

# Quality Management System for Concrete Construction

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*This document provides guidance for the development and implementation of quality systems for concrete construction projects. The system involves the identification of quality objectives and their incorporation into the quality plan, which is implemented by project participants. The system is intended to allow user judgment with respect to the owner's needs; the defined quality objectives; the project size, importance, and complexity; and the skills of the project organizations involved.*

*This document follows the ANSI/ISO/ASQC Q9000 Series of Quality Management Standards, which are also very similar to the auto industry QS 9000 Standards.*

**Keywords:** acceptability; concrete construction; evaluation; inspection; quality plans; quality systems; structural design.

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Reference to this document shall not be made in contract documents. If items found in this document are desired by the Architect/Engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the Architect/Engineer.

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### CHAPTER 1—INTRODUCTION

#### 1.1—Scope and purpose

This document provides guidance for the development and implementation of a quality system for concrete construction projects. It is based on the ISO 9000 Quality Systems Standards requirements. With the exception of management responsibility and servicing, all elements of ISO 9001 are mentioned briefly. Under the ISO system, where the committee has used the word “should,” ISO uses “shall” to make these requirements mandatory. The imposition of ISO would make the requirements mandatory. This document does not establish project work relationships. The project contract documents will define the owner/project team relationship and govern the performance of these parties through the duration of the project. This document is a management tool intended to facilitate successful interaction among project team members.

This guide will accommodate projects that vary in size, complexity, and number of organizations. On a large project, it is important that all major organizations involved develop a quality plan with appropriate elements. On a small project, a single overall quality plan and the contract documents may suffice.

#### 1.2—Definitions

The definitions given in this section are taken from American National Standards Institute/International Organization for Standardization/American Society for Quality (ANSI/ISO/ASQ) A8402-1994.

**1.2.0 Quality**—The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs.

**1.2.1 Quality assurance (QA)**—All the planned and systematic activities implemented within the quality system and demonstrated as needed, to provide adequate confidence that an entity will fulfill requirements for quality. There are both

internal and external purposes for quality assurance. Internal quality assurance, within an organization, provides confidence to management. External quality assurance, in contractual or other situations, provides confidence to the owner or others (such as building code officials or government agencies).

**1.2.2 Quality control (QC)**—Operational techniques and activities that are used to fulfill the requirements for quality. It involves operational techniques and an activity aimed at both monitoring a process and at eliminating causes of unsatisfactory performance at all stages in order to result in economic effectiveness.

**1.2.3 Quality plan**—Activities that establish the objectives and requirements for quality. It usually is project specific and makes reference to the quality manual.

**1.2.4 Quality policy**—A statement of an organization's objectives and commitment to quality.

**1.2.5 Quality system**—The organizational structure, responsibilities, procedures, processes, and resources needed to assure that an organization's quality objectives are met. As used in this document, the quality system is spearheaded by the owner and consists of the owner's internal policies and procedures for contracting, the (project) quality plan, and the quality manuals implemented by the project team.

**1.2.6 Quality manual**—A document that states company policy and describes the quality system of an organization.

**1.2.7 Contractor**—A supplier in a contractual situation.

**1.2.8 Owner**—The organization that is responsible for the project. The term encompasses the agents of the owner (such as project/construction manager, engineer, architect, quality consultant, and others) who have been delegated some responsibility. The word “owner” is used since that is the term used by ISO-9001. Many ACI documents use the term “owner.” The owner is the recipient of the product.

**1.2.9 Product**—A product is the result of activities or processes. It may include service, hardware, processed materials, software, or a combination thereof.

**1.2.10 Procedure**—A specified way of doing an activity. Note:

- In many cases, procedures are documented.
- When a procedure is documented, the term “written procedure” or “documented procedure” is frequently used.
- A written procedure usually contains the purpose and scope of an activity; what shall be done and by whom; when, where, and how it shall be done.

