined as:

" The identification, description, and implementation of all the planned and systematic actions necessary to provide adequate confidence that the goods produced or services provided will satisfy the customer's requirements" [5].

The most important aspect of the quality program is identifying the activities that affect the quality within the organization. Whether they are specifically documented or not, quality assurance activities are based on what the particular enterprise perceives as necessary to produce a satisfactory product, while complying with government regulations and industry standards [5],[6]. No two businesses are completely identical and managed in the same way, so each business enterprise should develop a quality program to fit its needs [5]. Determination of essential needs and careful examination of what is already being done to satisfy these needs are two important steps in the development of a quality assurance program, regardless of the type of the business.

The process of designing and installing the program can be broken down into the following steps:

Defining objectives

Collecting data
Preparing process flow chart
Correlating needs and practices
Establishing priorities and scheduling improvements
Installing the program
Monitoring and adjusting the program [6].

A table listing the quality related activities common to most business involved in design and production can be found in the Appendix A.

Quality Assurance Program Manual

The quality assurance program manual is the single most important document for an effective QA program. The role of the quality manual is to establish controls over all activities affecting quality to assure they are accomplished properly and in a uniform manner. QA manual provides management's policies for the various activities and describes responsibilities for the actions necessary to fulfill the company's quality objectives. Thus, the manual provides the framework for implementing procedures and instructions for conducting program activities [5].

Implementation

The implementation phase begins with three major kinds of activities: Training, administering the program, and amending the program to reflect new experiences and changing conditions.

The work of all employees affects product quality. It is essential that all employees support the program and think that quality assurance is a part of their normal job. Therefore, training in quality matters will provide employees what they need to know to perform the task properly and what constitutes acceptable quality.

After the quality program has been developed, installed, tested and debugged, it must be maintained effectively. Engineering, design, purchasing, and manufacturing operations should be conducted within the framework of the quality requirements. Quality regulating procedures should be followed and enforced, and work that does not conform to specifications should be rejected, repaired or rescheduled [6].

QUALITY PROGRAMS OR METHODS

ISO 9000

ISO 9000 is a series of three national standards and supplementary guidelines on quality management and quality assurance, which were first published in 1987 and revised in 1994. These standards can be applied both to manufacturing and service industries, they are not specific to any particular product. ISO 9000 standards are nonprescriptive; they do not specify how a firm's quality assurance processes must occur, but they do not mandate that a company define appropriate quality standards, document its process, and prove that it consistently adheres to both. The standards require that a basic quality system be in place to ensure that the company has the capabilities and systems to provide its customers with quality products and services.

ISO 9000 standards are as follows:

- ISO 9000 is a guideline that helps users to select and use the appropriate standard (ISO 9001, ISO 9002, ISO 9003, ISO 9004)
- ISO 9001 is the most comprehensive standard which covers design, manufacturing, installation and servicing system.
- ISO 9002 is the standard that covers production and installation.
- ISO 9003 is the standard that covers final product inspection and testing.
- ISO 9004 is a guideline for internal use for the producers who are developing their own quality system to meet their business needs [8].

Total Quality Management

Total Quality Management (TQM) is a quality system that combines quality culture, statistical tools, and quality principles. TQM is an integrative management concept for continuously improving the quality of goods and services delivered through the participation of all levels and functions of the organization. TQM is simply the process of building quality into quality goods and services from the beginning, and making quality everyone's concern and responsibility [1].

TQM incorporates several dimensions: The design of the products that meet customers' needs, control of processes to ensure their ability to meet design requirements, and quality improvement for the continued enhancement of quality [3].

Malcolm Baldrige

The Malcolm Baldrige award has set a national standard for quality and hundreds of major corporations use the Baldrige criteria as a basic management guide for quality improvement programs. It has created a set of standards; a benchmark for total quality management in any organization. In order to conform Malcolm Baldrige National Award criteria the following seven categories need to be addressed [2]:

1. Leadership
2. Information and Analysis
3. Strategic Quality Planning
4. Human Resource Development and Management
5. Management of Process Quality
6. Quality and Operational Results
7. Customer Focus and Satisfaction

Quality Function Deployment

Quality Function Deployment (QFD) is basically a philosophy and a set of planning and communication tools that focuses on customer requirements in coordinating the design, manufacturing, and marketing of goods. The customers' requirements are the collection of customer needs, including all satisfiers, exciters/delighters, and dissatisfiers. Under QFD, all operations of a company are driven by the voice of the customer, rather than by edicts of top management or the opinions or desires of design engineers.

