Contractor quality control: A method of construction inspection

John Scott Treadwell

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CONTRACTOR QUALITY CONTROL
A METHOD OF CONSTRUCTION INSPECTION

BY

JOHN SCOTT TREADWELL, 1942-

A THESIS

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ABSTRACT

It has become apparent in recent years that the United States Government's construction contract supervision and administration procedures are causing an increase in contractor claims and disputes and that the system itself is becoming prohibitively expensive. To deal with some of these problems, the Department of Defense is attempting to implement a new approach to construction inspection--Contractor Quality Control.

Under the Contractor Quality Control System the majority of the standard contract inspection and testing responsibilities are placed on the contractor, and the Government relinquishes its traditional step-by-step inspection and testing procedures and withdraws to a position of contract surveillance.

The Government's supervision and administration system has evolved through the years to the point where the Government practices preventive inspection rather than merely corrective inspection. The concept of preventive inspection has led the Government to the position of specifying construction methods and procedures in order to prevent failure of the contractor to meet contract standards. While the practice of preventive inspection has resulted in acceptable construction, it has had the undesirable effect of jeopardizing the independent contractor relationship between the Government and the contractor. Under the
Contractor Quality Control System the contractor is allowed to fail, but he also has an increase in flexibility and job control and an opportunity for a larger profit margin.

Contractor Quality Control offers the Government the chance to retain the independent contractor relationship, to cover a larger dollar volume of work with the same or fewer personnel, to expect fewer claims and, hopefully, to expect that the new system will discourage less competent contractors from bidding.

This thesis examines inspection during the current transition from the traditional Government methods, as practiced by the U.S. Army and the U.S. Navy, to the new system of Contractor Quality Control. The thesis points out possible danger points, cites successes and failures to date, and suggests future improvements for a more effective system.
ACKNOWLEDGEMENTS

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I. INTRODUCTION

When a construction contract is awarded, a problem which is always present during the life of the contract is to assure the owner that the contractor's product is meeting the minimum levels of quality established in the contract plans and specifications. Quality assurance is normally accomplished by construction inspection performed by the owner, a representative of the owner, or a neutral third party.

On federal construction, the Government, as the owner's representative, has traditionally taken all responsibility for construction inspection. This practice has required the Government's field organization for contract supervision and inspection to be much larger than its counterpart in private construction. Usually the organization is functionally divided into branches containing various engineering disciplines or into branches responsible for a specific contract, or both. The resident engineer's staff usually contains service groups such as personnel, general maintenance and secretarial services. Inspection is accomplished by highly trained construction or engineering materials inspectors who report to supervisory engineers.

With such a large staff the Government has been able to perform a very close step-by-step inspection of the contractor's operations. While this practice has normally
resulted in attaining good construction quality, it has recently become apparent that this practice has not only become prohibitively expensive, but has also led the Government into a position which jeopardizes the legal relationship between the Government and the independent contractor.*

A. DESCRIPTION OF CONTRACTOR QUALITY CONTROL

The Department of Defense, through the U. S. Army Corps of Engineers and the U. S. Navy, is responsible for the majority of federal civil works and military construction projects. In an attempt to alleviate some of the problems of past inspection practice, the Department of Defense is attempting to redefine the responsibility for quality control under a new system, Contractor Quality Control, called CQC in the construction field. By this system, the Government hopes to return much of the inspection responsibility to the contractor.

Contractor Quality Control has been defined as a contractually required management and inspection system set up by the contractor and used by him to assure that his procurement personnel and artisans buy and build in accordance with the plans and specifications. When the contractor exercises effective CQC the Government will relinquish its traditional step-by-step inspection and testing procedures

* Refer to Section VI for further discussion of the disadvantages of traditional Government inspection practices.
and withdraw to a position of surveillance, including random inspection and testing, to see if the contractor is meeting his CQC responsibilities.

The U. S. Government contract specification paragraphs GP-23 and SP-38 (see pages 14 and 15) are the basic contract provisions. They set the framework for the Contractor Quality Control System and require the contractor to establish a formal quality control organization. He may use his normal staff to fulfill the CQC responsibilities, if they are qualified and have sufficient time outside their normal duties.

The contractor's authorized CQC representative is the head of his quality control operation. The designated representative must report to no one lower than the senior project superintendent. The CQC representative becomes the point of contact with the Government on all matters relating to quality and he must be authorized by the company to take what actions are necessary to assure quality.

The contractor is required to submit a detailed CQC plan prior to the start of construction. The contractor must fully explain the methods he intends to use in demonstrating that his and his subcontractors' work meet the contract requirements, including test methods, independent testing labs and test report forms.
B. NEED FOR QUALITY CONTROL

There are compelling reasons for the owner to insist on quality control during construction. First is the necessary concern for public health and safety. A poorly constructed building can fail when subjected to actual loads much smaller than design loads and can be a threat to public safety. Likewise, an improperly constructed levee subjects inhabitants of the old flood plain to potential catastrophe. Public health and safety are protected by quality control.

Second, maintenance costs and operating efficiency of a project are directly proportional to construction quality. In most cases where poor construction quality is evident, catastrophic failure is not the result; rather, there is an increase of maintenance and repair costs to the owner. This point is brought out in a paper by Richard Q. Praegar (1)* presented during the ASCE Symposium on Quality Control in Construction in May 1965. He stated that, in the long run, the total cost of construction and lifetime maintenance of all building industry items is less than it would have been without quality control and that increased insurance and maintenance would negate any savings due to the omission of

* This thesis uses the references cited format of footnoting. The first figure within the parenthesis refers to the author's number in the bibliography on page 80. The second number, if any, refers to the page number.
quality control.

Finally, appearance of the finished structure is important. Appearance is the most apparent sign of quality control. Poor quality control can result in rock pockets in exposed architectural concrete because of poor consolidation; in paint blistering on finished surfaces because of an improperly prepared surface, and in many other ways which detract from the project's outward appearance. In federal public work projects the total project appearance will be the deciding factor in persuading the general public that they have received their money's worth.

Quality control is also important to the contractor. John S. Pearson (2, 55), a contractor, has stated that a thoughtful contractor is definitely in favor of competent, uniform inspection to assure quality for at least four good reasons.

1. Competent inspection protects his industry from the criticism and loss of public confidence that would result from inferior work.

2. Good inspection protects the contractor's reputation from the damage that would result from unintentional failure of trusted employees to perform properly.

3. Competent inspection protects him from being placed at the competitive disadvantage that would result if other contractors were allowed to do substandard work.

4. Good inspection protects a contractor who follows others in stage construction or as a subcontractor.
C. PHASES OF CONSTRUCTION QUALITY ASSURANCE

The cornerstone of construction quality is the contract plans and specifications. Because of the nature of construction, adequate plans and specifications must be developed to include materials and workmanship for each major phase and component of the project. Robert W. Abbett (3, 398), author of the text, "Engineering Contracts and Specifications," has summarized this as follows:

A comprehensive project, such as a building or a bridge, is made up of a large number of parts, and no practicable test or series of tests is available to prove that the finished structure will perform its required service throughout its desired period of time. It becomes necessary therefore to control the quality of materials and workmanship in the manufacture, fabrication, and assembly of the various parts and to rely on the sufficiency of the design to obtain satisfactory performance in the finished structure. Accordingly, specifications for materials and workmanship are used for most of the basic types of construction. In this type of specification, responsibility is placed on the contractor for furnishing materials and workmanship conforming to the requirements specified for each type of construction and for the assembling of the component parts of the structure, but, if these are free from defects, the overall performance of the assembled structure rests on the owner inasmuch as he furnished the plans and specifications.

Therefore, there are two phases of construction quality assurance. The first is the establishment of a good set of plans and specifications. The responsibility for this falls on the Government agency or sometimes on an independent architect-engineer firm. The responsibility for the second phase, that is, assurance that the construction conforms to
the contract plans and specifications, legally rests with
the contractor. According to Jarvis (4, 72):

...this is so because, for the consideration stated in the contract, he is the one who has agreed
to do the work and to furnish the material and
services as required by the contract--to the degree of perfection required by the specifications.

D. RESPONSIBILITY FOR QUALITY CONTROL

Even though the responsibility of quality control during construction is legally the contractor's, the Government has, through the years, created a supervision and inspection system which removed this responsibility from him.

Industry and manufacturing personnel have long realized the value of placing quality control directly in the hands of the producer. This is shown in the following statement by Gedye (5, 8):

In modern quality control an important feature is to overcome this conflict of interest between the producer and inspector and to integrate as closely as possible production and inspection. The more quickly and effectively information can be fed back to the producer, enabling him to take corrective action, the more perfect material will be produced. Under these conditions, the inspector becomes a valued member of the production team, helping not only to maintain quality, but incidentally to increase output. One of the greatest causes of lost output is time spent correcting faults, and if action can be taken in time to prevent faults from arising, many of the consequent stoppages of production can be avoided. There is often a strong case for the production manager being in charge of inspection of his own product. This helps him appreciate and accept his responsibility for the end product and gives him a strong vested interest in ensuring that the quality of his product is maintained. The logical extension of this principle is where possible to make the producer his own inspector, and so to return in
some measure to the advantages enjoyed by the craftsman who saw that his own work was up to standard.

An objective of the Contractor Quality Control System is to offer the contractor a chance to regain the responsibility for quality control.

A word about the results of CQC as used by the Army and the Navy: the preliminary returns of the Navy program are not in; the Army has had mixed results to date. According to the Army (6, 7):

Experience with Contractor Quality Control (CQC) over the past three years has produced varied results, i.e., a few examples of strong and sincere effort to use the CQC requirements to assure quality work; the majority of examples have been lackadaisical effort without positive results; and a few examples of positive resistance to the requirements, with bad results.

The problems will be discussed further in Chapter VIII. Suffice it to say at this point that the last few years have been primarily a learning period for both the Government and contractors.

E. THESIS OBJECTIVES

The objective of this thesis is to examine inspection during the current transition from traditional Government practices to Contractor Quality Control in order:

1. To recognize and define the problems resulting from traditional Government inspection.

2. To examine Contractor Quality Control and discuss how it might help solve the above problems.
3. To examine the Army's and Navy's CQC systems and suggest possible improvements.
II. REVIEW OF LITERATURE

Literature in the field of construction inspection and construction quality control is limited and is primarily devoted to developing inspector checklists. These checklists are available for most major construction components, such as concrete, asphalt, foundations, and utilities, and comprehensive inspector guides are available from many public agencies. Unfortunately, very little of the above literature discusses the overall picture of inspection and quality control. Such questions as the following ones are not mentioned. Which party should perform inspection? What problems are caused by agencies taking the responsibility for inspection? Should quality assurance rest primarily on the contractor? For this reason much of the discussion in this thesis is based on personal conversations and correspondence, on the author's past experience and on various Army and Navy Regulations and Memoranda.

The Department of Defense reviewed its policies regarding construction quality assurance and in November 1961 a new clause was added to the Armed Services Procurement Regulations (ASPR's). These regulations are issued by direction of the Secretary of Defense and they establish uniform policies and mandatory procurement procedures for the military services. The regulation ASPR7-602.10 (Contractor Inspection System) must be included in all contracts in excess of $10,000. It states:
The contractor shall (i) maintain an adequate inspection system and perform such inspections as will assure that the work performed under the contract conforms to contract requirements, and (ii) maintain and make available to the Government adequate records of such inspections, (7, 793).

The Army was first to issue guidance for implementing CQC (8). The Office of the Chief of Engineers (OCE) issued Engineering Regulation ER 1180-1-6 on 1 December, 1966. This regulation required some minor revisions to clarify organizational changes the contractor must make to implement CQC. Regulation ER 1180-1-6 was revised and reissued on 20 June, 1967, and it is currently in use.

