



COSTS OF QUALITY DEVIATIONS IN DESIGN AND CONSTRUCTION

**Bureau of Engineering Research
The University of Texas at Austin**

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Costs of Quality Deviations in Design and Construction

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EXECUTIVE SUMMARY

The average cost of rework on industrial projects exceeds 12 percent. For the \$140 billion U.S. construction industry, this means that *we waste in excess of \$17 billion annually*. These costs can be significantly reduced through better quality management. Design deviations (changes, errors, and omissions) accounted for roughly 80 percent of the increased costs, while construction deviations accounted for only about 20 percent. A Quality Performance Management System (QPMS) has been developed (Appendix E) that can be used as a management tool to identify and reduce deviation costs.

Objective of Study

The objective of the Quality Management Task Force study was to identify and quantify the magnitude of rework costs resulting from quality deviations in design and construction, and to present data that will encourage the construction industry to implement systems such as the QPMS to reduce these costs.

Recommendations

1. Reduce the number of design changes by:
 - establishing definitive project scope.
 - performing periodic reviews with participation of all parties.
 - establishing procedures to limit scope modifications.
2. Implement a quality management program that has total commitment at all levels in the firm.
3. Adopt the standard set of quality-related terminology presented in Appendix A.
4. Develop and implement a system to establish a database necessary to identify deviation costs and quality problem areas.
5. Implement a Quality Performance Management System.

BACKGROUND

Introduction

The CII Quality Management Task Force (QMTF) conducted research to identify and quantify the rework (including repair and replacement) costs of correcting quality deviations in design and construction (including fabrication, transportation, and operability). This publication presents a summary of the findings of the research and shows how the collection and analysis of deviation cost information can identify not only deviation costs, but also areas in which to concentrate efforts to reduce deviation costs.

Glossary of Quality-Related Terms

The task force developed a glossary of quality terminology (Appendix A) that is general in nature and has wide applicability. A complete discussion of the glossary and its development is presented in Reference 1. Two key definitions used in the glossary are *quality* and *deviation*.

Quality is defined as “conformance to established requirements.” By avoiding dealing with degree of goodness or satisfaction, this definition provides a basis for measurement, i.e., the requirements are either met or not met.

The term *deviation*, rather than failure or defect, indicates that a product or result that does not fully conform to all specification requirements does not necessarily constitute an outright failure. The term *deviation* includes changes to the requirements that result in rework, as well as products or results that do not conform to all specification requirements, but do not require rework.

DATA COLLECTION

To allow for meaningful comparisons, the study was limited to industrial projects for which construction began before project design was completed. Each of the projects was near completion or had been completed within the previous two years. Table 1 presents brief descriptions for the projects that were studied.

Table 1

DESCRIPTIONS OF THE INDUSTRIAL PROJECTS STUDIED				
Project Number	Type of Construction	Type of Contract*	Total Installed Project Cost	Designer & Constructor
1	Retrofit	FP	\$ 20 Million	Different
2	Retrofit	FP	\$ 6.8 Million	Different
3	New	FP	\$ 25 Million	Different
4	Upgrade	FP	\$ 11 Million	Different
5	Upgrade	CR	\$100 Million	Different
6	Upgrade	CR	\$900 Million	Different
7	New	CR	\$100 Million	Different
8	Retrofit	CR	700,000 work-hours	Different
9	New	FP	\$106 Million	Different
*FP-Fixed Price CR-Cost Reimbursement				

Types of Construction

The projects were divided into the following three categories:

1. New construction-the design and construction of the structure to house the operation as well as the installation of the process equipment and instrumentation.
2. Retrofit construction-design and installation of process equipment and instrumentation in an existing, but empty, structure. Removal of existing process systems prior to installation of new systems was not part of the retrofit projects considered in the study.
3. Upgrade construction-the design and construction associated with the modification of an existing facility, for example, technological advancements and process improvements.

Data Collection

A detailed description of the data collection procedures is presented in Appendix B. The deviation data collected included only the direct costs associated with rework (including repair and replacement) and therefore do not constitute the total costs associated with the deviations. These direct costs of correcting deviations are only the “tip of the iceberg”! Impact costs, such as the effects of the rework on the project schedule or on other project activities, generally were not available and are not included in the deviation costs presented herein. In addition, no data were available on the costs associated with quality management activities.

Classification of Data

The deviation cost data were divided into five major areas—design, construction, fabrication, transportation, and operability. Each of these areas was further subdivided by type of deviation, i.e., change, error, or omission. Since for the projects studies a large percentage of deviations were due to design changes (over 50 percent of the total number of deviations), the deviation category for design changes was expanded to seven design change categories. The categories used to classify the deviation data are shown in Table 2 and discussed in detail in Appendix 6. The categories are mutually exclusive, and each deviation is classified by only one of the categories.

Each deviation was also classified by source and a “source code” was assigned to each deviation. Source includes typical disciplines such as civil, electrical, and mechanical, as well as other sources of deviations such as piping, labor, and contract. The classification of deviations by source codes is mutually exclusive, and each deviation is assigned to only one of the source codes listed in Table 3 and described in detail in Appendix B.

Table 2

DEVIATION CATEGORIES USED FOR CLASSIFYING PROJECT DATA	
Deviation Category	Brief Description
CC Construction Change	Change in the method of construction
CE Construction Error	Error made during construction
CO Construction Omission	Omission made during construction
DCI Design Change/Improvement	Design revisions, modifications, and improvements
DCC Design Change/Construction	Design change initiated by construction
DCF Design Change/Field	Design change required due to field conditions (e.g., lack of as-builts)
DCO Design Change/Owner	Design change initiated by owner
DCP Design Change/Process	Design change initiated by operations or process
DCR Design Change/Fabrication	Design change initiated by fabricator
DCU Design Change/Unknown	Design change with an unknown source of initiation
DE Design Error	Error made during design
DO Design Omission	Omission made during design
OC Operability Change	Change made to improve operability
FC Fabrication Change	Change made during fabrication
FE Fabrication Error	Error made during fabrication
FO Fabrication Omission	Omission made during fabrication
TC Transportation Change	Change made to method of transportation
TE Transportation Error	Error made in method of transportation
TO Transportation Omission	Omission made in transportation