

ISO 9000 QUALITY STANDARDS IN CONSTRUCTION

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ABSTRACT: There is risk involved in any construction project. A contractor's quality assurance system is essential in preventing problems and the reoccurrence of problems. This system ensures consistent quality for the contractor's clients. An evaluation of the quality systems of 15 construction contractors in Saudi Arabia is discussed here. The evaluation was performed against the ISO 9000 standard. The contractors' quality systems vary in complexity, ranging from an informal inspection and test system to a comprehensive system. The ISO 9000 clauses most often complied with are those dealing with (1) inspection and test status; (2) inspection and testing; (3) control of nonconformance product; and (4) handling, storage, and preservation. The clauses least complied with concern (1) design control; (2) internal auditing; (3) training; and (4) statistical techniques. Documentation of a quality system is scarce for the majority of the contractors.

INTRODUCTION

Quality assurance is important in the engineering and construction industry because of the risk involved in any project. The risk involved in not completing the project on time is high, because many external factors will affect the performance of the project. It is vital that a built-in quality assurance system is developed to avoid any inefficiency that could result in poor quality of products and service being delivered to the customer. Everyone involved in the engineering and construction business has, in different ways, benefited from a common approach to quality work. Systematic quality work reduces the costs of failure in one's own work and in the final product. The standards can make quality work more efficient by creating uniformity. A contractor's in-house quality assurance system is of utmost importance; it prevents problems and their reoccurrence and allows his or her clients to relax. One of these quality system standards is the ISO 9000 standard, which has been adopted by a large number of countries around the world and is applied in various industries including engineering and construction.

Quality systems involve internal and external aspects.

An internal quality system covers activities aimed at providing confidence to the management of an organization that the intended quality is being achieved. This is called a "quality management system." Successful implementation of quality management systems can contribute to an increase in product quality, improvements in workmanship and efficiency, a decrease in wastage, and increased profit. An external quality system covers activities aimed at inspiring confidence in the client that the supplier's quality system will provide a product or service that will satisfy the client's quality requirements. This is called a "quality assurance system." The quality system 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. A contractor's quality assurance system is very important to her/his clients, who will gain confidence that "getting it right the first time" will be the contractor's norm.

In Saudi Arabia, the large volume of construction projects, in term of numbers and size, has led giant, multi-national construction contractors to the local market and created intensive competition. Although quality systems are relatively new in Saudi Arabia, especially in the construction industry, the concept is receiving the utmost attention from large construction companies who seek a competitive edge.

The quality systems of 15 major construction contractors in Saudi Arabia were assessed using the ISO 9001 standard requirements. This paper reports the findings of the assessment. The level of implementation and contractors' perceptions are also discussed.

BACKGROUND

ISO 9000 is an international standard intended to provide the generic core of a quality system standard ap-

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plicable to a broad range of industries and economic sectors. It outlines how a supplier can establish an effective quality system that will demonstrate commitment to quality and ability to meet customer requirements. ISO 9000 is based on, and is almost identical to, the American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) NQA-1, Quality Assurance Program Requirements for Nuclear Facilities, 1989 (Reedy 1994).

The acceptance of ISO 9000 standards in the construction industries is not as wide as in other industries, such as manufacturing. There are special features in the construction industry that limit the implementation of the ISO 9000 standard. The following are some of these features (Phenol 1994; "Quality" 1992):

- A construction project is usually a unique collection of people, equipment, and materials brought together at a unique location under unique weather conditions, while most manufacturing is a system of mass production wherein all of these factors are consistent with producing typical products over and over again.
- Performance testing in construction is generally not feasible as a basis for acceptance.
- It is common to have separate contracts for design and construction.
- It is not feasible to reject the whole constructed project after completion while attached to the purchaser's land.
- Decisions to reject a defective part of a constructed project need to be taken promptly before succeeding parts are constructed or installed.
- The number of parties involved in the constructed project's procurement are more than those involved in manufacturing procurement. Achieving quality construction requires effort from all parties. This makes the interface and responsibilities of the various individuals and organizations more complicated than in manufacturing.
- The organizational structure of a construction company varies depending on the nature of the project,

while the same structure in a manufacturing company is almost unchanging. This affects the smoothness of communication and interface between the responsible individuals.