The Navy (9) began its implementation on 10 April, 1970, with the issuance of Naval Facilities Engineering Command Instruction NAVFACINST 4355.6. The content of this regulation is similar to the Army's revised ER 1180-1-6. The Navy implemented CQC on a graduated basis, started 1 July, 1970, on contracts of one million dollars or larger with the dollar amount to be progressively lowered to $10,000 as soon as practicable.

Pertinent parts of both regulations are included in the body of this thesis, but, because of their length, they cannot be included in their entirety. They are on file, together with other referenced material, in the Department of Civil Engineering, University of Missouri-Rolla, Construction Management files, and are available for reference. Standard Government Contract Clauses which are pertinent to this discussion are included in Appendix C.
III. METHOD OF STUDY

By its very nature, a study of any management system requires subjective analysis. Management deals with the complex structure and behavior of groups of people, and therefore a management study does not lend itself to traditional scientific laboratory analysis. This fact, however, does not reduce the importance of a management study. Without a constant and critical evaluation of management systems, especially in large organizations like the Department of Defense, much of today's scientific and technological achievements and overall group effort will be lost or at best inefficiently used.

In the study of management, Harold Koontz and Cyril O'Donnell (10, 11) have said:

Certainly, the observations of perceptive managers must substitute for the desirable laboratory-proved facts of the management scientist, at least until such facts can be determined. Statistical proof of principles of management are desirable, but there is no use waiting for such proof before giving credence to principles derived from experience.

Because the concept of Contractor Quality Control is less than a decade old, the Department of Defense, including the Army and the Navy, is still in the learning process. Other than Government publications, very little has been written on this subject.

In order to study the CQC System the author has gathered available data from both the Army and Navy, particularly from the Army's Libby Dam Project in Northwest Montana, one
of the nation's largest civil works projects currently under construction. The author, having worked on the Libby Project for nearly three years, is personally familiar with attempts to implement CQC on that project. Not only was the author able to get firsthand knowledge of CQC in practice, but he also had many occasions to discuss CQC with Government personnel, many of whom have extensive construction backgrounds.
IV. CONTRACT SPECIFICATIONS FOR CONTRACTOR QUALITY CONTROL

Government contract specifications are divided into three successive sections—general provisions, special provisions, and technical provisions. The general provisions are the mandatory or boilerplate clauses reflecting and implementing statues; Presidential policy as embodied in Executive Orders; and the policies of the Department of Defense and the particular branch of the Armed Services. They are contained on standard GSA Forms. The second section, contract special provisions, elaborates on the general provisions; these are tailored to fit each individual contract. The third and normally by far the largest section is the technical provisions. The technical provisions contain the specific technical requirements for each work component and phase. In each of these provisions, paragraphs have been added or existing paragraphs revised to implement CQC. The following contract clauses are examples of the new requirements.

A. GENERAL AND SPECIAL PROVISIONS

Both the Army and the Navy include in all contracts the following two paragraphs in the general provisions or in the special provisions (18, encl. 1).

GP-23. Contractor Inspection System

The Contractor shall (i) maintain an adequate inspection system and perform such inspections as will assure that the work performed under the contract conforms to contract requirements, and
(ii) maintain and make available to the Government adequate records of such inspections.

SP-38. Contractor Quality Control

The contractor shall provide and maintain an effective quality control program that complies with General Provision 23 of the contract entitled "Contractor Inspection System."

a. The contractor shall establish a quality control system to perform sufficient inspection and tests of all items of work, including that of his subcontracts, to ensure conformance to applicable specifications and drawings with respect to the materials, workmanship, construction, finish, functional performance, and identification. This control will be established for all construction except where the technical provisions of the contract provide for specific government control by inspections, tests or other means. The contractor's control system specifically include the surveillance and tests required in the technical provisions of the contract specifications.

b. The contractor's quality control system is the means by which he assures himself that his construction complies with the requirements of the contract plans and specifications. The controls shall be adequate to cover all construction operations and should be keyed to the proposed construction sequence.

c. The contractor's job supervisory staff may be used for quality control, supplemented as necessary by additional personnel for surveillance, special technicians, or testing facilities to provide capability for the controls required by the technical provisions of the specifications.

d. The contractor shall furnish to the Government within ( ) days after receipt of the Notice to Proceed a quality control plan which shall include the procedures, instructions, and reports to be used. This document will include as a minimum:

(1) The quality control organization
(2) Number and qualifications of personnel to be used for this purpose

(3) Authority and responsibilities of quality control personnel

(4) Methods of quality control including that for his subcontractor's work

(5) Test methods including, as specified, name of qualified testing laboratory to be used

(6) Method of documenting quality control operation, inspection, and testing

(7) A copy of a letter of direction to the contractor's representative responsible for quality control, outlining his duties and responsibilities, and signed by a responsible officer of the firm.

e. After the contract is awarded and before construction operations are started, the contractor shall meet with the contracting officer, or his representative, and discuss quality control requirements. The meeting shall develop mutual understanding relative to details of the system, including the forms to be used for recording the quality control operations, inspections, administration of the system, and the interrelationship of contractor and government inspection.

f. Unless specifically authorized by the contracting officer, no construction will be started until the contractor's quality control plan is approved.

g. All compliance inspections will be recorded on an approved form (Figure 1), including but not limited to the specific items required in each technical section of the specifications. This form, to include records of corrective action taken, will be furnished to the government as required by the contracting officer.

h. If recurring deficiencies in an item or items indicate that the quality control system is not adequate, such corrective actions will be taken as directed by the contracting officer.
1. Preliminary Quality Control Plan

Navy (11, encl. 1) contracts have a special provision paragraph clarifying the CQC requirements and stating the requirements for the Preliminary Quality Control Plan:

SP-39. Contractor Quality Control

(a) This contract will be administered under General Provisions 37 and 38, of the Additional General Provisions, NAVFAC 4-4330/5 (Rev 1-70). The contractor shall provide the general and specific QUALITY CONTROLS required to obtain the QUALITY LEVEL established by the requirements set forth in the specifications and drawings.

(b) Submission of Preliminary Quality Control Plan. As a condition precedent to the award of this contract, the successful bidder must furnish to the Officer in Charge of Construction an acceptable preliminary Quality Control Plan in the detail set forth below. This plan must be submitted, in writing, within five days after receipt of a request for submission from the OICC and the failure to submit such a plan, will be grounds for rejection of the bid. As a minimum, the preliminary plan shall include the following:

(1) The name of the contractor's representative who will be responsible for the supervision and administration of the contractor's quality control plan at the work site and a detailed description of the prior professional and technical experience of this individual.

* The Navy abbreviation OICC is Officer in Charge of Construction, equivalent to the Army's Contracting Officer. ROICC is the Resident Officer in Charge of Construction, equivalent to the Army's Resident Engineer. Paragraph numbers vary with each contract. These numbers are included here for easy reference. The Navy's GP-37 and 38 are equivalent to GP-23 and SP-38 on page 14.
(2) A copy of the letter or other internal company instructions setting forth the authority and responsibilities of the individual designated in (1) above.

(3) An organization chart setting forth the contractor's proposed quality control organization. Accompanying this chart should be the names and brief description of the experience of persons assigned to key positions. If the individuals to be assigned to these positions are not known, a description of the qualifications and experience that will be required for the individual who will be assigned, must be provided.

(4) A listing of outside organizations such as testing laboratories and consulting engineers that will be employed by the contractor and a description of the services these firms will provide.

The information to be provided in the preliminary plan is in addition to that required by Article 38 of the General Provisions of the contract. Subsequent to award, the contractor will be required to provide a complete and detailed quality control plan including, as a minimum, all of the information set forth in Article 38.

(c) All submittals, shop drawings, catalog cuts, etc., unless otherwise specifically noted, shall be certified by the contractor as meeting the plans and specifications. copies of all shop drawings, catalog cuts, or other submittals, with the contractor's approval indicated thereon, shall be sent to the ROICC for record purposes, within 1 (one) working day of the contractor's approval, and 14 days prior to installation.
(d) Where test results by an approved testing laboratory are required, they shall include the acceptable value for each specification requirement tested, the actual test results therefore, and a statement that the product conforms (or not) to the specification requirements.

(e) The contractor's quality control organization is the means by which he assures himself that his construction complies with the requirements of the contract plans and specifications. The controls shall be adequate to cover all construction operations, including both on-site and off-site fabrication and shall be keyed to the proposed construction sequence and shall include as a minimum at least three phases of inspection for all definable items or segments of work, as follows:

(1) **Preparatory Inspection.** To be performed prior to beginning any work on any definable segment of work. To include a review of contract requirements; a check to assure that all materials and/or equipment have been submitted and approved; a check to assure that provisions have been made to provide required control testing; examination of the work area to ascertain that all preliminary work has been completed; and a physical examination of materials and equipment to assure that they conform to approved shop drawings or submittal data and that all materials and/or equipment are on hand. As a part of this preparatory work, contractor's Quality Control organization will review all shop drawings, certificates, and other submittal data prior to submission to the Contracting Officer.
(2) **Initial Inspection.** To be performed as soon as a representative segment of the particular item of work has been accomplished and to include examination of the quality of workmanship and a review of control testing for compliance with contract requirements, use of defective or damaged materials, omissions, and dimensional requirements.

(3) **Follow-up Inspections.** To be performed daily or as frequently as necessary to assure continuing compliance with contract requirements, including control testing, until completion of the particular segment of work.

(f) The contractor shall submit daily reports to the OICC/ROICC identifying the work accomplished; the inspections and tests conducted; results of inspections and tests; nature of defects found; causes for rejection; proposed remedial action; and corrective actions taken; together with the following certification: 'The above report is complete and correct and all material and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as noted above.'

2. **Shop Drawings**

To implement the Navy's change in shop drawing procedures the pertinent general provision is changed to read (11, encl. 1):

GP-67: **Shop Drawings**

'The Contractor shall submit to the Officer in Charge of Construction (for record purposes, except for those required by the specifications to be submitted for Government approval) six copies of all shop drawings as called for under the various headings of the contract specifications. These drawings shall be complete in detail. If approval by the Officer in Charge of Construction
is required, each copy of those drawings will be identified as having received such approval by being so stamped and dated. The Contractor shall make any corrections required by the Officer in Charge of Construction. If the Contractor considers any correction indicated on the drawings to constitute a change to the contract drawings or specification, notice as required under the clause entitled "Changes" will be given to the Officer in Charge of Construction. When Government approval is required, five sets of approved drawings will be retained by the Officer in Charge of Construction and one set will be returned to the Contractor. Submission of drawings by the Contractor will not relieve the Contractor of the responsibility for any error which may exist, as the Contractor shall be responsible for the dimensions and design of adequate connections, details, and satisfactory construction of all work.*

3. Material Submittals

The Navy's general provision concerning sample submittals is changed in a similar manner to the shop drawing clause. The first and last paragraphs of the old clause (see Appendix C) are deleted and the following are substituted (11, encl. 1):


'The proposed material submittals required of the Contractor shall be submitted to the Officer in Charge of Construction (for record purposes, except for those required by the specifications to be submitted for Government approval) prior to their procurement. Submittals shall be prepared and assembled as follows:'

Subparagraphs (a) through (f) are unchanged. Delete the last paragraph and substitute the following in lieu thereof:

'The Contractor shall certify on all submittals that the material being proposed conforms to all contract requirements. In the event of any variance, the Contractor, in separate

* The old clause included in Appendix C for reference. Subparagraphs 1 and 2 are unchanged.
correspondence, shall state specifically which portions vary and request approval of the substitute. The contractor shall also certify that all contractor furnished equipment can be installed in the allocated spaces. Incomplete submittals and submittals with inadequate data will not be accepted.'