**1.2.11 Subcontractor**—Organization that provides a product to a supplier (contractor).

**1.2.12 Supplier**—Organization that provides a product to the owner.

### CHAPTER 2—ADMINISTRATIVE ASPECTS OF A QUALITY SYSTEM

#### 2.1—Responsibilities of the owner

The owner is responsible for establishing a quality system, which includes selecting competent organizations and individuals. If the owner does not have the skills or personnel, or

**Table 2.1—Elements of a quality system**

DOCUMENT	CONTENTS	ORGANIZATION(S) RESPONSIBLE FOR DEVELOPMENT OF DOCUMENTS
Quality Plan, Chapter 3	<ul style="list-style-type: none"> <li>• Owner's policy statement</li> <li>• Quality objectives</li> <li>• Scope of work</li> <li>• Organizational relationships</li> <li>• Authority/responsibilities of various organizations</li> </ul>	Owner or designated project manager
Quality Manual with Elements, Chapter 4 and 5	<ul style="list-style-type: none"> <li>• Elements applicable to that organization's scope of work</li> <li>• Program</li> <li>• Implementing procedures</li> </ul>	All organizations required by the owner to develop a Quality Manual

**Table 2.2—Development of a quality system by project phase and responsibilities**

Project phases	Quality system phase	Source of quality requirements or reference guidance	Responsible review organization and action
Planning and definition of requirements	Owner* develops project quality plan	Owner, project manager, consultant, engineer, and this document	Owner review and approval is required if project quality plan was developed by another organization
Design	Designer develops quality manual	Owner's project quality plan and this document	Owner or project manager reviews and approves designer quality manual
Procurement	Owner or project manager, or both, develops procurement procedures	Owner, project manager, designer, contractor, and this document	Owner, project manager, designer, and contractor jointly review procurement procedures
Construction	Construction contractors develop and submit contractor quality manual	Any combination of owner's project quality plan, contract documents, and this document	Owner, project manager, and designer review contractor's quality manual
Material testing	Testing laboratory develops and submits a material testing quality manual	Any combination of owner's project quality plan, contract documents, and this document	Owner, project manager, designer, or contractor review material testing laboratory's quality manual

\*Indicates owner or his designated project manager who may be the architect, engineer, construction manager, general contractor, or quality consultant.

both, required to fulfill these responsibilities, the owner should designate an organization or individual to perform these functions. Table 2.1 describes the elements of a quality system.

## 2.2—Characteristics of a quality system

Table 2.2 indicates the various phases of a project and how the quality system is developed. These phases make up the life cycle of the project. The table also indicates responsibilities of the organizations involved. It should be modified to fit the specific organizational arrangements and quality objectives for the project.

The quality system is viewed in terms of information flow between project organizations and interaction among individuals in the project team. Information flow and management of information is the lifeblood of the project, essential for achieving effective interaction among project personnel. Appendix A explains the relationship of process flow and the hierarchy of documents.

This quality system ensures that project information flow is relevant, accurate, consistent, and timely. The project benefits because:

- standards of performance are established;
- areas of responsibility are specified;
- decision points are identified;
- appropriate follow-up, actions, and decisions are delineated;
- criteria for project performance and assessment are provided.

The arrangement of a quality plan into discrete project phases is not intended to imply that project phases do not overlap. Additionally, activities at a given phase may require that a new activity be initiated that relates to an earlier phase. Therefore, the boundaries between project phases are not sharply defined.

Each construction activity is unique because of the different and varying conditions, and requirements associated with each project. Additionally, an individual activity must comply with cost, safety procedures, and code and regulatory

requirements. Efficiency improves when a construction project is conducted with well-defined plans and detailed procedures.

The recommendations, in each phase, provide an overview of the quality principles and necessary elements to ensure that a coordinated quality plan is implemented for the project.

### 2.3—Initial project and preconstruction meetings

To facilitate communication among project organizations, the identification, responsibility, and authority for interaction and exchange of information among the project teams should be established. Good communications are the hallmark of a quality project. All members of the project team should communicate frequently their expectations and anticipated problems. Open and frank discussions are essential. Plan for frequent meetings.

Once the project team has been assembled, a meeting chaired by the owner is recommended. The agenda should be distributed prior to the meeting. The meeting should include the owner or the owner's representative, design professionals, contractors, principal subcontractors, testing agencies, and representatives from regulatory agencies.

After the project meeting, the contractor should chair a similar preconstruction meeting attended by subcontractors, materials suppliers, vendors, and other suppliers that support the contractor. The design professional may be invited to attend, but generally only as an observer or a source of information for the contractor. The meeting procedure and agenda items are similar to the initial project meeting, but particular emphasis is placed on performance of the contractor's team and commitment to the project. This is the phase where a review of such items as plans, specifications, unique requirements, and submittals is made and discussed to ensure that all parties are committed to the same quality assurance goals.