- Turnover of manpower in construction is higher than in manufacturing, which affecting the precision of long-term plans.
- Construction projects are very complicated and their execution may take years.

The generic nature of the standards often leads to differences in interpretations. In turn the implementation, use, and impact of ISO 9000 standards can vary from company to company and from country to country. The concept of ISO 9000 has been viewed in various ways; as a means of improving the overall quality of operations; as the requirements of customers to be complied with; as a necessary response to competition; as a way to reduce cost; as a means to improve the flow of activities and coordination in the organization; as a strategy to have better sales through an improved quality image; as a way to maintain competitive edge in the industry, etc. (Bhuian and Al-Zamil 1996; Lamprecht 1992). Thus, the impact of ISO 9000 standards may vary depending on how it is perceived by companies.

Case Study

With the help of the Chamber of Commerce, 34 major construction contractors—located in the Eastern Province of Saudi Arabia—were identified for the study. The selected contractors were contacted and introduced to the scope of the study. Only 15 contractors agreed to participate in the study, since each has some form of a quality system. The acute sampling problems in Saudi Arabia compel researchers to adopt nonprobabilistic sampling methods in most of the surveys (Al-Meer 1989). Because this study is adopting a nonprobabilistic sample, the sampling of 15 contractors was judged sufficient for an exploratory study. Table 1 lists the contractor numbers, years of experience, number of employees, specialty, and position of the contacted person. The annual construction volume data is not listed in the table, since some con-

TABLE 1. Contractors' Background Information

Contractor number (1)	Years in business (2)	Number of employees (3)	Construction type (4)	Position of contacted person (5)
1	4	700	electrical, piping, piping mechanical, structural steel	General Manager
2	35	6,346	civil, structural steel, piping mechanical, electrical	QA Manager
3	34	1,000	mechanical, electrical civil	QA/QC Engineer
4	23	80	reinforced concrete and steel work	Projects Manager
5	40	4,000	petrochemical, refining, desalination, process control	QA/QC Manager
6	49	1,000	roads and civil	Business Manager
7	16	2,100	buildings, mechanical, electrical, and HVAC	QA Manager
8	25	1,000	mechanical, electrical, and instrumentation	QC Manager
9	5	450	mechanical, piping, and tanks	Business Manager
10	35	1,500	buildings (schools)	Operations Engineer
11	17	475	building, civil	Projects Manager
12	20	600	mechanical, electrical, civil	Projects Managers
13	8	3,000	buildings, structural steel	QC Manager
14	40+	2,500	mechanical, electrical, civil	Procurement Manager
15	29	425	roads, sewer	Projects Manager

tractors feel it is preparatory information. All of the companies are Saudi-owned companies with Western management staffs.

The assessment consisted of personal structured interviews with key representatives and inspection of documents. Each interview took between 2 and 4 hours. A questionnaire form was used as a checklist. The questionnaire consists of two parts, the first part being general and intended to get information about the contractors' general interest in and perception towards the ISO 9000 standards. The second part asks specific questions about the ISO 9000 clauses (Table 2 lists the clauses). Contractors were asked if they have a means in their quality system that satisfies each ISO 9001 clause, and whether these means are documented and implemented. Contractors' input was evaluated and rated according to the following criteria:

- A contractor who has a system that fully complies with the respective clauses of the ISO 9001 standard was rated "Y" and given a value of 1.0 point.
- A contractor who has a system that partially complies with the respective clauses of the ISO 9001 standard was rated "NF" and given a value of 0.5 points.
- A contractor's system that did not meet the requirement of the ISO 9001 standard was rated "N." It was given a value of 0 points.