B. TECHNICAL PROVISIONS

The technical provisions of each contract must be carefully prepared in order for CQC to be effective. The Contracting Officer, with the assistance of design and construction personnel, must determine the minimum quality control requirements for each project, and these must be included in the appropriate technical provisions. The Navy (9, 14) requires each technical provision paragraph of the contract specifications, which concern an item, group of items, equipment, etc., to include a specified quality level and quality control. The quality level is, in most cases, the normal specification paragraph, or paragraphs, as they have been written in the past. These paragraphs state the specific degree of excellence, basic nature, character, kind of performance of a particular item or group of items required by the designer. They can include references to military specifications, American Society for Testing Materials (ASTM) Specifications, federal specifications, etc. Examples of physical characteristics included in quality level would be strength, modulus of elasticity, durability, hardness, chemical composition, electrical properties, and acoustical
properties. A separate paragraph entitled, "Quality Control," must be included with each technical provision where specific quality control provisions are required of the contractor to verify achievement of the specified quality level. These requirements may include laboratory tests, manufacturer's notarized certificates, and field tests. The technical provisions must also indicate any inspections or tests which will be retained as a responsibility of the Government. Any special quality control staff requirements must be spelled out. In cases where a specialist is deemed necessary to insure quality, the number and duration of specialists to be used by the contractor must be included.

The technical provisions are a major influence in the effectiveness of the CQC system. They must be specific enough to allow a contractor an accurate cost estimate of the CQC requirements in preparing his bid. Areas which must be considered in determining the scope of the quality control requirements are (11):

1. Size of the job
2. Size of a job component in relation to the project
3. Criticality of a component's function
4. Structural integrity
5. Hazard potential
6. Maintenance potential
7. Impact on design responsibilities
8. Complexity
The Navy (11) has developed a guide for specification writers to use in preparing the technical provision quality control paragraphs. It describes construction of varying levels of complexity and indicates the wording to be used in the technical specification to obtain the required quality control. The following list is from the Navy's guide and shows the recommended CQC requirements to be included in the technical provisions for construction components of increasing importance (11, encl. 2).

1. Routine requirements, including those for materials which the contractor can be expected to cover under the basic CQC requirements imposed on him by the new general and special provisions. Requires no additional Quality Control (QC) technical provision paragraphs.

2. Moderately important requirements which can be verified by field tests, including, for example, concrete slump tests. "Testing shall be accomplished by or under the supervision of CQC personnel."

3. Important requirements which can be verified by laboratory testing; for example, concrete cylinders. "The contractor shall submit certified test results from an approved laboratory showing conformance to the above technical provision."
4. Important requirements that have a high potential for latent defects, or that, because of failure, would have a significant impact on the function of the structure or equipment. For example, the placing of structural concrete. "The above requirements shall be accomplished in the presence of CQC personnel."

5. Very important requirements which, if not met, would result in a potential hazard to life, limb, or property, or would seriously affect the structural integrity or function to be performed. For example, the placement of splicing in reinforcing steel in critical areas. "The above requirements will be inspected and approved by the Government."

6. Shop drawings, where control should be maintained because of criticality or complexity, or where they are by necessity an extension of design; should be submitted to and approved by the Contracting Officer. For example, detailing of reinforcing steel in a thin shell arch. "These shop drawings shall be submitted to the Contracting Officer for approval."

7. Very important or complex requirements which would be unreasonably difficult for the contractor's CQC organization to handle. For
example, Quality Control of cement at the manufacturer's plant. Use QC paragraph, "Inspection will be performed by the Government."

8. When a requirement exists which is continuing throughout all or a significant part of the project, the contractor should develop QC procedures for that requirement and include them in his Quality Control Plan, outlining the frequency and type of inspection and testing. This QC requirement may be used alone or in conjunction with many of the above. For example, concrete aggregates. "The contractor shall include in his Quality Control Plan the procedures by which conformance to the above requirements will be met."
V. DUTIES AND RESPONSIBILITIES OF THE CONTRACTING PARTIES UNDER THE CONTRACTOR QUALITY CONTROL SYSTEM

Prior to contract award, the contractor must submit a Preliminary Contractor Quality Control Plan, as specified in paragraph SP-39(b), and the agency must review it carefully. It is at this time that the Government must determine if the contractor intends to emphasize quality if he is awarded the contract. The preliminary plan must include the name and qualifications of the contractor's CQC representative, his letter of authority, the contractor's intended CQC organization (including names, if possible), and a listing of all outside testing laboratories or consultants which will be used during the contract. The testing laboratories and consultants will be checked by the resident engineer or higher authority to assure that they have adequate and competent personnel, the necessary equipment, and that they have the necessary test standards available. Appendix B includes a sample Preliminary Plan.

After the contract has been awarded there are additional duties and responsibilities for the Government's personnel and the contractor's personnel under the CQC system, as described in the following paragraphs.

A. ADDITIONAL CONTRACTOR RESPONSIBILITIES

There are several new areas of contractor responsibility under the CQC System (9). He must organize his field
staff for CQC. He must prepare and maintain a formal CQC plan and submit periodic reports to the Government. During the course of the work, he must check and approve shop drawings, accomplish all required field and laboratory testing and inspection, and coordinate the quality of his subcontractors' work. Finally, the contractor must maintain complete and accurate CQC records.

1. Field Organization and Staffing

A separate quality control organization is not usually required or necessary (8). The CQC responsibility is normally distributed among the contractor's usual field staff supplemented as necessary with technicians and testing facilities. The requirements for any special inspection forces or professional help specified in the contract provisions is held to a minimum. The contractor's inspection personnel should meet the minimum requirements suggested by the Federal Construction Council (12, 9). They should possess training and experience sufficient to ensure recognition of improper construction and should be capable of reading plans and specifications. They should be particularly experienced in the trade to which the assignment is made.

Common to all CQC organizations, and by far the most important component of the system, is the designated Contractor Quality Control Representative. He must have a letter of authorization signed by an officer of the company
and be approved by the Government. He represents and acts for the company on matters of quality and is responsible for making job corrections necessary to assure quality. In most cases, in order to prevent any division of responsibility, the company designates the senior project superintendent as the CQC representative. In no instance does either agency allow the CQC representative to report to anyone lower than the senior project superintendent.

2. **CQC Plan**

   The final plan must be submitted by the contractor to the Government, and must be approved prior to the start of construction. It must include the personnel and procedures the contractor intends to use in his CQC operation. The plan must include the responsibilities and authority delegated to each person, test methods, and methods of documentation. (Refer to GP-38, subparagraph (d).)

3. **CQC Reports**

   Under the CQC system the contractor must submit periodic reports to the Government. Normally these reports are submitted daily and the recommended format is shown in Appendix A. The reports must cover all items of work, including those found defective and the proposed corrective action to be taken. These reports must include the following fraud statement (8) and must be signed by the Authorized CQC Representative:
Contractor's Certification: The above report is complete and correct and all material and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as noted above.

The body of the CQC daily report should include (9):

1. Prime contractor and subcontractors on the job during the reporting period, including their areas of responsibility

2. Locations and descriptions of all work performed

3. The results of the CQC inspection, including actions taken and any deficiencies noted

4. Any verbal instructions from Government personnel on construction deficiencies or retesting, etc., requiring action, and action taken on previously noted instructions

5. General remarks including descriptions of proposed remedial action, conflicts and specifications and problems beyond the contractor's control

4. **Shop Drawings**

   All shop drawings, except those where Government approval is specifically called for in the contract, must be checked and approved by the contractor. An information copy of all shop drawings must be supplied to the Government within one day after the contractor's approval and 14
days prior to starting construction. These drawings will be spot-checked by the Government but will not undergo the formal approval procedures (refer to SP-39(c)).

5. Field and Laboratory Testing and Inspection

The contractor must perform all inspection and testing during the course of the work, unless it is specifically noted in the contract that the Government retains such inspection and testing responsibility.

6. Subcontracted Work

The contractor's CQC plan and his field and laboratory testing and inspections must be complete enough to assure that all subcontracted work complies with contract plans and specifications.

7. Contractor Records

In accordance with GP-23 (refer to pages 14 and 15), the contractor must maintain complete records of all CQC operations during the contract period and they must be open to Government review.

B. ADDITIONAL AGENCY RESPONSIBILITIES

The resident engineer's responsibility to the Government and to the people has not been reduced by the implementation of the CQC System. He must still be sure that only work conforming to the quality requirements of the contract plans and specifications is incorporated into the project, accepted, and paid for. The Contractor Quality Control
System should allow the contractor to practice his own preventive inspection, but the responsibilities of making the "punch lists" and final acceptance inspections are retained by the Government. The traditional responsibilities of the resident engineer have not changed (12) such as ensuring project progress according to schedule, effecting correction of errors or omissions in plans and specifications, and assuring the necessary coordination with user agency or design agency.

There are additional responsibilities for the resident engineer and for the Government agency under the CQC System. They must produce better contract plans and specifications and emphasize the importance of CQC during the preconstruction conference and while they approve a contractor's final CQC plan. The resident engineer and his staff must review the contractor's CQC reports and perform the necessary contract surveillance. Finally, both the agency and the resident engineer must educate all involved personnel in the CQC system.

1. **Plans and Specifications**

   It was pointed out earlier that project plans and specifications are a cornerstone of quality. It must be emphasized that the CQC system will not correct the deficiencies of poorly prepared contract documents. The importance of plans and specifications to quality was emphasized in a paper by Elmer B. Isaak, "Applications of Quality Control,"
presented at an American Society of Civil Engineers symposium on quality control (1, 160):

... at the moment the bidding takes place and the contract is let, the whole situation changes. Then those plans and specifications must stand on their own feet. They become the contract documents, and the designer is no longer free to revise or interpret the plans. The requirements for the work must be evident on the face of the contract documents if there is not to be extensive difficulty achieving the desired final product. A clear set of plans and specifications, taking into account all contingencies that can be foreseen, is really the first basic step toward quality control.

The designers and specification writers under the CQC System must not only specify carefully the desired quality level, but must include the specific quality controls which, when conscientiously applied by the contractor, will assure the specified quality level. If the quality level and controls are not stated properly, disputes may arise over what the contract requirements are and a contractor will have difficulty including the quality control cost in his bid. If a contract is awarded to the lowest bidder who has not included a contingency for implementing CQC, he may be inclined to shortcut CQC requirements whenever possible during the life of the contract.

2. Preconstruction Conference

Any remaining difficulties or misunderstandings not resolved during the review of the preliminary plan should be handled during the pre-construction conference prior to approving the contractor's final CQC plan. The contractor
should understand that approval of his plan is contingent on satisfactory working performance and that the Government reserves the right to require any necessary modifications of the plan at a later date, including the removal of an unsatisfactory CQC representative. The fraud statement which must be included in the CQC reports should be emphasized during the preconstruction conference. The contractor should be aware that his CQC representative is an agent of the company and any necessary fraud action will be against the company.

3. Final CQC Plan Approval

The final CQC plan must be reviewed and approved prior to the start of construction. This plan must include all items mentioned in the pertinent contract general, special, and technical provision paragraphs. In addition, the Government should be sure that the following questions are answered in the CQC plan (6. 11).

1. Is the CQC staff adequate to give complete coverage?

2. Will the normal supervisory duties of the contractor's CQC staff prevent them from having adequate time for CQC activities?

3. Is each staff member adequately qualified to perform his assigned tasks?

4. Is the delegation of authority to the CQC representative clear and adequate?
5. Are the organizational lines of authority and responsibility clear and logical?
6. Are the individual inspection and test duties clearly assigned to CQC personnel by name?
7. Does the plan cover all the required inspections and tests included in the technical provisions, and have they been assigned?
8. If a commercial laboratory or consultant is proposed, has it been approved?
9. Does the overall test coverage appear adequate?
10. Do the proposed inspection and test report forms include all the necessary features?
11. Will the contractor report frequently enough to the Government?
12. Does the plan indicate that the contractor thoroughly understands his responsibilities under CQC?
13. Are the contractor's procedures adequate for shop drawings, samples and submittals?
14. Are his procedures adequate for inspection or certification of off-site fabrication?
15. Are all phases of inspection (preparatory, initial and follow-up) adequately covered?