Both meetings should develop common goals and lines of communication for the participants involved in the project. Minutes of both meetings should be kept and distributed in a timely manner to all attendees by the chairman or a designee.

Critical interface and authority issues (such as who can authorize the addition of water to concrete) should be decided upon. Contingency authority delegation should be established in the event that the originator authority is not available.

## CHAPTER 3—QUALITY PLAN

The project quality plan documents the owner's quality objectives and should be developed early in the project. As a minimum, the plan should include the following elements:

- owner's policy statement;
- Quality objectives and expectations;
- Scope of the plan;
- Organizational relationships and interfaces;
- Authority and responsibilities of organizations and contractors;
- A description of the quality manual those organizations are required to establish and implement.

As a project goes through the phases outlined in [Table 2.2](#), the plan may change. The owner and the project team should periodically review and, if necessary, update the plan during the life of the project. Updated copies of the plan should be provided to all affected organizations. Verification of implementation of changes should be conducted.

## CHAPTER 4—QUALITY MANUAL

### 4.1—Elements

Each organization assigned responsibility in the plan should detail in a quality manual the methods used to meet the owner's quality objectives stated in the plan. The quality manual should include those elements described in Chapter 5 as appropriate to their scope of work. A quality manual will normally contain or refer to, at a minimum:

- Quality policy;
- The responsibilities, authorities, and interrelationships of the personnel who manage, perform, verify, or review work-affecting quality;
- The procedures, such as quality system procedures, design procedures, and construction procedures;
- A statement about reviewing, updating, and controlling the manual.

A quality manual can vary in depth and format to suit the needs of the organization.

### 4.2—Responsibilities of the project team

A listing of quality manual elements that should be addressed by each project organization is shown in [Table 4.1](#). A similar table should be developed by the owner or the owner's designee in the project quality plan. Each organization shown in the table should develop their own manual. Typically, these manuals, once developed, would serve more than one project.

### 4.3—Quality policy

Management with executive responsibility should define its policy for quality, including objectives for quality and its commitment to quality. The quality policy should be relevant to the owner's goals and the expectations. Management should ensure that this policy is understood at all levels of the organization.

### 4.4—Organization responsibilities

The quality manual should define the organizational structure, responsibility, and authority of personnel and organizations that manage, perform, verify, or review work affecting quality. This should include designation of the person or organization responsible for management and direction of quality assurance.

### 4.5—Management representative

The design professional or contractor's management, or both, with executive responsibility should appoint a member of their own management who, irrespective of other responsibilities, should have defined authority for ensuring that a quality manual is established, implemented, and maintained in accordance with the contract.

**Table 4.1—Elements of a quality manual**

Element	Supplier, Architect, Engineer	Supplier, Contractor	Subcontractor	Subcontractor, Material Supplier	Material Testing Laboratory
Quality policy	X*	X	X	X	X
Organization responsibilities	X	X	X	X	X
Contract review, Section 5.2	X	X	X	X	X
Design control, Section 5.3	X	—	—	—	—
Document and data control, Section 5.4	X	X	X	X	X
Purchasing, Section 5.5	X	X	X	—	—
Control of owner-supplied product, Section 5.6	X	X	X	—	—
Product identification and traceability, Section 5.7	—	X	X	X	—
Process control, Section 5.8	X	X	X	X	X
Inspection and testing, Section 5.9	—	X	X	X	X
Control of measuring and test equipment, Section 5.10	X	X	X	X	X
Inspection and test status, Section 5.11	—	—	—	—	X
Control and nonconforming product, Section 5.12	X	X	X	X	X
Corrective and preventive action, Section 5.13	X	X	X	X	—
Handling and storage, Section 5.14	—	X	X	X	—
Control of quality records, Section 5.15	X	X	X	X	X
Internal quality audits, Section 5.16	X	X	X	X	X
Training, Section 5.17	X	X	X	X	X
Statistical techniques, Section 5.18	X	X	X	X	X

\*An “X” indicates that the organization should have a section in their quality manual addressing the scope of responsibility (such as review, approve, comment, reject) for that element.

## CHAPTER 5—QUALITY MANUAL ELEMENTS

### 5.1—Quality system procedures

The project team members should:

- prepare procedures consistent with the requirements of the contract and the owner’s stated quality policy, and
- effectively implement the quality system and its procedures.

### 5.2—Contract review

The supplier and any subcontractor should have a documented procedure for reviewing bids or accepting a contract. The purpose of this procedure is to ensure that the scope of work is clearly defined and the supplier and any subcontractor has the capability to meet the contract.