For each clause, the three aspects (i.e., "existing," "documented," and "implemented") were totaled based on the above rating system. The term "existing" indicates the presence of the clause in the organization system either documented and/or implemented or not. The term "documented" indicates the knowledge and proper procedural documentation of that clause irrespective of

TABLE 2. ISO 9001 Clauses

Clause number (1)	Title of clause (2)	Remarks (3)
4.1	Management Responsibility	
4.2	Quality system	
4.3	Contract review	
4.4	Design control	
4.5	Document and data control	
4.6	Purchasing	
4.7	Purchaser supplied product	
4.8	Product identification and traceability	
4.9	Process control	
4.10	Inspection and testing	
4.11	Inspection measuring and test equipment	
4.12	Inspection and test status	
4.13	Control of nonconforming product	
4.14	Corrective and preventive action	
4.15	Handling, storage, packaging, and delivery	
4.16	Quality records	
4.17	Internal audits	
4.18	Training	
4.19	Servicing	
4.20	Statistical techniques	
Not included		

TABLE 3. Contractors' Compliance with ISO 9001 Clauses

ISO 9001 Clauses	Total	%	ISO 9001 Clauses	Total	%		
4.1	Exist	7.5	50	4.11	Exist	13.5	90
	Documented	6.5	43		Documented	7	47
	Implemented	7.5	50		Implemented	13	87
4.2	Exist	9	60	4.12	Exist	14.5	97
	Documented	9	60		Documented	12.5	83
	Implemented	9	60		Implemented	14.5	97
4.3	Exist	14.5	97	4.13	Exist	14	93
	Documented	6	40		Documented	10.5	70
	Implemented	13.5	90		Implemented	13	87
4.4	Exist	3.5	23	4.14	Exist	7.5	50
	Documented	0	0		Documented	6	40
	Implemented	3.5	23		Implemented	6.5	43
4.5	Exist	11	73	4.15	Exist	15	100
	Documented	7	47		Documented	8.5	53
	Implemented	10	67		Implemented	15	100
4.6	Exist	8.5	57	4.16	Exist	12.5	83
	Documented	6	40		Documented	8	53
	Implemented	8	53		Implemented	12.5	83
4.7	Exist	9.5	63	4.17	Exist	3	20
	Documented	7	47		Documented	3	20
	Implemented	9.5	63		Implemented	3	20
4.8	Exist	10	67	4.18	Exist	8.5	57
	Documented	7.5	50		Documented	3	20
	Implemented	10	67		Implemented	7.5	50
4.9	Exist	13	87	4.19	Not included in the study		
	Documented	9	60		Exist	6	40
	Implemented	12.5	83		Documented	6	40
4.10	Exist	14.5	97	4.20	Exist	6	40
	Documented	12	80		Documented	6	40
	Implemented	14.5	97		Implemented	6	40

whether it is implemented. The term "implemented" indicates the knowledge and practice of that clause even though it may not be documented. For example, in the case of clause 4.17 of ISO 9001 (internal quality audit), if a contractor has a system of scheduling and performing internal quality audits, it was rated "Y" and a value given equal to 1. If it was found that the contractor does not have any documented procedure for internal audits, it was rated "N" and given a value of zero. Finally, if the contractor performed some of the scheduled internal quality audit and did not document the audit findings, it was rated as "NF" and given a value of 0.5. The rating of the clauses is shown in Table 3. Then the percentage of the companies complying with the ISO 9000 clauses was determined. A company was deemed to be complying with that particular clause if it had received a rating of "Y" in both the "documented" and "implemented" aspects of the clause. Table 4 lists the most-used and least-used clauses. As examples, the following sections give more information regarding clauses 4.3, 4.10, 4.12, 4.13, and 4.15.

Contract Review (Clause 4.3)

The standard requires that the organization has documented procedures for contract review and for the coordination of activities. Before the acceptance of the contract with the customer, the organization must review the proposed contract to ensure that (1) all requirements are adequately defined; (2) all verbal requirements are

TABLE 4. Most Complied with and Least Complied with ISO 9000 Clauses

Most complied with ISO 9000 clauses	Percentage compliance	Ranking
clause 4.12	80.0	1
clause 4.10	80.0	1
clause 4.13	60.0	3
clause 4.15	53.3	4
Least complied with clauses of ISO 9001		
clause 4.9	46.6	5
clause 4.8	46.7	5
clause 4.7	46.7	5
clause 4.11	40.0	8
clause 4.3	33.3	9
clause 4.16	33.3	9
clause 4.1	33.3	9
clause 4.2	26.7	12
clause 4.6	26.7	12
clause 4.14	26.7	12
clause 4.5	20.0	15
clause 4.20	20	15
clause 4.18	13.3	17
clause 4.17	13.3	17
clause 4.4	0	19

documented; (3) all differences are resolved; and (4) the organization is capable of meeting all contract requirements. One-third of the interviewed contractors reported that they had encountered a problem (during the execution of the projects) due to improper initial reviews of the project contracts. This inadequate contract review caused financial losses because of underestimated or overestimated bidding, and delayed project completion due to the contract's inability to plan for meeting contract requirements.

