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THE YEAR 2000 VERSION OF ISO 9000 AND THE PROCESS COST MODEL FOR MEASURING QUALITY COSTS IN CONSTRUCTION PROCESSES

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ABSTRACT
One of the main focuses of the Year 2000 version of the international standard ISO 9000 is continual improvement. The Standard clearly indicates that the top management of an organization should make an effort to continually improve both its quality management system and the quality of its products. In order to demonstrate compliance to this requirement, measurement of cost data showing continual improvement should be made and the cost data so obtained must be analyzed. In manufacturing and servicing industries, the measurement of quality costs has been traditionally viewed as one of the most effective tools for evaluating the success of a quality management system. Data obtained from such measurement can also be used to identify areas for improvement. However, due to the special features of construction projects, the measurement of quality costs is seldom carried out in the construction industry.

Activities in construction projects are not rarely repetitive in nature and can be grouped as different processes. An alternative approach, Process Cost Model, as described in the British Standard BS 6143, can be used to measure quality costs. In this paper, the correlation between the two standards (ISO 9000 and BS 6143) is discussed. The common point of the two standards is the Process Approach. An attempt is also made to use the Process Cost Model approach as a tool for measuring quality costs in order to fulfil the ISO 9000 latest edition's requirement of continual improvement in construction processes.

KEYWORDS
ISO 9000, Process Cost Model, Cost of Quality, Construction

1. INTRODUCTION

As the 1994 edition of the ISO 9000 was replaced by the 2000 edition in December 2000, many organizations certified to the 1994 edition have encountered difficulties in the re-certification process. In order to demonstrate compliance to the new standard, it is essential for the organizations to understand the changes made to the old standard and to take appropriate measures for re-certification. The objectives of this paper are (1) to compare 1994 and 2000 editions of ISO 9000 on the issues of process approach and continual improvement, and (2) to examine the

correlation between 2000 edition of ISO 9000 and BS 6143 requirements and the formulation of a process cost model approach for measuring quality costs in construction.

2. COMPARISON BETWEEN 1994 AND 2000 EDITIONS OF ISO 9000

The main differences between the two editions were the merging and restructuring of the previous standards. The key standards of 1994 ISO 9000 family (9001, 9002, and 9003) were merged into a single ISO 9001 standard. The 1994 ISO 9004 were also revised to a new 2000 ISO 9004 standard that provides guidance on quality management system. The twenty requirements of the 1994 edition have been regrouped into four sections, namely, management responsibility, resource management, product realization, and measurement, analysis & improvement. These four sections, together with customer requirements as input and product as output, form the "Process Approach Model" on which the Quality Management System is based. The spirit of the revised ISO 9001 is to move the standard closer to the philosophy of Total Quality Management. The well-known TQM principles of customer satisfaction and continual improvement are mentioned in many parts of the standard. Since the requirements for *continual improvement* and the approach of the *process-based model* are less clear in the 1994 edition, much more attention should be paid to the fulfillment of the related requirements should a company plans for re-certification. The following paragraphs summarize the requirements described in the ISO 9001 and the guidance suggested in ISO 9004 of the 2000 edition.

2.1 Continual Improvement

In the 2000 edition of the ISO 9001, Clause 5.1 clearly indicates that the top management of the organization shall continually improve the effectiveness of the quality management system through the use of quality policy, quality objectives, audit results, data analysis, corrective and preventive actions and management review. This commitment shall be included as part of the organization's quality policy (Clause 5.3). The organization shall also determine and provide the resources needed to apply the continual improvement principles (Clause 6.1). A new clause (Clause 8.5 Improvement) is added to the section "Measurement, Analysis and Improvement" in the 2000 edition. The requirement of "continual improvement" is described in Clause 8.5.1. All the clauses related to continual improvement are summarized in Table 1 and they can be considered as derivatives of the requirement in Clause 4.1. In the 1994 edition of the ISO 9001, no equivalent requirements were found. The only similar requirement was identified in Clause 4.1.3, Management Review, which stated that management should periodically review the quality system for continued suitability and effectiveness in satisfying the requirements of the standard and the quality policy and objectives.