4. **Review of CQC Report**

The CQC report (see Appendix A) is usually required to be submitted on a daily basis. This report must be reviewed
thoroughly each day and any deviations or omissions must be directed in writing to the contractor's CQC representative. Reviewing this report and insisting on its completeness is the best method of determining and evaluating the effectiveness of the contractor's CQC program. This daily report should be compared with any records from Government surveillance and if known deficiencies have not been reported in the contractor's CQC report, the system is not working. All known deficiencies, corrective action proposed and taken, and conflicts must be included in the contractor's report. The contractor's inspection report must cover all work in progress. If more than one report is required, all must be signed by the inspector and submitted to the CQC representative for checking and approval and each must be countersigned by him.

5. Contract Surveillance

With the contractor taking the responsibility for the step-by-step inspection process the Government's position will be changed from inspection to surveillance (9). The role of Government inspection personnel in contract surveillance will be to monitor the contractor's CQC system to ensure that it is functioning correctly. The monitoring will be done by observing the actual performance of CQC testing and inspection requirements, and spot checking where necessary. Except for the critical items for which the Government has specifically retained the quality control responsibility, the Government inspector will no longer give any
on-site approval or guidance. This is now the responsibil-
ity of the contractor's CQC staff and all necessary Govern-
ment action concerning quality will be addressed to the
contractor's authorized CQC representative. The Government
inspector may orally advise the CQC representative of any
non-compliance items he has noted, but in all cases such
notification must be followed up in writing. The Govern-
ment inspector will not advise the contractor on how to cor-
rect non-conforming items. This is the contractor's respon-
sibility. The contractor, however, will not be allowed to
build upon or conceal work containing uncorrected deficien-
cies, and payment for deficient items will be withheld un-
til the work is corrected or other approved action is taken.

6. Educate Personnel

Every member of the resident engineer's staff assigned
supervisory, inspection, or testing duties on the contract
must be thoroughly familiar with the approved CQC plan (6).
The added responsibilities of Government personnel must be
periodically reminded that they are performing contract
surveillance rather than the traditional contract inspection.

In summary, the additional responsibilities which have
been discussed above must be thoroughly studied and under-
stood by both parties. The contractor must be aware of
these new responsibilities in order that a proper contin-
gency for the CQC System be included in his bid. The Gov-
ernment personnel must understand them so that the maximum
benefit can result from the new system at the least cost in time or money.
VI. DISADVANTAGES OF TRADITIONAL GOVERNMENT INSPECTION METHODS AND THE ADVANTAGES OF CONTRACTOR QUALITY CONTROL

Inspection, as defined in the U. S. Armed Services Procurement Regulations (7) means the examination and testing of supplies and services (including raw materials, components, and intermediate assemblies) to determine whether such supplies and services conform to the contract requirements. Inspection on federal construction projects is usually accomplished by the establishment of a field supervision and inspection staff of Government employees who perform or coordinate such activities as mill inspection, shop drawing approval, sample approval, field inspection and testing, progress payments, and acceptance inspections.

According to a recent study by the National Research Council (12) the field staff on any Government construction project of appreciable size includes a resident engineer, one or more supervisory engineers for each major branch of work (mechanical, electrical, civil) involved on the project, inspectors who assist supervisory engineers, plus the necessary clerical and administrative staff, technical assistants and specialists. An example of the supervisory and inspection organization necessary for a large construction project is shown in Figure 1. It shows the resident engineer organization at the U. S. Army Corps of Engineers multipurpose
Figure 1. Organization Chart for the Libby Dam Resident Engineer Office.

Total Personnel - 103
project in Northwest Montana. The project includes a 3.8 million cubic yard concrete gravity dam, a sixty-mile relocation of the Burlington Northern Railroad mainline track, a seven-mile-long railroad tunnel, a powerhouse, over a hundred miles of road relocation, and many small structures such as schools, a U. S. Forest Service Ranger Station, and railroad station facilities. The total cost of this project is approximately 373 million dollars; major construction lasts for eight years.

An important function of such a large staff is to perform the traditional step-by-step Government inspection. These procedures are the accumulation of years of past construction experience whereby the Government contractually retains the responsibility for performing inspection, and gives the contractor guidance based on the inspection results. While good quality construction has generally resulted from this practice, there have been many undesirable side effects. The major problems for the Government and contractors are:

1. Inspector inadvertently directs the contractor's work
2. Excessive Government supervision and administration costs
3. Construction delays
4. Inspector's silence can be misunderstood
5. Government inspection policies can attract less competent contractors
6. Poor quality plans and specifications

These points are examined in the following paragraphs and CQC is analyzed in each case to determine whether it may offer a solution to the problem. Past problems with architect-engineer contracts for supervision and inspection are also discussed.

A. GOVERNMENT INTERFERENCE--INSPECTOR INADVERTENTLY DIRECTS THE CONTRACTOR'S WORK

Under the present system of close Government inspection the inspector sometimes inadvertently directs the contractor's work. It is very difficult for a highly trained inspector to sit by and watch a construction method used, when he knows from past experience that it could produce undesirable results. Many times he takes it upon himself to direct the correction of the contractor's methods and thereby jeopardizes the Government's rights under an independent contractor relationship. If, during a later dispute, such actions were found to have occurred, the Government can lose its right to insist on correction of poor quality work at no increase in cost to the Government.

In some cases the Government, by way of this interference, may become mutually liable to a third party for a contractor's actions. According to Abbett (3, 52):

The acts and torts of an independent contractor do not obligate the principal...and the principal is not liable for any damages caused thereby.
Under the usual types of construction contracts, it is usually desired that the contractor be completely independent and not an agent of the owner. This relation can exist only if the owner specifies the final results to be obtained and gives the contractor freedom as to the methods he uses to obtain results. Therefore there is a risk if he should interfere with the methods or personnel of the contractor. The owner does have the right, however, to exercise complete control over the quality of materials and workmanship of the contractor in enforcing the requirements of the plans and specifications.

In discussing this problem as related to Army contracts, Stephenson (6, 5) has stated that, "supervision and detailed inspection coverage has been adequate in most cases to result in 'preventive' rather than only 'corrective' inspection." It is submitted that while corrective inspection is the contractive right and duty of Government personnel, preventive inspection threatens the independent contractor relationship and both parties become mutually responsible for the outcome of the work.

To illustrate this point, the author is familiar with a recent claim by a contractor for recovery of damages. In this case a contractor was preparing for a very large concrete roof slab placement. The contractor's quality performance had been exceptionally bad prior to this placement, and one result was a complete lack of mutual respect between the contractor's staff and Government personnel. The relationship had long since degenerated to an adversary situation. Because of the importance of this concrete placement (which included embedded post-tensioning strands
and architectural concrete), the Government temporarily assigned additional inspection forces, including a structural engineer. During the early stages of the placement it became apparent that the contract was ill-prepared for such a large placement. This was extremely frustrating to the inspection forces who could visualize the extent of tear-out and replacement costs and delay resulting from poor concrete consolidation and placement practices. At one point during the placement the structural engineer, seeing the poor placement around the post-tensioning strands, entered the placement area and took a vibrator away from an inexperienced laborer and began to demonstrate how and where to use it correctly. While this act was entirely well intentioned and under a normal contractor-Government relationship would have gone unnoticed, it was one point mentioned in the contractor's claim of undue Government interference. The results of the claim are not yet determined but the engineer's seemingly minor act is a good example of the unforeseen legal implications that "preventive" inspection can have.

How can the CQC System prevent this problem? CQC will place the complete responsibility for compliance with contract plans and specifications on the contractor. The division of responsibility resulting from "preventive" inspection will be eliminated. This should reduce the conflicts (and resulting claims) between the contractor and the
Government inspector. CQC returns construction supervision to the contractor, where it belongs; this is the primary reason for its development.

In the case mentioned above, an effective CQC system may have prevented some of the problems. A careful review of the contractor's preliminary CQC plan may have revealed that he was not quality-conscious. CQC may not have prevented the structural engineer's actions during the concrete placement. However, its inclusion might have reduced early conflicts between Government and inspection personnel on this job and given the Government a sounder legal footing for initiating default proceedings as a result of the concrete placement.

The Government's contract administration system has resulted in part from an attempt to prevent contractors' failures. With the implementation of CQC, failures will no longer be prevented by the Government but by the contractor. The contractor is faced with the possibility of failure, or as the Navy put it during a joint meeting with the Association of General Contractors and the American Institute of Architects, each contractor must have a "right to failure" (13, 3):

The genesis of this system of bidding public works is founded in the economic marketplace where each can offer his wares for sale. The contractor's organizational capability, his ingenuity, his business and construction leadership is brought into full play in direct competition with his fellow builders. This is the American way. But this way
of the economic marketplace must have one fundamental--the right of success. And since success, in all its glory, is relative, you must also have the right to failure. For, without the possibility of failure, you cannot have success. Success itself is the avoidance of failure.

Under the Contractor Quality Control System the contractor will have this "right to failure" and he will have to exercise his capability, business leadership and ingenuity in order to avoid exercising this right.

B. EXCESSIVE GOVERNMENT SUPERVISION AND ADMINISTRATION COSTS

A second major problem area for the Government is the current cost of supervision and administration (S and A). The cost of labor for Government, as well as for private enterprise, has spiralled in the last decade. Unlike business, the Government cannot pass on all or part of these increases to the customer or to the public. Their budget for supervision and administration of construction is fixed at a small percentage (perhaps a maximum of five per cent of the total contract cost). This must cover all overhead and direct costs--salaries, office and field equipment, rent, supplies, reimbursement to other agencies for services, etc. An example of the magnitude of these costs for the Libby Dam Project is shown in Table 1.

The resident engineer at the Libby Project is required to hold his yearly S and A expenses at or near three per
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<tbody>
<tr>
<td>July</td>
<td>$126,448</td>
<td>$7,419,000</td>
<td>1.7</td>
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<tr>
<td>Aug.</td>
<td>145,681</td>
<td>7,479,000</td>
<td>1.9</td>
</tr>
<tr>
<td>Sept.</td>
<td>170,200</td>
<td>4,860,000</td>
<td>3.5</td>
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<tr>
<td>Oct.</td>
<td>163,216</td>
<td>5,588,000</td>
<td>2.9</td>
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<tr>
<td>Nov.</td>
<td>106,300</td>
<td>9,111,000</td>
<td>1.1</td>
</tr>
<tr>
<td>Dec.</td>
<td>127,876</td>
<td>1,340,000</td>
<td>9.4</td>
</tr>
<tr>
<td>Jan.</td>
<td>111,380</td>
<td>938,000</td>
<td>11.8</td>
</tr>
<tr>
<td>Feb.</td>
<td>116,910</td>
<td>1,288,000</td>
<td>9.0</td>
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<tr>
<td>Mar.</td>
<td>102,348</td>
<td>1,023,000</td>
<td>10.0</td>
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<tr>
<td>Apr.</td>
<td>118,571</td>
<td>2,767,000</td>
<td>4.2</td>
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<tr>
<td>May</td>
<td>114,971</td>
<td>4,033,000</td>
<td>2.8</td>
</tr>
<tr>
<td>June</td>
<td>143,347</td>
<td>3,708,000</td>
<td>3.8</td>
</tr>
<tr>
<td>Total</td>
<td>$1,547,251</td>
<td>$49,563,000</td>
<td>3.1</td>
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Table 1. Government Supervision and Administration Budget at the Libby Dam Project for Fiscal Year 1970.
cent of construction placement. The table shows total construction placement in Fiscal Year 1970 at $49,563,000. Total S and A expense was $1,547,251, or 3.1 per cent of placement.