Inspection and Testing (Clause 4.10)

The main objective of the contractor's inspection and testing is to provide objective evidence that the con-

structed project and related components meet contract requirements. The top-ranked contractors indicated that inspection and testing activities are performed during all phases of the project—receipt, storage, field fabrication, erection, and upon completion prior to handing over to the client. The inspection and testing procedures specify the quantitative and qualitative acceptance criteria for construction workmanship and materials.

Inspection and Testing Status (Clause 4.12)

The top-ranked contractors have well-documented procedures to identify the acceptability of construction items with regard to inspection and tests performed throughout the construction process. This requirement covers all inspection and testing of materials, equipment, or construction work. The contractors use tags, marks, or routing cards to distinguish between inspected and uninspected construction items. Such procedural practice safeguards against the use of unacceptable materials and against shoddy workmanship.

Control of Nonconforming Product (Clause 4.13)

This clause is one of the most difficult aspects of the quality system because it requires the contractor's personnel to admit openly and in writing that they have done something wrong. This may cause the contractor not to notify the customer. Some of the contractors admitted that the nonconformance reports issued by the quality control personnel are either ignored or overruled by project engineers. This is due to the lack of authority given to the quality control personnel (ISO 9001, clause 4.1.2). Few stated that the nonconformances are undocumented.

One contractor relates the cost of quality to the nonconformance. Whenever a Nonconformance Report (NCR) is issued and the disposition is agreed upon, the value of the problem (i.e., the cost of rework, replacement, project delay, etc.) is calculated and documented on the NCR. Documenting the nonconformance not only serves as a tool to track the problem areas from beginning to end—it also helps in taking corrective measures to prevent reoccurrence of these problems in the future. The historical data developed through documenting the nonconformance occurring during projects can be used to reduce the costs of future projects.

Handling and Storage (Clause 4.15)

All contractors agreed that the packaging, preservation, and delivery required by clause 4.15 applies to products not for construction work. The top-ranked contractors showed evidence that the procured project materials and equipment, when received at the site or during construction, are handled properly and in such a way that their quality will not be degraded because of inappropriate handling, lifting, and rigging. Also, that materials and equipment are properly stored to ensure that they

are preserved safely prior to their use or installation in the project.

Assessment Findings

Quality Systems

The quality systems of the contractors vary in complexity, ranging from an informal inspection and test system to a comprehensive system where inspection and testing is only one element among many others. Four contractors have comprehensive, corporate, documented quality systems. The systems of these four contractors are documented in quality manuals and procedures. Ten out of the 15 contractors have limited, project-wide quality control systems. In other words, the quality system in these companies covers only the activities associated with certain projects at the job site. This type of limited quality system concentrates heavily on inspection and testing. One contractor, however, has no formal system.

Registration

Of the 15 contractors, two are registered to the ISO 9002-1994 standard, four are planning to be registered in the near future, and three have hired external consultants to assist in the process of establishing formal quality systems and preparing for registration. The other four contractors are interested in being registered but not in the near future.

The registered contractors and the ones pursuing registration mentioned that the reasons for registration are top management's interest in the standard's potential to improve the quality of their projects, and the current or expected demand from customers. They believed that it is going to be compulsory in the future for public and private contracts. They wanted to be ahead of others when registration becomes a prerequisite for acceptance of bids. Some construction managers indicated that currently there are several international agents, working in Saudi Arabia, that administer registration of companies for ISO 9000. It is possible to "shop around" to find the certifying organization that offers the "best deal." As a result, not all ISO 9000-registered companies are following the same requirements and the cost of implementing the program can very tremendously.