For the 2000 version, while the ISO 9001 specifies the requirements for a quality management system, the ISO 9004 gives guidance on a wider range of objectives of a quality management system than ISO 9001 does, particularly for the continual improvement of an organization's overall performance and efficiency. In addition to the top management's responsibility stated in the ISO 9001, Clause 5.1.2 of the ISO 9004 indicates that consideration should be given to conduct data analysis to facilitate continual improvement of processes. Clause 8.2.1.4 also suggests that cost analysis, such as prevention and appraisal costs analysis, and nonconformity cost analysis, can be used to convert data from processes to financial information in order to provide comparable measures across processes and to facilitate the improvement of processes. Financial data derived from such analysis can be used as inputs to support improvements. The organization's processes for management activities, provision of resources, as well as product realization should be included in the analysis. Improvements can range from small-step ongoing continual improvement to strategic breakthrough improvement projects. A process presenting continual process improvement for implementation by an organization is described in annex B of the ISO 9004.

Table 1: ISO 9001:2000 Clauses related to Continual Improvement

Clause	Description
4.1	The organization shall establish, document, implement and maintain a quality management system and continually improve its effectiveness.
4.1 f)	The organization shall implement actions necessary to achieve continual improvement of the processes needed for the quality management system.
5.1	Top management shall provide evidence of its commitment to continually improving the effectiveness of the management system.
5.3 b)	Top management shall ensure that the quality policy includes a commitment to continually improve the effectiveness of the quality management system.
5.6.3	The output from the management review shall include any decisions and actions related to a) improvement of the effectiveness of the quality management system and its processes, and b) improvement of product related to customer requirements.
6.1	The organization shall determine and provide the resources needed to continually improve the effectiveness of the quality management system.
8.1 c)	The organization shall plan and implement the monitoring, measurement, analysis and improvement processes needed to continually improve the effectiveness of the quality management system.
8.4	The organization shall determine, collect and analyze appropriate data to evaluate where continual improvement of the effectiveness of the quality management system can be made
8.5.1	The organization shall continually improve the effectiveness of the quality management system through the use of the quality policy, quality objectives, audit results, analysis of data, corrective and preventive actions and management review.

2.2 Process Approach

ISO 9001 considers a process as an activity using resources, and it is managed in such a way to enable the transformation of inputs into outputs. There are numerous interlinked processes in an organization. For an organization to function effectively, individual process and its interactions with other processes must be identified and managed systematically. The ISO Standard refers this approach as “Process Approach”. Clause 4.1 of the ISO 9001 states that the organization shall identify, monitor, measure and analyze the processes needed for the quality management system and their application throughout the organization. The main clauses that address the process approach principle are Clause 4.1/4.2.2 (identification of processes and their interaction), Clause 6.1 to 6.4 (provision of resources for processes) and Clause 8.2 (Measurement and monitoring of processes). Processes should include not just the processes for management activities and provision of resources, but also the processes for product realization and measurement. While there were equivalent clauses in the 1994 edition of the ISO 9000, the requirements in the new standard have been widened from focusing just the production and installation processes to all processes needed for the management of quality. The main requirements that address the process approach principle are summarized in Table 2.

Table 2: ISO 9001:2000 Requirements for Process Approach

Requirement	Clause
General requirements related to the process approach	4.1 a) to f)
Provision of resources, infrastructure and information for processes	6.1, 6.2, 6.3, 6.4
Planning of product realization processes	7.1
Definition of process inputs, output, and review	7.3
Requirements for purchasing process	7.4
Requirements for production and service operations	7.5
Measuring and monitoring processes	8.2.3
Processes for nonconformity control	8.3
Processes for corrective and preventive actions	8.5.2, 8.5.3

2.3 Continual Improvement in the Product Realization Process

Continual improvement can be targeted not just at the efficiency and effectiveness of the quality management system and its processes but also the product realization processes. On the other hand, the application of process approach should include processes for management activities, provision of resources, product realization and measurement. Bringing the two new requirements, i.e. "continual improvement" and "process approach", of the ISO 9000:2000 together and focusing them on product realization, organizations can make continual improvement in the product realization process. The above concept is illustrated in Figure 1. In order for an organization's product to be competitive in the market, top management should identify key product realization processes that directly related to the success of the organization for continual improvement. Figure 2 summaries the steps for continual process improvement as required by the ISO 9001/9004.