According to Stephenson (6, 5) the Corps of Engineers has been subjected to "an ever increasing chorus of complaint from our military customers and from the Congress on costs of supervision, inspection and administration of contract construction."

Because there has been no alternative to Government inspection, the attempts at budget trimming have resulted in less quality control. The author is familiar with the continual budgetary restraints on allocations for inspection at the Libby Dam Project. There have been instances when contractors used two shifts during the construction season and, because the budget was already strained, no additional Government inspectors were available. This resulted either in no inspection coverage for one shift or in splitting the inspector's work day between the contractor's two shifts. Either way, the contractor was without inspection fifty per cent of the time. This benefits neither party. The Government would sometimes have to go ahead without any quality assurance, and many times the contractor suffered long delays waiting for the Government to perform the required tests.
According to the National Research Council (12), another frequent undesirable practice that sometimes results from budget limitations involves giving inspectors work assignments based on construction site area rather than in an organized branch according to specialties. A project usually encompasses many specialties--mechanical, electrical, and civil engineering. Supervision and inspection personnel must be able to recognize errors or omissions in drawings or specifications, lack of coordination, ambiguities in contract documents and field conditions differing from those shown in the contract. Specialized personnel assigned to a construction area rather than to an organization branch cannot be expected to recognize and effectively resolve problems occurring in different specialties.

The National Research Council (12) has found other staffing problems that sometimes are an indirect result of budget limitations. They are determination of staff composition on the basis of rigid organization charts, omission from the staff of personnel needed to perform particular or specialized functions, delay in selection of the basic staff until construction is imminent.

CQC offers the possibility of reducing the demands on the Government supervision and administration budget and might eventually allow the budget to be reduced by transferring many traditional Government responsibilities to the contractor. While the contractor's bid will be increased
to reflect his CQC duties and responsibilities, the author feels that overall contract cost may be reduced in the future (see discussion on page 77).

Government project engineers will be under increased pressure in future contracts to reduce S and A costs. According to the Army (16, 18):

Manpower limitations have always made it very difficult for the resident engineer to get all the help he wants and needs. Current trends indicate we...will probably have to operate with fewer people in the future and still produce the high quality work we have in the past.

Contractor Quality Control will help to reduce S and A costs by allowing more efficient use of Government inspection personnel.

1. During a given period of time, the inspector will be able to cover a larger dollar volume of work. He will no longer have to perform routine inspections, tests, and will be relieved from some of the usual report writing (9).

2. Traditionally the resident engineer and his staff spent a good deal of their time in noting, recording and follow-up on deficiencies and corrections. Effective CQC, with the contractor actively engaged in inspection and deficiency correction, will result in savings (6).
3. Eliminating the burdensome chore of shop drawings and other approval actions for all but the very critical or complex items will allow a reduction of personnel assigned to these tasks.

C. CONSTRUCTION DELAYS

The contractor has often been delayed significantly by relying on the Government for quality control. According to Stephensen (6, 5):

...when the inspection and testing coverage has delayed the contractor, or when corrective action has been necessary due to a failure of preventive inspection, the contractor has been able to claim and collect additional money.

Delays have occurred because Government inspectors are too pressed for time or because a lack of coordination between the Government staff and the contractor's staff existed concerning the time, date, place or number of Government tests required. Because the Government has taken the responsibility for preventive inspection, any inspection oversight resulting in delays from removal and replacement becomes the mutual responsibility of both parties. These delays have left the Government open to claims for such items as equipment and operator standby time, lost labor effectiveness and extended overhead costs to the contractor.

Other areas which have caused significant delays have been the Government required shop drawing, contractor
submittal, and mill inspection practices and procedures. Many items received on the job for incorporation into the work are preassembled components or are specially manufactured or processed. Some examples are turbines, generators, pumps, motors, high strength structural steel, galvanized material, and high strength pipe. The overall project quality is often a reflection of the quality of these items. However, field inspection has no direct control over them. This has led to the use of elaborate shop drawing, submittal and mill inspection procedures. The National Research Council (12, 42) has produced a summary of the overall approach used by most agencies.

a. Contract documents indicate general performance and/or material requirements for items to be used on the project; brands and model numbers are not listed, and as a rule, details are not provided for items to be specially fabricated.

b. Contractors are required (sometimes explicitly, sometimes implicitly) to indicate to the construction agency by means of submittals--shop drawings, brochures, acceptance certificates, technical literature, samples, test reports--exactly what is to be provided to meet the contract documents.

c. Personnel familiar with the contract documents (e.g. construction agency personnel and/or design agency personnel and/or personnel from the A-E design or supervision and inspection firm) check submittals against the contract requirements to determine whether the items proposed for use meet such requirements; based on this check, a recommendation of approval or disapproval of a proposed item is made to the Government officer authorized to act officially.

d. The authorized Government officer (usually either the contracting officer, or the resident engineer or chief design engineer under authority delegated by the contracting officer) reviews the recommendation and notifies the contractor that the item is either approved or
disapproved (if an item is disapproved, the contractor can either appeal or propose an alternative item); submittals for approved items become, for all practical purposes, part of the contract documents.

e. Appropriate measures are taken to ensure materials, assemblies, and equipment used on the project conform to the submittals (if provided) and/or to the contract documents. The appropriate measures to be taken (which can be for example, Government inspection during manufacture at the supplier mill or plant; shop, laboratory, or field tests; and/or checking of labels and stamps on received goods) are sometimes but not always delineated in contract documents.

The above procedures are lengthy and cumbersome; to a new contractor they can present seemingly insurmountable problems, especially problems of time. These procedures require a very long lead time in order to prevent delays in construction. If the project is large enough to include a shop drawing staff to process submittals in the resident engineer's organization, approval action on submittals will normally take one to two weeks. If shop drawings cannot be processed at the residency because of a lack of personnel or because the submittals are so complex that they must be reviewed by the design agency, they will be forwarded to the contracting officer for action. It is the author's experience that if this is necessary, approval action will require from two weeks to six months from the date of submittal.

The problem is frequently compounded by the fact that many specialized components are often subcontracted by the prime contractor. This may cause problems in coordination if additional information or clarification is needed prior to
approval.

The shop drawing, submittal and mill inspection procedures have caused many construction delays. The last minute disapproval of some items can and has stopped construction entirely. When approval of items becomes critical, the pressure is on agency personnel doing the checking to expedite approval. This can result in hurried and incomplete checking—potentially harmful to both parties if removal and replacement becomes necessary at a later date. Sometimes the fear of holding up a project caused Government personnel to correct and include missing items in a shop drawing in such a manner that they are essentially preparing complete shop drawings for a contractor. This practice has led some contractors into submitting substandard shop drawings knowing that the Government staff will make any necessary additions and corrections for them. Thus, the Government ends up doing the contractor's work for him and at the same time jeopardizes the independent contractor relationship.

The Government has also abused the submittal procedures. The National Research Council (12, 45) has stated, "design personnel have, understandably, been known to evaluate submittals in light of what is desired rather than what the contract calls for, resulting in legal disputes which the contractor is likely to win." This is usually the result of unclear or incomplete contract drawings or specifications which are interpreted by the designers in their
favor, at the time they check the submittals. The incomplete plans or specifications may result from the designers not being sure what they want when they originally prepare them or their being rushed to complete the plans and specifications because of imposed deadlines. In any event, they have, in the past, let an incomplete specification go, knowing that they will have shop drawings on which to complete the design.

Questions which continually arise from mill inspection, submittals and testing plague specification writers and the field staff. According to the National Research Council (12, 43), these are:

a. For which type of material, assembly, and equipment should the contractor be required to provide submittals?
b. What information should be included in submittals for different items?
c. By whom should submittals be checked and by whom approved?
d. What is the best method to use in various circumstances to ensure that items actually received and used on the job are the same as the ones described in approved submittals (or conform to contract requirements if no submittal has been required), and by whom should the determination of appropriate method be made?

These problems can cause additional contract ambiguities which easily result in delays to the contractor.

Contractors' complaints over delays caused by waiting for Government testing and inspections should be significantly reduced with CQC. If the contractor has an effective CQC system, his inspection and testing can proceed on time,
with only Government surveillance, and can produce results which can be immediately fed back to the contractor. He will make any necessary adjustments. This immediate feedback of information will reduce the chances of mistakes that result in lost time for removal and replacement.

Under the revised CQC shop drawing, submittal and mill inspection procedures, the delays previously experienced while awaiting Government approvals should be nearly eliminated. The contractor will be able to establish his own shop drawing procedures and schedules. He will be able to work closely with subcontractors and suppliers in their preparation and approval. He will be required to submit these procedures and schedules to the Government for information only, within one day of his approval and fourteen days prior to use. This will give the agency an opportunity to unofficially double-check them, if desired. Because of the reduced quantity of items submitted for approval, the Government will be able to expedite the remaining items and reduce the turnaround time to a minimum.

D. INSPECTOR'S SILENCE MISUNDERSTOOD

Under the traditional Government supervision and administration system the contractor has relied on the Government for all inspection and testing results. This reliance has had another undesirable result. Recent court cases have awarded recovery of removal and replacement costs to
the contractor because neither the contractor nor the Government inspector recognized non-compliance with plans and specifications while the work was in progress. The contractor thus assumed that an inspector's silence meant his approval. This was pointed out in a statement by the Navy (9, 10):

Recently, the Government has lost claims by contractors because neither the contractors nor the Navy inspectors recognized non-compliance prior to or during a specific construction operation. This is but one example of the integration of contract construction and inspection functions that was never intended.

Thus, under the traditional S and A system an inspector's silence can sometimes cause difficulty.

Under the CQC System, the Government inspectors will no longer give field approval except for those few items specifically stated in the contract. Under the CQC system there can be no misinterpretation of an inspector's silence.

E. GOVERNMENT INSPECTION POLICIES CAN ATTRACT LESS COMPETENT CONTRACTORS

Traditional inspection procedures have not only caused claims by contractors for undue Government interference but they may attract less competent contractors. This is shown in the following excerpt from a paper presented by Roger H. Corbetta (14, 646) in November, 1967, to the American Concrete Institute at the Des Moines, Iowa:

Inspection...as we know it today...is obsolete. It constitutes a division of responsibility. It serves to aid and abet unqualified and question-
able contractors, who rely on supervision or guidance by inspectors, then later disclaim responsibility.

According to the Navy (9, 10):

NAVFAC (Naval Facilities Engineering Command) construction practice and bureaucracy inadvertently has created an environment in which certain construction contractors have become 'experts' in Navy construction and contract administration. The result is that many excellent construction contractors do not bid Navy work.

Under the "right to failure" concept of CQC, less competent contractors will be forced to use better management principles and emphasize quality in their operations or they will fail. Government contracts will become less attractive to poor contractors while progressive contractors will be attracted by the greater flexibility in scheduling and execution of their work under the CQC system.

F. POOR QUALITY PLANS AND SPECIFICATIONS

Problems with inspection often result from poor plans and specifications. On Government construction projects, federal employees cannot deviate from the specific requirements of the contract documents without a formal change in the contract. If construction methods are specified or expressly prohibited, the inspector has no choice but to enforce the contract. The tendency to specify construction methods is common, and according to the Navy (16, 21), this is undesirable because:
1. Specifying methods shifts the responsibility from the contractor to the Government if trouble develops.
2. Specifying methods restricts the contractor's initiative and ingenuity.

Perhaps Roger H. Corbetta (15, 5), a contractor, put it best in a discussion on concrete construction:

Under present-day contractual policy, in many areas, no particular party is entirely responsible for an end result in the production of a concrete structure. Contractors today (1965) have almost no legal responsibilities for a finished concrete project. This is true because specifications, with some exceptions, of course, tell a contractor what, when, and how to perform in concrete construction.

What responsibility do you leave a contractor? You leave to him the furnishing of men and equipment; and you leave to him the freedom to resort to all the trickery that is possible in concrete construction and to get the greatest rewards from the handling of a job in the most profitable fashion, without any responsibility whatsoever, as is proven time and again.