A major benefit of QFD is improved communication and teamwork between all constituencies in the production process. QFD allows companies to bring new products into the market sooner and gain a competitive advantage [3].

QFD process has six steps:

1. Determine and prioritize customer demands.
2. Identify technical requirements of the customer and the firm's production process; then correlate them.
3. Identify and score each pairing of what the customer wants with how the firm will meet those needs.
4. Multiply each pair of "what-how' relationships by the weight or priority the customer attaches to it. That is, first the "how" analysis shows that the firm can easily match 'what" customer wants. The final score for this item depends on how important the what is to the customer.

5. Use benchmarking to determine competitive disadvantages and advantages, and to improve the firm's ability to satisfy important customer expectations.
6. Repeat the process until the customer's requirements are translated into specific production processes [1].

QUALITY ASSURANCE IN DESIGN

Quality Assurance requires multi-level support in the organization and each individual has to be committed to it. A quality system has to be defined clearly and precisely.

Definition: Quality system is the organization structure, responsibilities, activities, resources and events that together provide organized procedures and methods of implementation to ensure the capability of the organization to meet quality requirements (BS4778).

Quality assurance requires a quality system which generates objective evidence of quality which demonstrates compliance. The quality system is subject to review and evaluation.

It must be concerned with the way work is normally done and controlled. The specifications require that the quality system be documented, so there is a requirement to produce a document which describes the way design work is undertaken, including management, organization, policies and procedures [14].

QUALITY CONTROL SYSTEM

All along the work process, from the conceptual design, through detailed design, into manufacture, the character of work changes. So 'work instructions' can be expected to increase as one moves from design to manufacturing. It is important here to maintain the responsibility of the designer. A clear definition of the responsibilities of the various individuals is essential [11]. The 'work instructions' will include :

- Company quality assurance policy,
- The terms of references for the department manager,
- 'Departmental' instructions on how work is received into department, handled, issued, etc.
- Job descriptions for individuals in the department.[14]

An effective project control is required with procedures which maintain control without restricting the designer flexibility.

Since quality planning requires technical resources, it is necessary that such planning be appropriate to the project. A code of design practice is also required and may take the

form of company design standards that contains records of previous designs and their performance.

During the design process, many changes are made. Many drawings, specifications and reports are changed. Thus, one must ensure that :

- The original design intent is not violated,
- Unnecessary changes are not incorporated,
- Financial and time scale limits are not exceeded.[14]

Because corrective actions may affect the design intent and manufacture, a procedure for dealing with these corrective actions has to ensure the designer agreement. Such actions be required, for example, when design faults are detected during testing and commissioning [11].

OBJECTIVE EVIDENCE OF QUALITY

Documentation provides evidence that the hardware conforms to requirements. These documents define and substantiate the designers proposals and assumptions. At the design concept stage, there is no hardware, but the objectives statement, drawings, technical reports, calculations are backed up by :

- Detailed hand calculations,
- Computer print outs,
- Correspondence,
- Minutes of meetings, etc.

So, it is necessary to develop an organized way of retaining support documentation [14].

REVIEW AND EVALUATION

Traditionally, drawings and formal technical reports are signed, checked and approved. Review and evaluation have to be done early in the design work. Reviews are required to demonstrate that all appropriate specialists have had their input to the design.

A quality audit has to be done by examining the effect on the product of the way work is controlled across the company (design documentation). It provides confidence in the quality system and identifies areas where some changes are necessary.

QUALITY ISSUES

To meet a client's schedule and budget requirements, an engineering firm must often aggressively press it's professional and technical team to successfully complete a project.