Applicability and Benefits

The majority of contractors believe that the ISO 9000 standards are applicable to the construction industry and will be beneficial to their companies. These contractors made no exception to any of the clauses of the standards. Two contractors have some reservations about whether or not the standards add value to the quality of construction projects.

Processes, rather than products or services, are ISO certified. The rationale is that if process management is good, then resultant products or services will also be good. It is important to recognize that some process steps add value, while other activities add cost but provide no value relative to the output of the process. These non-value-added activities include all delays in processing,

temporary or permanent storage, inspections, and any rework necessary to meet customer requirements or engineering design specifications. In general, value is added in a process whenever all three of the following conditions are simultaneously met: (1) A desired physical change noticeable by the customer occurs; (2) given a chance, the customer would pay for the activity to be performed; and (3) the activity is done right the first time (Gamsby et al. 1996).

Difficulties Surrounding ISO 9000 Requirements

Six contractors reported that the ISO 9000 standards are not difficult to implement, while other six contractors reported the following difficulties:

- Voluminous amounts of required paper work associated with the documentation of the quality system and its implementation
- Difficulty in controlling the subcontractors
- Difficulty in full implementation of all the requirements, and the possibility of occasional deviation
- Difficulty in understanding the terminology of the standards
- Difficulty in sparing company personnel to undertake an additional workload in order to establish quality system and its requirements
- Lack in ability to afford full-time quality managers and specialists

Obstacles to Implementation

The contractors have identified various obstacles that discourage successful implementation of the ISO 9000 standard in their companies. These are

- High cost, especially initial cost
- Resistance to change at various levels in the organization
- Loss of productivity of the workforce due to the effort exerted in learning the new system and implementation, besides their regular duties
- Management interference
- Limited ability of personnel
- Remote job sites, making it hard to control and track the quality system implementation in all sites
- Communication problems between personnel because of language differences
- Cultural differences within the workforce

Remarks

There are several observations regarding contractor quality systems. These are highlighted below:

- There is a misconception about the objective of the ISO 9000 standards. They believe that it requires only a documented consistent level of quality, whether low or high—i.e., "write what you do and do what you write." This misconception must be replaced by the correct concept, the "plan-do-check-act," where the quality system is continuously monitored and updated to make sure that

- continuous improvement is achieved and the organization's quality policy objectives are met.
- The contractors who have just started developing quality systems in their companies do not consider setting up priorities in developing the various elements of the quality system.
 - Most contractors confuse the understanding and implementation of clause 4.13 (nonconformance) and clause 4.14 (disposition and corrective action). To explain the difference, whenever a nonconforming work is constructed or wrong equipment is installed in the job site, and a decision is made to correct the problem, this is "disposition." When measures are taken to prevent reoccurrence of the nonconformance in the future, this is "corrective action."
 - Procedure effectiveness evaluations are lacking in the contractors' quality system. The objective of internal quality audits (according to ISO 9000 standards) is to verify implementation and to evaluate effectiveness. In other words, the auditor must not only check if the quality procedures are adhered to but must also check whether the procedures are adequate and effective in achieving quality and quality assurance.
 - Setting up priorities is another area of concern, especially for those who have just gotten started with their new quality systems. They should consider their company operations and make a list of priorities, starting with areas needing immediate improvement. It was observed that ISO 9000 consultants look at all quality elements in the same way. It is the role of the contractor's management to identify the priorities for the consultants, and improvement progress should be followed up.

SUMMARY AND CONCLUSIONS

The quality systems of 15 construction contractors were evaluated. The quality system complexity varies from an informal inspection and test system to a regis-

tered ISO 9002 quality system. The most appealing reasons for registration are top managements interest in improving project quality and current or expected demand from customers. The ISO 9000 clauses most often complied with are (1) inspection and test status; (2) inspection and testing; (3) control of nonconformance product; and (4) handling, storage, and preservation. Misunderstandings were observed regarding the quality system documentation, method of implementation, and the difference between disposition of nonconformances and corrective actions. Setting up priorities for improvement is another area that contractors are not performing.

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