When has a contractor ever been made to pay for poor workmanship? When has a contractor ever been made to take out concrete that has been improperly placed? When has he been made to pay for it? There may be exceptions, but they are few and far between.

Construction methods have been specified or prohibited in Government plans and specifications partially because of past experience with incompetent contractors. The Navy has said (13, 4):

...It is an oversimplification, but it might be said that the summation of our specifications today is almost the summation of our construction failures. We have specifications a page long in our concrete specs concerning the turbidity of water because some character sometime, someplace, threw a suction line in a sewer outfall. We submit, Gentlemen, that the contractor should have been penalized--not a new specification written.
Under the CQC System, construction methods will no longer be included in the contract plans and specifications. The contractor will be free to use his own methods and procedures to attain the quality levels specified. He will be required to demonstrate his work's conformance by submitting the results of the quality control procedures expressly stated in the contract specifications. He will not be allowed to build upon, conceal, or incorporate into the job any non-compliance items and payment will be withheld for them until they have been corrected to the satisfaction of the Government. Thus, with correctly prepared plans and specifications under the CQC System, the contractor will be held fully responsible for any non-compliance work.

G. ARCHITECT-ENGINEER CONTRACTS

Some mention should be made of using a separate Architect-Engineer (A-E) Contract for supervision and inspection of construction. This has been done occasionally on small contracts where Government personnel are not available. This does not appear to have the same potential as CQC for solving the problems outlined, i.e., interference with the contractor's work, construction delays, and budget restraints. In fact, there has been in the past much dissatisfaction with A-E supervision and inspection contracts. According to the National Research Council (12) the dissatisfaction has usually resulted from a lack of clear and
firm contractual agreements. Common arguments concern the scope of the A-E responsibilities, including the minimum number of personnel on site, the availability of design personnel for consultation, and the lack in coordination of change orders. Other problems have resulted from disagreements about the minimum qualifications required of inspection personnel, as well as the maintenance, disposition, and ownership of project files. The National Research Council (12, 24) lists three additional problems.

1. The authority to make changes, to officially interpret the contract documents, to authorize payment to the contractor, or deviate in any manner from contract provisions, cannot legally be delegated to other than a federal employee. Accordingly, only limited supervision and inspection authority can be delegated to an A-E firm. Without greater authority an A-E firm cannot make the necessary decisions to keep the job moving. They must refer problems to district or regional Government offices resulting in delay.

2. An A-E firm is not as well qualified for supervision-inspection as Government personnel. They lack the value of familiarity and continual experience with the peculiarities of Government contracts. Experience and efficiency
gained by A-E personnel is lost to the Government at the end of the contract.

3. The cost of personnel is greater to an A-E firm which, by necessity, hires many short-term personnel during the life of the project. The demand for personnel will fluctuate widely and higher salaries will have to be offered. This, plus the necessary profit margin, results in fewer workers for the same amount of money in comparison to Government-staffed projects. Some firms could try to increase personnel by using lower salaried and less qualified personnel.
VII. ENFORCEMENT OF CONTRACTOR QUALITY CONTROL REQUIREMENTS

The standard provisions of U. S. Government construction contracts which are required by the Armed Forces Procurement Regulations include sufficient enforcement tools to correct most deficiencies which occur with the Contractor Quality Control System. The Army (6, 15) has summarized problems which have occurred with contractors using CQC under four general categories.

1. The contractor is late in submitting the CQC plan, or he delays in making the revisions and additions necessary for an acceptable plan.

2. The contractor's inspection is inadequate or his inspectors prove unqualified. The contractor is slow making follow-up inspections on known deficiencies.

3. The contractor's test coverage is inadequate or is faulty because he uses unqualified personnel or unsuitable equipment.

4. The contractor's inspection and test reports are inadequate. There are insufficient data, inaccuracies, or delays in reporting.

The general and special provisions of the contract allow a resident engineer the following options in bringing pressure on a contractor to complete the CQC requirements.
The referenced provisions are included in Appendix C of this thesis.

1. Stop the work. Paragraph SP-38(f) (refer to page 17 of the text) of the CQC provision allows the resident engineer to refuse to permit the work to start before the contractor has an approved CQC plan. Paragraph GP-10(c) allows the Government to stop the work if the contractor does not promptly replace rejected material or correct rejected workmanship.

2. Remove incompetent personnel. General provision 9(b) allows the contracting officer to require the contractor to remove "any employee the Contracting Officer deems incompetent, careless, or otherwise objectionable." Under GP-11 the contractor is required to have a general foreman or superintendent who is satisfactory to the contracting officer and is authorized to act for the contractor. He is in charge of the work at all times. If the contractor does not wish to delegate authority, he must give his personal superintendence.

3. Remove and replace deficient materials and workmanship. If, during Government surveillance and acceptance inspections uncorrected
deficiencies are noted, GP-10(b) and 10(c) require the contractor to make the necessary corrections at no additional cost to the Government. If he refuses to make prompt correction, the Government may make the corrections, by separate contract or other means, and charge the expenses to the contractor. This is the most effective enforcement tool in the contract. If the contractor realizes that the Government's surveillance will be thorough enough to detect most deficiencies, he will be encouraged to avoid expensive tear-out and replacement costs by employing an effective CQC system.

4. Terminate the contract. Termination under clause GP-5(a) is the most drastic enforcement tool available to the Government. It has been used very sparingly in the past. One reason, as mentioned earlier, has been that the Government, through its contract administration system, has often compromised its legal position. This has allowed the contractor to disclaim responsibility in many cases, giving the Government's position in any termination proceeding a somewhat shaky foundation in the eyes of the courts. Termination of a contract which includes the CQC
provisions should be more legally justifiable because the responsibility for failure is clearly the contractor's; however, termination should still be a last resort.

5. Give the contractor a poor rating. After completion of any Department of Defense construction contract the resident engineer is required to fill out DD Form 1596, "Construction Contractor Performance Evaluation Report," in which the resident engineer rates the contractor's performance. The contractor should be informed that an unsatisfactory performance appraisal will be given if he fails to meet his responsibilities under the CQC system. Thus, if he is subsequently a low bidder on a Department of Defense contract, his bid may be rejected by declaring him not a "responsible bidder."

If, after repeated enforcement efforts by the Government, the contractor still fails to meet his CQC responsibilities and termination for default is impossible because of time or monetary restraints, then the Government can return to using it traditional contract administration procedures. The CQC provisions GP-23, SP-38 and 39 do not prohibit the Government in any way from performing all inspection and testing. This action ordinarily would not be taken without a formal change order giving the Government
a substantial credit for CQC not performed. If the contractor's shop drawings and submittal performance under the new GP-67 and GP-98 is also unsatisfactory, an additional credit to the Government should be received and the old clauses reinserted in the contract.

An additional CQC incentive is being considered by the Army (6). The current payment clause, GP-7, requires the Contracting Officer to withhold ten per cent of the contractor's monthly earnings until fifty per cent of the work is completed. After the work is fifty per cent complete, the monthly retention of earnings may be stopped if the work is on schedule. The Army is considering changing the requirements to allow stopping retention at twenty-five per cent completion if the work is on schedule and the contractor is providing effective CQC. In the long run, this reduction in earnings retention would cost the Government little and would sharply reduce the contractor's financing costs. With interest rates at their current high level this would be an effective incentive.

Two additional areas which may give contractors problems under CQC are:

1. Small contractors may not have the technical personnel to implement CQC, and

2. A working conflict may arise between the CQC representative and the superintendent.

When the Contractor Quality Control System is included in a new contract to be let, a "Notice to Bidders" alerting
them to the additional CQC requirements should be given each prospective bidder. This should be adequate warning to small contractors that additional personnel may be required.

Settling conflicts between members of his staff is the contractor's responsibility. In most cases, the CQC authority is delegated by the contractor to the senior project manager to avoid any possible conflict.

In summary, the standard provisions of U. S. Government contracts give sufficient legal authority to the contracting officer and to his resident engineer to enforce the Contractor Quality Control requirements. If the contractor does not respond to enforcement efforts, one of two options may be taken, either termination of the contract or return to Government inspection. In either case, such severe action should be sufficient basis to reject any future low bids from that contractor.
VIII. CONCLUSIONS AND RECOMMENDATIONS

Based on the early results of the CQC System in practice and on this study, there are two areas in which conclusions can be drawn and recommendations made. They concern the scope of the CQC System and the implementation of the System. In the final section, the author has included some additional possibilities for benefits from CQC.

A. SCOPE OF CONTRACTOR QUALITY CONTROL

The concept of Contractor Quality Control (CQC) as presented in this thesis is a combination of both the Army's and the Navy's approaches. While both the Army's and the Navy's CQC systems are essentially the same there are three differences in scope which should be mentioned. First, the Army considers CQC as augmenting Government inspection. They see little change in the resident engineer's functions. Regulation ER1180-1-6(8, 2) states:

...Duties of the Corps field personnel will be essentially unchanged, with perhaps greater emphasis on spot checking work and verifying that the contractor is actually performing the required quality control functions in the proper manner.

Stephensen (6, 8) goes on to say that the Army will

...still supervise and inspect the materials and workmanship, and perform testing necessary to verify the contractor's test results. The Government's inspection and test activity will proceed concurrently with and often adjacent to, the contractor inspection and test activity.
The Navy considers that their effort is being changed from the role of traditional inspection to that of surveillance—a close watch or observation kept over a contractor's inspection system to insure that it is functioning properly. According to the Navy (9, 12) the CQC System is an attempt to "get the inspector out of the position of day-to-day supervision and into a role of job surveillance." If, as a result of the Navy inspector's surveillance, the CQC System is determined to be functioning properly, the Navy will rely on the contractor's daily reports and their day-to-day contact with the contractor's quality control staff in assuring construction quality.

It is recommended that CQC be implemented as a new and separate system. Without a clean break from the Government's traditional inspection system it is hard to imagine that the intended benefits of CQC, as presented in Section VI, could materialize. For instance, if the Army continues to run both systems concurrently, they cannot expect to reduce their interference with the contractor's work, nor can they expect any future savings in Government supervision and administration expense. By its very nature, the CQC System needs to operate by itself. Its essence involves allowing the contractor freedom, even if it is only freedom to fail or succeed on his own. The contractor's freedom for failure is limited to an economic loss. The CQC system does not allow faulty construction to be incorporated into the
work. As in the past, the contractor is required to take corrective action at his expense.

The second difference is in the proposed handling of shop drawings. To date, the Army has made no mention of changing the traditional Government shop drawing procedures. These procedures are cumbersome and the resulting problems have been discussed in Chapter VI.

The Navy (11, p. 1, encl. 1), on the other hand, has completely revised their procedure on shop drawings.

Under CQC, when the design requirement is defined by dimensions or other means and a shop drawing is required to guide fabrication or installation of an item, the contractor should be required to furnish shop drawings for the record. These drawings are not to be 'approved' by the designers. Exceptions to this procedure should be only in those cases where the designer feels that the particular installation is so critical or complex that he must retain control or where the design has not been detailed because the contractor has the option of choosing one of several alternate designs to accomplish specific functions. In these cases, approval of shop drawings should still be required and specifically identified in this paragraph devoted to shop drawings paragraph of the project specification. Designers have the obligation to insure that there are sufficient details included in plans and specifications to insure that a misunderstanding does not occur as to what is required. The designer should not depend on shop drawings to cover deficiencies in the plans and specifications.

The Navy asks that contractor-approved shop drawings be submitted for record within one day of contractor approval and at least fourteen days prior to installation, to provide an opportunity for informal checking. If a contractor approved a non-compliance item, it will be his responsibility
to replace it at no additional cost to the Government. Sample requirements will be handled in a manner similar to the handling of shop drawings. Mill inspection procedures will remain unchanged except that the use of manufacturers' certificates of compliance is encouraged where at all feasible. These new submittal procedures are consistent with the concept of Contractor Quality Control in allowing the contractor more flexibility in his construction operations by removing step-by-step Government control. The Navy's revision in submittal procedures is recommended. The revised specification paragraphs implementing these changes, GP-67 and GP-98, are shown on pages 20 and 21.