### 5.3—Design control

The design professional should establish and maintain procedures to control and verify the design of the product in order to ensure that the specified requirements are met.

### 5.4—Document and data control

The project team members should establish and maintain procedures to control all documents and data that relate to the requirements of the contract including, to the extent applicable, documents of external origin such as standards and owner’s drawings.

Document control is critical to a project’s success to ensure that the latest revisions of drawings and specifications are used in the execution of the work.

### 5.5—Purchasing

The project team members should establish and maintain procedures to ensure that purchased products conform to specified requirements. These requirements apply only to those responsible for purchasing permanent building materials or equipment.

The selection of a supplier should be based on an evaluation of the supplier’s capability to process materials in accordance with the requirements of contract documents and to deliver the materials at a rate consistent with the project schedule. The evaluation should include review of the supplier’s history of performance, a review of appropriate documentation for objective evaluation, and a determination of the supplier’s technical capability. For concrete production facilities, certification by National Ready Mix Concrete Association (NRMCA) procedure is recommended. For precast concrete production facilities, certification by the Precast/Prestressed Concrete Institute (PCI) is recommended.

### 5.6—Control of owner-supplied product

The supplier should have documented procedures for control of verification, storage, and maintenance of owner-supplied product.

### 5.7—Product identification and traceability

Where appropriate, the supplier should establish and maintain procedures for identifying the product by suitable means from receipt and during all stages of production, delivery, and installation.

Where and to the extent that traceability is a specified requirement, the subcontractor or supplier shall establish and

maintain procedures for unique identification of individual product or batches. This identification should be recorded.

### 5.8—Process control

The supplier should identify and plan the production and installation processes, which directly affect quality. They should ensure that these processes are carried out under controlled conditions. Controlled conditions include the following:

- Procedures defining the manner of production and installation where the absence of such procedures could adversely affect quality;
- Use of suitable production and installation equipment and suitable working environment;
- Compliance with reference standards/codes, quality plans, or documented procedures, or all three;
- Monitoring and control of suitable process parameters and product characteristics;
- Approval of processes and equipment, as appropriate;
- Criteria for workmanship, which should be stipulated in the clearest practical manner (i.e., written standards, representative samples, or illustrations);
- Suitable maintenance of equipment to ensure continuing process capability;
- Qualifications of personnel that will be assigned to the project.

### 5.9—Inspection and testing

The supplier should establish and maintain procedures for inspection and testing activities in order to verify that the specified requirements of the product are met. The required inspection and testing, and the records to be established, should be detailed in the quality plan or procedures. Materials testing should be performed by a laboratory accredited according to the requirements of ASTM C 1077.<sup>4</sup>

Minimum requirements for inspection of all construction operations should be defined and inspection should follow the guidance of ACI 311.4R, and ACI SP-2.<sup>5</sup> Inspectors should have appropriate certification per ACI. Minimum requirements may include inspection of the formwork system, the proper installation of reinforcing steel, the concrete quality as evidenced by required tests, verification of operations and facilities of production, concrete placements, and curing. Other considerations that could be included are reshore and form removal requirements, repair work, core drilling, sampling and testing, weather conditions, bonding and jointing, leveling and alignment operations, finishing operations, grouting operations, and protective coating operations. Periodic photographs documenting construction sequence, job progress, and construction details are desirable.

### 5.10—Control of measuring and test equipment

The supplier and subcontractor should establish and maintain procedures to control, calibrate, and maintain inspection, measuring, and test equipment (including test software) used by the supplier to demonstrate the conformance of the product to the specified requirements. Inspection, measuring, and test equipment should be used in a manner that

ensures that the measurement uncertainty is known and is consistent with the required measurement capability.

### 5.11—Inspection and test status

The inspection and test status of the product should be identified by suitable means that indicate the conformance or nonconformance of the product with regard to inspection and tests performed. The identification of inspection and test status should be maintained, as defined in the quality plan or procedures, or both, throughout production and installation of the product to ensure that only products that have passed the required inspections and tests (or released under an authorized concession) are dispatched, used, or installed. ACI 311.4R and 311.5R contain detailed recommendations for the inspection of concrete construction.

### 5.12—Control of nonconforming product

The supplier should establish and maintain procedures to ensure that products that do not conform to specified requirements are prevented from unintended use or installation. This control should provide for identification, documentation, evaluation, segregation (when practical), disposition of nonconforming products, and for notification, as required in the project quality plan.