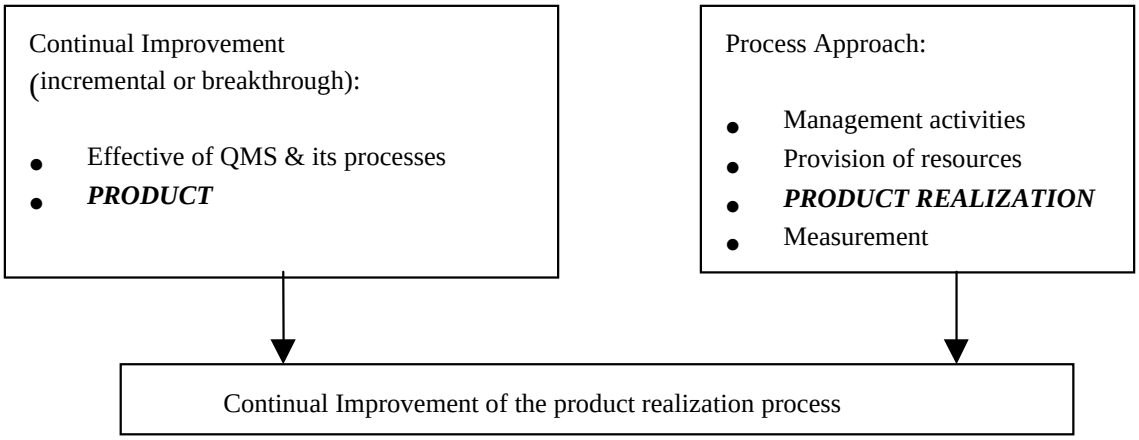

Figure 1: ISO 9001:2000 Focuses of Continual Improvement and Process Approach

3. TOOLS FOR MEASURING PROCESS IMPROVEMENT OF PRODUCTS

In order to identify areas for improvement, effective and efficient methods for measurement have to be employed. Different methods, such as client satisfaction surveys for customers, internal audits, financial measurements, and self-assessment, are contained in the ISO 9004. Due to the uniqueness of construction projects and the complexity of the construction industry, financial measurements are likely to be the most practical method used to identify areas of improvements. ISO 9004 also suggests the use of cost analysis, such as prevention and appraisal costs, nonconformity costs, internal and external failure costs, and life-cycle costing, as financial measurements. These analyses are indeed what are commonly known as quality costing. The costs of quality are traditionally classified into four categories: (1) prevention, (2) appraisal, (3) internal failure, and (4) external failure. *Prevention* costs are those resulting from activities used to avoid deviations or errors, while *appraisal* costs are the costs incurred from activities used to determine whether a product, process or service conforms to established requirements. *Failure* costs are those incurred either during the production process (*internal*) or after the product is shipped (*external*). It is generally believed that by investing more in the areas of prevention and appraisal costs, the failure costs, and therefore the total quality costs, could be substantially reduced. The reduction in the total quality costs can be regarded as an indicator of continual improvement of a company's products. The British Standard BS 6143 Part 2 (BSI 1990) provides guidance on the determination of prevention, appraisal and failures costs in the so-called PAF model.

3.1 Quality Costing in Construction Projects

The PAF model is a traditional method of product quality costing used in the manufacturing industry. Due to the differences between the manufacturing and construction industries and the uniqueness of construction projects, using PAF model as a tool for quality costing is poorly accepted by the construction industry. Interviews carried out by the

authors (Aoieong *et al.*, 2002) with key personnel in the Hong Kong construction industry suggested some reasons for such unpopularity. Although there were a few successful case studies with the PAF model reported by various researchers (Davis, 1987; Winchell and Bolton, 1987; Hall and Tomkins, 2001), the resources involved for implementation in each case seemed to be enormous and therefore not practical for ordinary use. Because of the competitiveness and the speed of the construction industry, it is essential that the quality cost measuring tool must be feasible and simple to use.