The Navy has recently begun to require a contractor to submit a Preliminary Contractor Quality Control Plan (PCQCP) prior to award and as a condition of award. This emphasizes the importance of CQC early in the game and allows the agency and the contractor a chance to settle any major differences prior to contract award. Prior to this requirement, emphasizing quality has not been a major factor in awarding a contract. Mr. Cole, the resident engineer on the Army's Libby Dam Project, emphasized the importance of recognizing a quality-conscious contractor in a letter to the Seattle District Engineer (17, 2):

I endorse Contractor Quality Control wholeheartedly and have attempted to instill these requirements into contractor's top management. In spite of our best efforts, Contractor Quality Control is less than satisfactory and we find that, as in the past, our good contractors exercise quality
control, while others do only that required by the inspector, providing an end product which can be termed only acceptable. A system must be devised to identify the contractor who recognizes and utilizes quality control so as to provide him with either added monetary incentive or job preferences. It is submitted that the low bidder is not necessarily the most concerned with quality control. While it is implied that penalties invoked under the terms of the contract and requiring strict compliance with specifications are sufficient to insure quality control, such is not always the case. Unfortunately, many contractors practice law with more success than they supervise actual construction.

The standard Government bid form allows the Government sixty days from the bid opening to accept the offer of the lowest responsible bidder. The determination of responsibility has in the past revolved around the bidder's bank account. A careful examination of a bidder's PCQCP including any available records of past performance should, if found to be unresponsive, form the basis for rejecting his bid. This would be a step toward recognizing competent contractors.

The author recommends that a PCQCP be required of the contractor for the reasons stated above. The Navy's specification paragraph, SP-39, has been included in the text on pages 17-20.

B. IMPLEMENTATION OF CONTRACTOR QUALITY CONTROL

In the words of C. B. Olmstead, Chief of the Construction Division, North Pacific Division, U. S. Army Corps of Engineers (18, 2):
The effectiveness of any system is limited less by what it is, than by what people understand it to be. There is probably no better example of this than the Contractor Inspection System.

It is the author's opinion that the majority of the Army's poor results (see page 8) from CQC are caused by poor system implementation. The author's experience gained at the Libby Project and while researching this subject has led him to conclude that Government construction personnel completely mistrust the new system. Inspection and testing personnel see CQC as a deliberate attempt to eliminate their jobs. They see no other purpose in it. There have not been any significant education or training efforts made to inform construction personnel of their new duties. After nearly a decade since the ASPR regulation was written, the Army has yet to develop any guide or manual on effective use or enforcement of the CQC requirements in the field. This has left management and staff personnel at all levels without sufficient guidance for implementing and trouble-shooting the CQC System. To resolve this, the Army should make and distribute to all concerned personnel a manual including specific problems which might be encountered in implementing or enforcing CQC provisions and possible solutions to these problems. The manual might give Government personnel more confidence in using CQC.

Past experience has indicated that the following important factors must be considered in any system implementation and they are applicable in this case (19).
1. The implementation of any program requires the understanding and unqualified support of senior management and higher authority. In this case, support must be offered with the awareness that the CQC System largely supplants older and more familiar ways.

2. The details of implementation require the close attention of the highest caliber personnel. Any concepts of implementation which are not well thought out will be expensive and ineffectual.

3. Full details of the work to be performed in the new system must be available and fully documented. All relevant documentation, including types of forms, should be available in sufficient quantities so that concerned personnel can have the information readily available.

4. All changes that CQC will bring to the user organization must be planned to coincide with implementation. All details including job descriptions giving precise definitions of each task and responsibility must be worked out. All personnel involved must be informed of any changes in their responsibilities.

5. Training sessions must be held early to insure that everyone involved understands why the
new system is being introduced, and to stress the importance of their cooperation. Emphasis should be placed during training sessions on the objectives of the CQC system, organizational and procedural changes, and the responsibilities of each department or branch. Implementation schedules and the costs and benefits of the new system should be explained.

Sometimes users of a new system are not ready to accept it, or are suspicious of the accuracy or usefulness of the output. This has been the case with CQC. When this occurs, system engineers recommend using "parallel processing" during implementation (19). Parallel processing involves processing current data by both the new and old systems, resulting in two separate outputs which are compared. This offers physically convincing proof that the new system works or does not work. Applying this process to Contractor Quality Control means that during an initial indoctrination period on a new contract the Government will perform complete testing and inspection concurrently with the contractor's CQC staff. If the results show that the contractor's system is adequate, the Government will withdraw to a position of surveillance. This "parallel processing" method is recommended until such time as contractors and Government personnel are fully trained in the new CQC requirements.
Training sessions should emphasize that the CQC System does not threaten the jobs of most Government and inspection personnel. Many of these people will be necessary when Government surveillance is being used. Their services will be required on the critical items whose quality control was reserved as a Government responsibility. They will also be required to perform the random inspection and testing necessary to be sure that the CQC System is performing effectively. As mentioned earlier, the resident engineer's organization has already been severely reduced by budget restrictions. Any surplus inspection or testing personnel should be retrained to fill organization vacancies in other areas. Also, the contractor will be in the market for trained inspection and testing personnel for his CQC staff. This will give displaced persons additional job opportunities.

C. ADDITIONAL BENEFITS OF CONTRACTOR QUALITY CONTROL

With the efficient use of CQC, the contractor will have a real opportunity to improve his competitive position and perhaps increase his profits. A major factor is the decrease in feedback time for information on the quality of output. The results of the CQC operation will be readily available to the contractor's firstline supervisors or foremen who are in the best position to make immediate changes. Opportunities for savings will be increased because the sooner errors are found, the cheaper they are
to correct. Fast correction will decrease construction delays, thereby decreasing labor and equipment standby costs and overhead, and trouble areas can be easily pinpointed and the causes removed to prevent future errors. Reduced delays from the revised shop drawing and submittal procedures will offer increased savings and efficiency.

With the inspection and testing responsibilities being returned to the construction contractors, it will be to their advantage to examine the traditional inspection and testing methods and procedures for possible improvement and savings. Progressive contractors can develop new and cheaper methods and procedures for use on their contracts. One area which has just begun to be applied in construction inspection is the use of statistical sampling methods. The tools for this approach have been available for years but without the continual emphasis on cost reduction common to private industry, the Government agencies have been slow to adopt statistical inspection and test procedures. It is not unreasonable to assume that there are many construction processes for which the same degree of confidence we now get from intensive Government inspection could result from a less costly statistical sampling approach.

Another possibility for savings to a contractor would be for him to evaluate tradeoffs between construction processes and inspection costs. According to Kirkpatrick (20, 19), two interrelated functions are involved in
quality control--"(1) determining the capability of the process to meet specifications, and (2) monitoring processes to assure conformance to specifications." There should be a tradeoff of cost between choosing processes with greater capabilities and therefore more assurance that products meet specifications, and the cost of "rectifying (100%) inspection" (20, 10), which insures quality.

It is possible to use processes which are too exacting. An alternative with less production cost but which results in a higher percentage of defects may be cheaper even after including the costs of rectifying inspection necessary to bring the construction quality to acceptable levels.

There are probably areas where new hardware developments could increase an inspector's productivity. Such recent developments as the nuclear soils testing device for testing soil compaction and the instruments for X-ray inspection of weldaments are examples of this.

New ideas on inspection and testing when approved as part of the contractor's CQC plan would lead to a future reduction in his bid contingency for the CQC responsibilities.

An additional fringe benefit will be that an effective CQC operation which results in good quality work will enhance one of the contractor's most treasured assets, his reputation. A feeling of pride for quality work and increased recognition as a quality-conscious firm is as important to a contractor as it is to any competitor in the free enterprise system.
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VITA

John Scott Treadwell was born May 23, 1942, in Seattle, Washington. He received his primary and secondary education in Seattle, Washington. He received his undergraduate college education and a Bachelor of Science degree in Civil Engineering from the University of Washington in Seattle, Washington, in June 1965.

Mr. Treadwell worked for the Washington State Department of Highways for a period of one year directly upon graduation. In June 1966 he entered the civilian engineer training program offered by the U. S. Army Corps of Engineers. Upon completion of this program he accepted a position at the Libby Dam Resident Engineer Office, Seattle District, U. S. Army Corps of Engineers, located in Libby, Montana. He has been awarded an Outstanding Performance Commendation for his work at Libby.

In November 1969 Mr. Treadwell was nominated by the Libby Resident Office for consideration in the nation-wide selection of personnel to participate in the Army's advanced training program. He was elected to receive this advanced training and entered the Graduate School of the University of Missouri-Rolla in September 1970.

Mr. Treadwell is a Registered Professional Engineer in the state of Montana, No. 3069E, and an Associate Member of the American Society of Civil Engineers.
APPENDIX A

SAMPLE FORMAT OF TYPICAL CONTRACTOR QUALITY CONTROL REPORT

Contractor's Name (Address)

Date: ___________ Report No. ___

Contract No.: _______

Description and Location of work: ________________________________

Weather: (Clear) (P. Cloudy) (Cloudy); Temperature ____

                   Min, ___ Max;       Rainfall ___ inches

Contractor/Subcontractor and Area of Responsibility

  a. ___________________________________________________________________
  b. ___________________________________________________________________
  c. ___________________________________________________________________
  d. ___________________________________________________________________
  e. ___________________________________________________________________
  f. ___________________________________________________________________
  g. ___________________________________________________________________

1. Work Performed Today: (Indicate locations and description of work performed. Refer to work performed by prime and/or subcontractors by letter in table above.)

2. Results of Surveillance: (Include satisfactory work completed, or deficiencies with action to be taken.)

3. Test Required by Plans and/or Specifications Performed and Results of Tests:
4. Verbal Instructions Received: (List any instructions given by government personnel on construction deficiencies, retesting required, etc., with action to be taken.)

5. Remarks: (Cover any conflicts in plans, specifications, or instructions.)

Inspector

CONTRACTOR'S CERTIFICATION: The above report is complete and correct and all material and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as noted above.

Contractor's Approved Authorized Representative
APPENDIX B

SAMPLE PRELIMINARY CONTRACTOR QUALITY CONTROL PLAN

A. C. P. CONSTRUCTION COMPANY, INC.
235 Waterdown Street
Shoreline, Kansas

22 September 1970

Mr. George A. Henry
A. C. P. Construction Company, Inc.
235 Waterdown St.
Shoreline, Kansas

Re: Contract N12345-70-B-1234
Seashore Naval Station

Dear Mr. Henry:

You are hereby appointed to the position of Contractor Quality Control Representative for the above referenced project, and are relieved of all other duties with the company for the duration of that project.

Your duties for this position will be as follows:

1) You will see that the project is built in complete accordance with the contract documents.

2) You will check all materials and equipment before installation in the project.

3) You will make all inspections in accordance with the project specifications.

4) You will perform or have performed all tests required by the project specifications.

5) You will direct the correction or replacement of any work not in conformance with the contract documents.

6) You will assure yourself that all work performed by our company and our subcontractors is in accordance with the contract documents.

7) You will prepare, sign and submit the CQC daily report to the ROICCC on a daily basis.
8) You will coordinate the submission of all shop drawings, certifications, cuts, samples, etc., required by the contract documents to the ROICC on a timely basis.

9) You will coordinate your work with the project superintendent to the maximum extent possible in order to insure a smooth flow of work.

10) You will be present on the site during all phases of construction.

Your authority for this position will be as follows:

1) You will report directly to the vice president in charge of operations.