This pressure may lead to the team succumbing to the temptation to take shortcuts, or raise the potential for design error or omission of a key item of information.

Technological change that is occurring at a more rapid pace is also increasing the pressure on a firm's technical organization [11]. A higher degree of technical specialization creates a complex organization, with fragmented lines of authority and responsibility.

Increased reliance on computers has greatly affected the design office. With greater speed and accuracy, the designer can solve previously insolvable problems and access vast amounts of data. However, false accuracy and improper use of computer programs can lead to erroneous computer output and potentially skewed analysis.

Increasing safety and consumer protection pressures and associated legislative requirements affect the quality of the design process. The Nuclear Power industry has been a prime example of legislated standards and requirements [10].

For this study, these issues (and others) have been synthesized into categories of importance. These issues are listed in the survey questionnaire that was sent to several engineering companies(see *Acknowledgment* section), to determine the level of importance of each of these issues, as perceived by these firms. Each firm was asked to rank the level of importance, whether or not they had a QA program. The quality issues are as follows:

- Customer Satisfaction
- Design Error Reduction
- Schedule Requirements
- Design Costs
- Construction Cost Overruns
- Document Control
- Staff Morale
- Staff Turnover

Customer Satisfaction

Customer satisfaction is defined as the degree by which the engineering firm successfully completes the tasks that were agreed upon by the firm and the customer. The relationship of customer satisfaction with the overall perceived quality of the completed project may be questioned, however. The perceived project quality may simply be based on the customer's definition of project success, based on schedule and cost limitations, and lower customer expectations. Therefore, customer satisfaction as a determination of quality may not be adequate. Yet, the simple fact that customer satisfaction must be a driving force in a project's success cannot be underscored.

Design Error Reduction

Design error reduction has been a prime indicator of quality in the completed project. Historically, the design professional has always pursued for excellence in their work. This has been heightened by the need for the design professional to reduce errors, curb insurance costs, and control office and legal expenses associated with a claim [15]. Statistical surveys reveals that up to 90% of structural failures and malfunctions, or loss of use, have been attributed to human error, [16], [17]. It has been said that an engineer cannot hide his or her mistakes. They are there for the whole world to see.

Schedule

Schedule can be loosely linked to quality, in that an engineering firms inability to meet time requirements can be an indication of other deficiencies in the design process. Often, a slip in the schedule can be the result of the discovery of a design error, where the engineering firm or design professional must remedy the situation. The issue of schedule maintenance can also reflect on an overall ability to fulfill the projects' requirements, also affecting "customer satisfaction".

Design Cost Overruns and Construction Cost Overruns

Design cost overruns and construction cost overruns are also perceived quality issues, affecting the customer's perception of the completed design project. Design cost overruns can be the result of poor planning on the part of the design professional, lack of funding on the part of the customer, inadequate documentation for additional services requested by the customer or executed by the designer, or any number of other reasons.

Document Control

Document control is how an engineering firm maintains a record of evidence of work performed. The primary deliverable of an engineering firm is the delivery of a document, such as specifications, drawings, calculations, etc. These documents are subsequently used to construct, assemble or fabricate a particular product, system or structure. Other documents of importance are detailed hand calculations, computer printouts, correspondence, and meeting minutes and notes. The ability of a firm to access these documents can be of primary importance, such as for the defense of a particular design process [14].

Staff Morale and Turnover

Staff morale and turnover, while not direct indicators of quality, may be affected by the quality of the delivered product. The inability of a project team to consistently deliver a successful project may adversely affect team morale, further hampering future projects and the firm's ability to attract quality people.

METHODOLOGY

The purpose of this research paper was to collect data on the types of quality assurance programs utilized by design firms in the Portland area and to analyze the data obtained and make inferences regarding the following topics:

- Use of quality assurance programs in the design process.
- What types of programs are being currently used by design firms.
- What issues the firms expect to resolve with the implementation of quality assurance programs.
- What degree of success the firms have achieved as a result of the implementation of quality assurance programs.