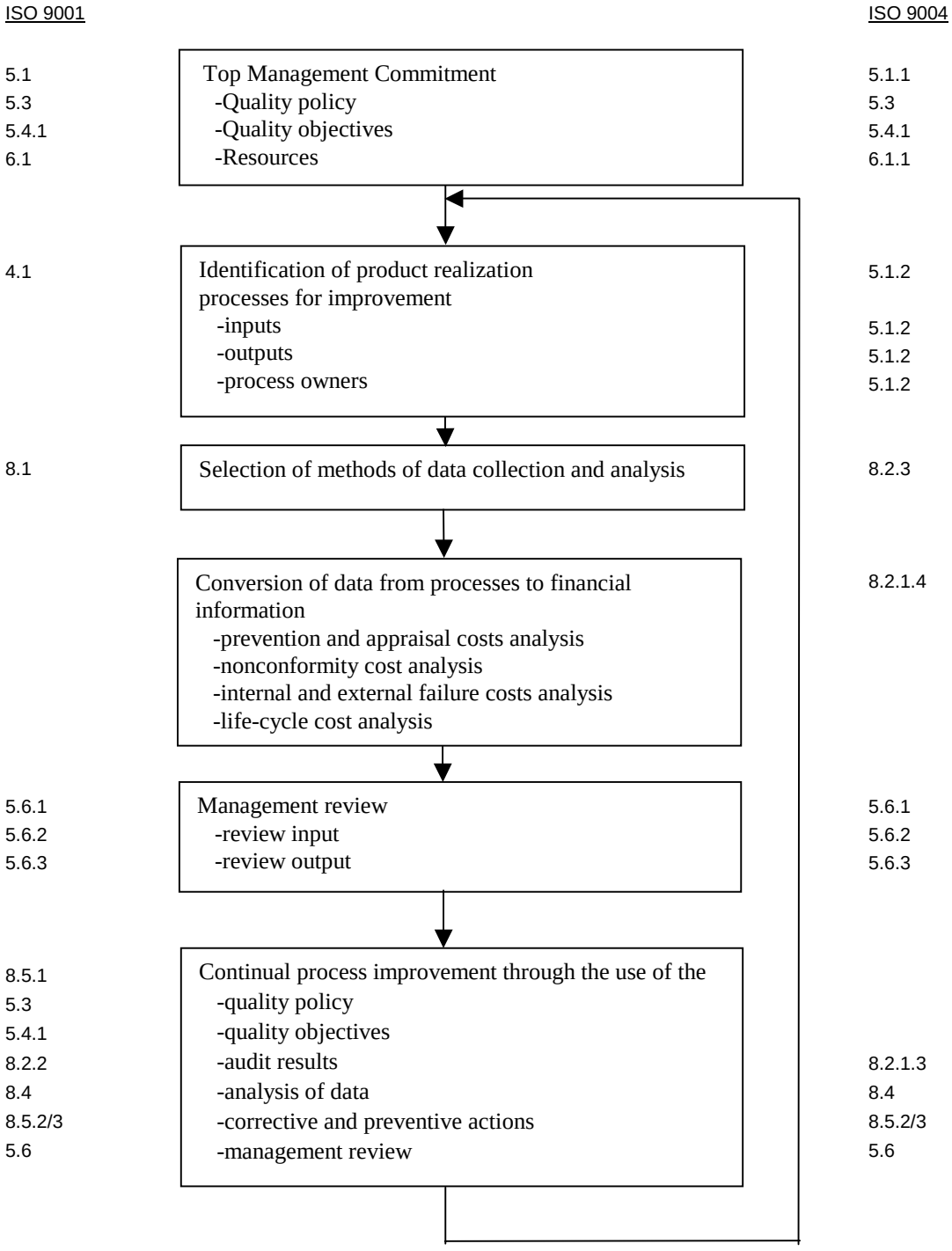

Figure 2: Continual Process Improvement of Products

3.2 BS 6143: Part 1 Process Cost Model

The Year 2000 edition of ISO 9000 did not call out specifically quality costs analysis as a financial measure of the effectiveness and efficiency of the quality system. The guideline of 1994 edition (i.e. ISO 9004), however, did mention briefly three models for collecting and reporting financial data. The three models are (1) the PAF approach, (2) the process cost approach, and (3) the quality loss approach. Interviews carried out by the authors (Aoieong *et al.*, 2002) with key personnel in the Hong Kong construction industry suggested that, amongst the three models, the process cost approach is more feasible and simple to use. In the process cost approach, the "process cost" for a particular process, as defined in BS 6143 Part 1 (BSI, 1992), is the total of cost of conformance (COC) and cost of nonconformance (CONC). Cost of conformance is the intrinsic cost of providing products or services to declared standards by a given, specified process in a fully effective manner. Cost of nonconformance is the cost of wasted time, materials and resources associated with a process in the receipt, production, dispatch and correction of unsatisfactory goods and services. The process cost approach is more in tune with the TQM culture because (1) it includes all activities related to a process, and (2) the COC and CONC can be continually improved. The basic process model (BSI, 1992) is shown in Figure 3. The definition of a process in BS 6143 is very much identical to that of ISO 9001. In the context of building construction, process cost models can be developed for any selected construction processes. For example, the process of "concreting" is shown in Figure 4. Once a particular process is selected for analysis, the costs related to all the key activities could be listed as either COC or CONC. The top management can then monitor the process and make changes that will have impact on both parts of the process cost. Comparison with previous periods can also be made and areas for improvement identified.