2) You will have complete authority over all construction superintendents on the project in all areas pertaining to contract requirements.

3) You will represent the company in all dealings with the Navy in regard to the quality of the work and requirements of the contract documents including authority to sign the CQC daily report.

4) Your authority will include whatever measures are necessary, including stopping the work if necessary, to assure compliance with the contract documents.

Sincerely,

I. M. BUILDER
Vice President for Operations
1. Mr. George A. Henry has been appointed as the Contractor Quality Control Representative for the ACP Construction Company, Inc. on the above contract and will be responsible for the supervision and administration of the contractor's quality control plan at the work site. Mr. Henry is 46 years old and has been with our firm for the past 18 years. During this time he has progressed from carpenter foreman to estimator to assistant superintendent to superintendent. Mr. Henry has been one of our outstanding superintendents for the past 10 years and has been in charge of the construction of several large industrial type projects. His last two projects were: Camero Razor Factory addition at $6,500,000 and Blower Glass Works at $6,000,000.

2. See copy of attached letter.

3. U. R. BUILDER
   President

   I. M. BUILDER
   Vice President
   for Operations

   G. A. HENRY
   CQC REP

   B. R. JONES
   Ass't CQC REP

   S. A. SMITH
   Electrical
   Inspector

   D. C. BROWN
   Mechanical
   Inspector

   W. E. TESTUM
   Inspection
   Service Inc.

   KANSAS
   Consultants
   Inc.

   a. Mr. B. R. Jones will be the Assistant CQC representative on the project and will be assigned full time to the work site. Mr. Jones is 30 years old, a graduate Civil Engineer from Kansas Tech. and has been with this firm since his graduation. During his time he has worked as an estimator, materials expediter, and assistant superintendent.

   b. Mr. S. A. Smith will be the electrical inspector for the project. He will work out of our home office in his normal capacity as electrical troubleshooter for the company and will be on the site whenever needed by the CQC Representative. Mr. Smith is a graduate electrical engineer from
Kansas Tech., is 35 years old and has held his present position with this firm for the past five (5) years.

c. Mr. D. C. Brown will be the mechanical inspector for the project. He will work out of our home office in his normal capacity as mechanical troubleshooter for the company and will be on the site whenever needed by the CQC Representative. Mr. Brown is 65 years old and has held his present position with this firm for the past two (2) years. Prior to coming with this firm, Mr. Brown was a Mechanical technician with the Corps of Engineers for 30 years.

4. a. The firm of Kansas Consultants Inc. has been retained to check and approve all shop drawings requiring contractor approval. This firm is well known in the area.

b. The firm of W. E. Testum Inspection Service Inc. has been retained to perform all concrete testing and all density and compaction testing as required by the specifications.
GP-5. TERMINATION FOR DEFAULT--DAMAGES FOR DELAY--TIME EXTENSIONS.

(a) If the Contractor refuses or fails to prosecute the work, or any separable part thereof, with such diligence as will insure its completion within the time specified in this contract, or any extension thereof, or fails to complete said work within such time, the Government may, by written notice to the Contractor, terminate his right to proceed with the work or such part of the work as to which there has been delay. In such event the Government may take over the work and prosecute the same to completion, by contract or otherwise, and may take possession of and utilize in completing the work such materials, appliances, and plant as may be on the site of the work and necessary therefor. Whether or not the Contractor's right to proceed with the work is terminated, he and his sureties shall be liable for any damage to the Government resulting from his refusal or failure to complete the work within the specified time.

(b) If fixed and agreed liquidated damages are provided in the contract and if the Government so terminates the Contractor's right to proceed, the resulting damage will consist of such liquidated damages until such reasonable time as may be required for final completion of the work together with any increased costs occasioned the Government in completing the work.

(c) If fixed and agreed liquidated damages are provided in the contract and if the Government does not so terminate the Contractor's right to proceed, the resulting damage will consist of such liquidated damages until the work is completed or accepted.

(d) The Contractor's right to proceed shall not be so terminated nor the Contractor charged with resulting damage if:

1. The delay in the completion of the work arises from causes other than normal weather beyond the control and without the fault or negligence of the Contractor, including but not restricted to, acts of God, acts of the public enemy, acts of the Government in either its sovereign or contractual capacity, acts of another contractor in the performance of a contract with the Government, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, unusually severe weather, or delays of subcontractors or suppliers arising from causes other than normal weather beyond the control and without the fault or negligence of both the Contractor and such subcontractors or suppliers; and
(2) The Contractor, within 10 days from the beginning of any such delay (unless the Contracting Officer grants a further period of time before the date of final payment under the contract), notifies the Contracting Officer in writing of the causes of delay.

The Contracting Officer shall ascertain the facts and the extent of the delay and extend the time for completing the work when, in his judgment, the findings of fact justify such an extension, and his findings of fact shall be final and conclusive on the parties, subject only to appeal as provided in Clause 6 of these General Provisions.

(e) If, after notice of termination of the Contractor's right to proceed under the provisions of this clause, it is determined for any reason that the Contractor was not in default under the provisions of this clause, or that the delay was excusable under the provisions of this clause, the rights and obligations of the parties shall, if the contract contains a clause providing for termination for convenience of the Government, be the same as if the notice of termination had been issued pursuant to such clause. If, in the foregoing circumstances, this contract does not contain a clause providing for termination for convenience of the Government, the contract shall be equitably adjusted to compensate for such termination and the contract modified accordingly; failure to agree to any such adjustment shall be a dispute concerning a question of fact within the meaning of the clause of this contract entitled "Disputes."

(f) The rights and remedies of the Government provided in this clause are in addition to any other rights and remedies provided by law or under this contract.
GP-9. MATERIAL AND WORKMANSHIP.

(a) Unless otherwise specifically provided in this contract, all equipment, material, and articles incorporated in the work covered by this contract are to be new and of the most suitable grade for the purpose intended. Unless otherwise specifically provided in this contract, reference to any equipment, material, article, or patented process, by trade name, make, or catalog number, shall be regarded as establishing a standard of quality and shall not be construed as limiting competition, and the Contractor may, at his option, use any equipment, material, article, or process which, in the judgment of the Contracting Officer, is equal to that named. The Contractor shall furnish to the Contracting Officer for his approval the name of the manufacturer, the model number, and other identifying data and information respecting the performance, capacity, nature, and rating of the machinery and mechanical and other equipment which the Contractor contemplates incorporating in the work. When required by this contract or when called for by the Contracting Officer, the Contractor shall furnish the Contracting Officer for approval full information concerning the material or articles which he contemplates incorporating in the work. When so directed, samples shall be submitted for approval at the Contractor's expense, with all shipping charges prepaid. Machinery, equipment, material, and articles installed or used without required approval shall be at the risk of subsequent rejection.

(b) All work under this contract shall be performed in a skillful and workmanlike manner. The Contracting Officer may, in writing, require the Contractor to remove from the work any employee the Contracting Officer deems incompetent, careless, or otherwise objectionable.
GP-10. INSPECTION AND ACCEPTANCE.

(a) Except as otherwise provided in this contract, inspection and test by the Government of material and workmanship required by this contract shall be made at reasonable times and at the site of the work, unless the Contracting Officer determines that such inspection or test of material which is to be incorporated in the work shall be made at the place of production, manufacture, or shipment of such material. To the extent specified by the Contracting Officer at the time of determining to make off-site inspection or test, such inspection or test shall be conclusive as to whether the material involved conforms to the contract requirements. Such off-site inspection or test shall not relieve the Contractor of responsibility for damage to or loss of the material prior to acceptance, nor in any way affect the continuing rights of the Government after acceptance of the completed work under the terms of paragraph (f) of this clause, except as hereinabove provided.

(b) The Contractor shall, without charge, replace any material or correct any workmanship found by the Government not to conform to the contract requirements, unless in the public interest the Government consents to accept such material or workmanship with an appropriate adjustment in contract price. The Contractor shall promptly segregate and remove rejected material from the premises.

(c) If the Contractor does not promptly replace rejected material or correct rejected workmanship, the Government (1) may, by contract or otherwise, replace such material or correct such workmanship and charge the cost thereof to the Contractor, or (2) may terminate the Contractor's right to proceed in accordance with clause 5 of these General Provisions.

(d) The Contractor shall furnish promptly, without additional charge, all facilities, labor, and material reasonably needed for performing such safe and convenient inspection and test as may be required by the Contracting Officer. All inspection and test by the Government shall be performed in such manner as not unnecessarily to delay the work. Special, full size, and performance tests shall be performed as described in this contract. The Contractor shall be charged with any additional cost of inspection when material and workmanship are not ready at the time specified by the Contractor for its inspection.

(e) Should it be considered necessary or advisable by the Government at any time before acceptance of the entire work to make an examination of work already completed, by removing or tearing out same, the Contractor shall, on request, promptly furnish all necessary facilities, labor, and material. If such work is found to be defective or non-conforming in any material respect, due to the fault of the Contractor or his subcontractors, he shall defray all the
expenses of such examination and of satisfactory reconstruction. If, however, such work is found to meet the requirements of the contract, an equitable adjustment shall be made in the contract price to compensate the Contractor for the additional services involved in such examination and reconstruction and, if completion of the work has been delayed thereby, he shall, in addition, be granted a suitable extension of time.

(f) Unless otherwise provided in this contract, acceptance by the Government shall be made as promptly as practicable after completion and inspection of all work required by this contract. Acceptance shall be final and conclusive except as regards latent defects, fraud, or as regards the Government's rights under any warranty or guarantee.
GP-67. SHOP DRAWINGS.

The Contractor shall submit to the Contracting Officer for approval six copies of all shop drawings as called for under the various headings of these specifications. These drawings shall be complete and detailed. If approved by the Contracting Officer, each copy of the drawings will be identified as having received such approval by being so stamped and dated. The Contractor shall make any corrections required by the Contracting Officer. If the Contractor considers any correction indicated on the drawings to constitute a change to the contract drawing or specifications, notice as required under the clause entitled "Changes" will be given to the Contracting Officer. Five sets of all shop drawings will be retained by the Contracting Officer and one set will be returned to the Contractor. The approval of the drawings by the Contracting Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Approval of such drawings will not relieve the Contractor of the responsibility for any error which may exist as the Contractor shall be responsible for the dimensions and design of adequate connections, details, and satisfactory construction of all work.

(1) When reproducible shop drawings are required by the specifications, the following provision shall be added to the clause above:

Upon the completion of the work under this contract, the Contractor shall furnish a complete set of reproducibles of all shop drawings as finally approved. These drawings shall show all changes and revisions made up to the time the equipment is completed and accepted.

(2) If reproducible shop drawings are not required by the specifications, the following provision shall be added to the clause above:

Upon the completion of the work under this contract, the Contractor shall furnish two complete sets of prints of all shop drawings as finally approved. These drawings shall show changes and revision made up to the time the equipment is completed and accepted.
GP-98. PROPOSED MATERIAL SUBMITTALS REQUIRED OF THE CONTRACTOR.

Proposed material submittals required of the Contractor all be made allowing sufficient time for processing, reviews, approval, and procurement before the contractor is ready to use the material. No material shall be used prior to written approval. Submittals shall be prepared and assembled as follows:

(a) Submit 7 copies of each submittal.

(b) Present all submittals for each specification section as a complete bound volume, titled with project title and contract number.

(c) Provide index of included items with each volume. Title the index with applicable specification section name and number.

(d) Clearly mark each item in volume with specification paragraph number to which it pertains.

(e) Assemble each volume in same numerical sequence as specifications section paragraphs.

(f) See individual technical sections for additional information.

The Contractor shall certify on all submittals that the material being proposed conforms to contract requirements. In the event of any variance, the Contractor shall state specifically which portions vary, and request approval of a substitute. The Contractor shall also certify that all Contractor-furnished equipment can be installed in the allocated spaces. Incomplete submittals and submittals with inadequate data will be rejected.