In the collection of data, it was a determined effort of the group to include small as well as large corporations that are engaged in the design work in the local area. It was our expectation that the scale of the organization would play an important role in the selection of a quality assurance program and also the success as well as failure of such programs in the firm.

The procedure we followed was to utilize a questionnaire based on fifteen questions (see Appendix B). Some of the questions were to be answered on a scale set up from; *none* to *very high*. This scale was later converted into a numerical scale for ease of data analysis. Other questions in the data gathering survey required more subjective answers. The results from these questions were to be utilized in the discussion part of the study.

The choice of companies selected was kept as broad as possible to get a good sampling and also to evaluate any correlation that might exist between the size of the company and the selection criteria for a particular type of quality assurance program. Our questionnaire contained some questions that could be answered more subjectively. The purpose of such questions was to get the participants to share more of their insights about QA programs in general and their effects on workers at the selected firms.

The questionnaire was developed in a way such that with the use of appropriate statistical analysis techniques we would be able to make judgments regarding the success of QA programs and the various factors associated with the overall performance of the company

and their final product. The participants in the survey were also encouraged to give their impression about how the program could be made more effective, if it had not provided the benefit that was initially required. This was done for the benefit of other firms who might be interested in the implementation of a quality assurance program and also to provide a basis for further research topics.

With time available to us as a constraint, the group had access to a limited number of responses. 10 surveys were returned to us by the deadline that was assigned by the group. We were able to remove any bias from such surveys by making sure that the respondents were all in responsible positions within the company and were directly involved in the design of products within their organizations.

It was also our goal to bring to light any one program that has been more successful than the others in the firms surveyed. The questions were also composed in such a way that the internal impact (to the firm) with the establishment of quality assurance program surfaced as well as the external benefits (to the customer) were brought to light. Our aim was to look at both tangible as well as intangible results of the implementation of a quality assurance program.

DISCUSSION

QUANTITATIVE ANALYSIS

With only 10 usable results to our survey, we were unable to perform any in-depth statistical analysis of the results. It was possible however to gain some insight as to the types of programs these ten firms use and the issues they faced. The effect of their quality assurance (QA) programs and other concerns can also be generalized by their responses to the survey.

The majority of firms (6) used in house programs with a combined total of 456 months that they have been using the program. Three firms used TQM and another 3 use ISO 9000 with 144 and 38 months of use respectively. One of the larger firms which has been in business for 15 years has no quality assurance program but plans to implement one in the future (Some firms reported using more than one program, hence the total exceeds the number of firms surveyed).

On a scale of 1 (none) to 6 (very high) for the level of importance, the three top issues faced by these ten firms are customer satisfaction (mean 5.2), design error reduction (4.5), and staff morale (4.4). The remaining issues of schedule, design cost overruns, construction cost overruns, document control, and staff turnover all fall in the medium range of importance.

Customer satisfaction and design error reduction were both rated as highly affected by the quality assurance programs. This corresponds with the top two issues for level of

importance. Document control was also highly affected by the QA programs. This is expected since many of the programs stress document control. Even though document control was greatly affected, it was rated as a medium concern for most of the organizations. The influence of QA on staff turnover was very low. In comparing the results of issues level of importance and affect of QA programs on these issues it is clear that the level of importance is closely tied to the affect of the program. This means that the QA programs are affecting the issues that are most important to the firm.

With the majority of programs being implemented by corporate directive and project managers being one of the main groups responsible for implementation, it is not surprising that these two groups have high acceptance of the QA programs. The professional, para-professional, and clerical staff all have medium levels of acceptance. While top management, project management and professional staff had a high level of acceptance for this programs, para-professional and clerical staff had lower levels of acceptance. Because of the emphasis on document control, the lower acceptance of non-professional staff, which is responsible for processing these documents, is not surprising.

The success of these programs, for the eight firms with QA programs, ranges from high to low. Three firms had high success and another three had medium success with their programs. Only two respondents rated rate the success of QA as low. This result in an overall medium level of success for these eight companies.

With six firms using in house programs, the seven firms using in house programs is not surprising. Two others use outside professionals and another uses individual study. Although only 8 firms have a formal QA program the nine responses for this question is because one firm uses in-house seminars for ISO 9000 and outside seminars for auditors and project managers.