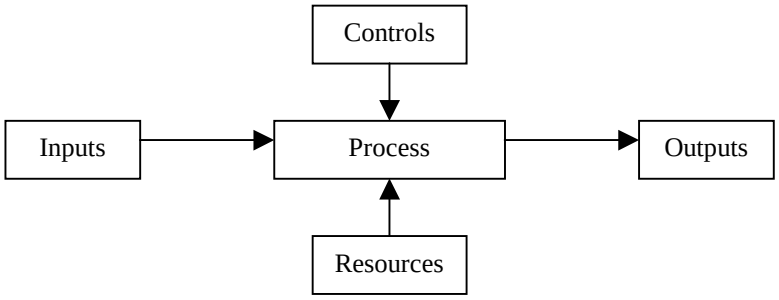

Figure 3: The basic process model based on BS 6143: Part 1

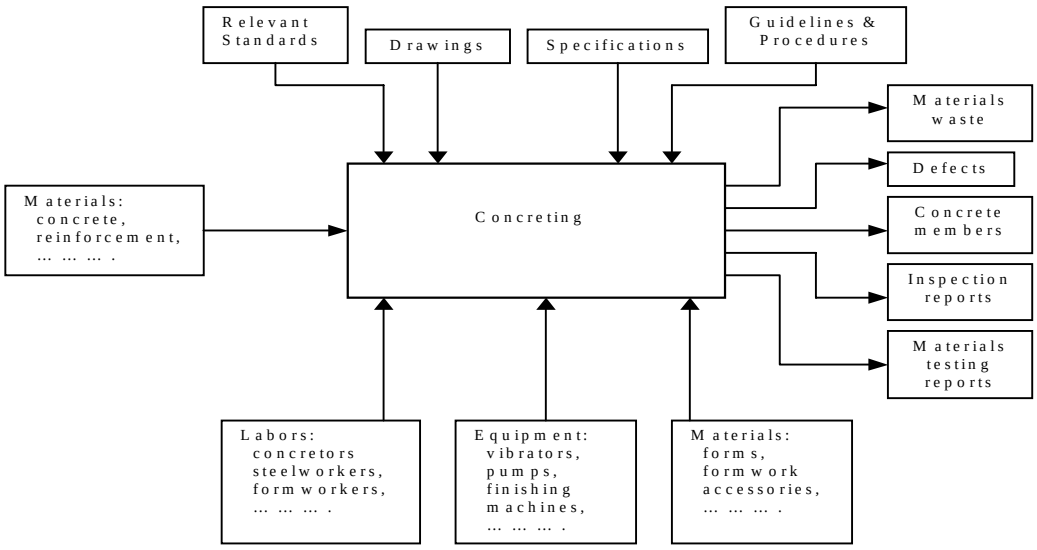

Figure 4: Process Model for "concreting" as Suggested by this Paper's Authors

3.3 Correlation between ISO 9000:2000 and BS 6143: Part 1

In comparing the ISO 9000:2000 and BS 6143: Part 1, many similarities can be found between the two standards. First of all, the definition of process used in both standards is identical. Both standards emphasize the importance of process effectiveness and continual improvement of processes. While cost measurement is one of the methods suggested in the ISO 9000:2000 to identify areas for improvement, the process cost model described in the BS 6143 could be the tool to be used to satisfy the former requirement. Although the ISO 9001:2000 made no reference to TQM, the ISO 9004:2000 gives guidance on a wider range of objectives of a quality management system particularly in the area of continual improvement and this is considered as a guide for organizations in the pursuit of TQM. As for the BS 6143, the emphasis of continual improvement of processes based on cost measurement is fully compatible with the TQM philosophy. The correlation between the two standards is summarized in Table 3.

Table 3: Correlation between BS 6143 (Part 1) and ISO 9001/9004:2000

	ISO 9001/9004	BS 6143
Definition of process	An activity using resources, and managed in order to enable the transformation of inputs into outputs.	Any activity that transforms inputs into outputs, utilizing resources and being subject to particular controls.
Emphasis of the process approach	• Understanding and meeting requirements • The need to consider processes in terms of added value. • Obtaining results of process performance and effectiveness. • Continual improvement of processes based on objective measurement.	• Effectiveness of processes • Continual improvement of processes based on cost measurement.
Areas of application	• Management activities • Provision of resources • Product realization • Measurement	• Any level within the organization • Overall process of operating the business
Financial measurements Analysis suggested:	One of the methods used to identify areas for improvement. • Prevention and appraisal costs analysis • Nonconformity cost analysis • Internal and external failure cost analysis • Life-cycle cost analysis	A tool used to determine costs associated with any process in a manner consistent with the pursuit of continuous improvement. • Process cost analysis (Cost of conformance + Cost of nonconformance)
Total Quality Management	A guide for organizations in pursuit of TQM	Compatible with the TQM philosophy

3.4 Application of Process Cost Model in Construction

In a highly competitive construction market, it is very common to have a few levels of contracting between the general contractor and the laborers. There are also numerous activities executed by each level of subcontractors in a construction project. This explains why quality costing of a whole project is not commonly accepted as a tool for cost measurement in the construction industry. Unlike the traditional PAF model, which is adopted mainly in the manufacturing industry, the process cost approach is a simpler and more practical model when applied in the construction industry. The main advantage of adopting the process cost approach in the construction industry is that the focus is on specific processes in a project identified for monitoring and improvement. The project manager can identify specific processes with high occurrence of nonconformities and target them for quality costing. Moreover, the process cost model can easily be used as a simple tool to measure process improvement, a requirement in the ISO 9000:2000.

4. CONCLUSION

The emphasis of customer satisfaction, process approach, and continual improvement is the main theme throughout the 2000 edition of the ISO 9000. The differences between the 1994 and 2000 editions of ISO 9000 on the issues of process approach and continual improvement have been briefly highlighted in this paper. Both requirements are new and have no equivalent clauses in the 1994 edition. Among the different types of cost analyses suggested in the ISO 9004:2000 as tools for measuring improvement of processes, the process cost model has been briefly discussed. It is believed that the process cost model is a better alternative to be applied in the construction industry because of its simplicity and practicality. Organizations in the industry may still have negative view regarding quality costing, but this trend may be changed if the proposed process cost model can be regarded as one of the ways to fulfil the requirement of continual improvement stipulated in the ISO 9000:2000.

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