One of the two firms which does not use a customer questionnaire to gauge the quality of their services, also has no QA program. This firm has responded that customer satisfaction is a very important issue for their firm. Whether it is an important issue because they have problems with it or just because the firm values customer satisfaction, is unclear at this time.

The seven of the ten firms employed over 250 people while the remainder had between 25 and 250 people. The average years in business for these ten firms was 32.5 years with a median of 20 years. (Appendix C)

QUALITATIVE ANALYSIS

In addition to the quantitative analysis of the survey, several qualitative questions were included to give the respondent an opportunity to clarify or otherwise express their impressions.

Question 9 asked the respondents if there were any permanent changes in the organization as a result of the implementation of a QA program. Of the 11 respondents, 6 or 55% provided a response to this question. (It should be noted that only 1 of the 11, or 9% indicated that they did not currently have a formal QA program). The comments of the respondents varied from mild skepticism to acknowledgment of their programs implementation and success. The comments include the following:

> *"...need to know if all activities are value added or just in place to satisfy top management. Some activities in QA program seem to create additional burden even though they are of no value to better the customer or the company.."*
>
> *"...professional and para-professional are more keenly aware of the importance of doing it right the first time."*
>
> *"...In general, the program has been accepted by the P.M.'s (project managers) who routinely include the effort in the work estimate."*
>
> *"...we make decisions in a more deliberate way."*
>
> *"...Documentation and accessibility of files has improved...."*

The responses generally indicate some degree of change within the organizations represented, as a result of the implementation of a QA program. With the exception of the first sample, the response appears to be positive.

Question 11 asked respondents why they had not chosen to implement a quality assurance program. Only two respondents had been in this situation where their company had not implemented such a program. The reason given was - Cost. It was noted by these respondents that in order to keep the cost to the client as low as possible, they had chosen to 'handle problems as they arose' instead of setting up measures to avert them in the first place. Another company replied negatively to this question and was waiting for results from an overseas office that was in the process of implementing ISO standards.

Question 12 required a subjective answer regarding the impact of the program and how it was measured. To this the responses varied from, no formal measurement techniques utilized to measurement of defects per drawing noted or the number of specification changes done or the numbers of contractor change orders issued for a particular design project. Some of the respondents utilize formal customer surveys that are sent to the customer after their project has been completed to obtain their feedback. It is important to note here that once a quality assurance program has been put in place, the firms nearly always set up some form of information feedback. The goal being to constantly improve on their work and gain from the experiences of the customer and their design project.

CONCLUSION

Of the firms surveyed, most indicated that they have implemented a Quality Assurance program in one form or another. Two firms had not implemented any QA procedures, and only one of those indicated that they would not implement a program in the foreseeable future. The survey results, and the amount of literature found on the subject, appears to show a high industry awareness of the issue of quality in the design process. Most firms tailored the system to their own organization, rather than using outside consultants or systems. Interestingly, most firms did not use ISO9000, or did not feel it helped their process when it was used. One firm indicated continued use of ISO9000, but noted that it was for it's foreign operations.

It was found that most firms were able to benefit from the implementation of a Quality Assurance program. The issues of customer satisfaction and design error reduction had the highest degree of importance. It was also noted that "Document Control" scored in the "medium" to "high" degree of impact, yet was ranked lower in the degree of importance. This appears consistent with literature, which emphasized document control procedures in implementation plans. Qualitative remarks indicated a general acceptance and acknowledgment that the firms benefited from the program.

Future studies could utilize a larger sampling of firms. The relatively low level of response precluded the use of a statistical model, which may have provided a more accurate distribution of responses. Also, no "small" firms were included in the survey, which may have altered the results.

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Ellerbe Beckett, Minneapolis, Minnesota
IDC, Portland, Oregon
Jeddeloh, Hayes, Incorporated, Portland, Oregon
SJO Consulting Engineers, Portland, Oregon
Tefen, USA, Santa Clara, California

Many of these organizations are using their organizations

→ How willing are they to justify their response?

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