Categories of dispositions are as follows:

- Repair: the process of restoring an item to an acceptable condition even though the repaired item may not comply with the original requirements;
- Rework: the process of restoring an item to the original requirement;
- Accepted as is: a nonconforming condition that, after evaluation, is determined to satisfy requirements, including those of performance, maintainability, fitness for use, and safety;
- Reject: a disposition that indicates an item is unsuitable for its intended purposes and cannot be economically reworked or repaired. The item should be segregated or removed and replaced.

Repaired or reworked items should be reinspected. Because repaired items may not comply with the original requirements, criteria for the acceptability of the repair should be furnished to the individual or team performing the inspection. Reworked items should be inspected in accordance with the original requirements.

### 5.13—Corrective and preventive action

Corrective action request: Significant nonconformance of a recurring nature, that indicates a system problem should be addressed in a corrective action request. Determining the root cause of such conditions, as well as the appropriate corrective actions, should preclude future similar nonconforming conditions.

The supplier should establish and maintain procedures for implementing corrective and preventive action. Any corrective or preventive action taken to eliminate the causes of actual or potential nonconformities shall be to a degree appropriate to the magnitude of problems and commensurate

with the risks encountered. Changes to the procedures resulting from corrective and preventive action should be implemented and recorded.

#### 5.14—Handling and storage

Procedures for handling and storage should be established as required by the contract.

#### 5.15—Control of quality records

Procedures for identification, collection, indexing, access, filing, storage maintenance, and disposition of quality records should be established. Quality records should be maintained to demonstrate conformance to specified requirements and the effective operation of the quality system. The following is a list of some of the records and documents that may be applicable:

- Contract documents;
- Procedures;
- Personnel qualification records;
- Design drawings and calculations;
- Specifications;
- Procurement documents;
- Material qualification records;
- Field sketches and working drawings;
- Change orders;
- Technical reports and photos;
- Inspection and test records;
- Nonconformance reports;
- Concrete mixture proportions and delivery tickets;
- Placing drawings;
- As-built drawings;
- Contractor's log books.

Generally, the minimum storage requirement is 3 years after the project has received final acceptance. If the owner requires a longer period, it should be specified.

#### 5.16—Internal quality audits

Quality audits should be scheduled on the basis of the status and importance of the activity to be audited and should be carried out by personnel independent of those having direct responsibility for the activity being audited. The design professional, contractor and other project team members may have a procedure for internal quality audits. Such a procedure is a requirement for ISO 9001.

Companies certified by ANSI/ISO/ASQC 9001, QS9001, NRMCA, and PCI are subject to external audits on an annual basis, if not more frequently.

The owner should establish and maintain procedures for planning and implementing external quality audits to verify whether quality activities and related results comply with planned arrangements and to determine the effectiveness of the quality system. Use of companies subject to independent external audits such as ANSI/ISO should reduce the frequency and extent of external audits by the owner.

#### 5.17—Training

The supplier should establish and maintain procedures for identifying training needs and provide for the training of all personnel performing activities affecting quality. Personnel performing specific assigned tasks should be qualified on the basis of appropriate education, training, experience, or all three, as required. Appropriate records of training should be maintained.

The American Concrete Institute certification programs should be used to establish qualifications for concrete construction inspectors, concrete craftsmen, and laboratory technicians.

#### 5.18—Statistical techniques

The supplier should identify the need for statistical techniques required for establishing, controlling, and verifying process capability and product characteristics.

ACI 318 requires the use of statistics to establish mix proportions or conservative assumptions are required (ACI 318-95, Section 5.3.3.2 and 5.4). ACI 214 provides the method of evaluation of strength testing.

The owner should ensure that the concrete supplier is furnished copies of all concrete test reports.

### CHAPTER 6—REFERENCES

#### 6.1—Cited and recommended references

The documents of the various standards-producing organizations referred to in this document are listed below with their serial designation:

##### *American Concrete Institute (ACI)*

SP-2	ACI Manual of Concrete Inspection
116	Standard Specifications for Tolerances for Concrete Construction and Materials
214	Recommended Practice for Evaluation of Strength Testing of Concrete
311.4R	Guide for Concrete Inspection
311.5R	Batch Plant Inspection and Field Testing of Ready Mix Concrete
318	Building Code Requirements for Structural Concrete
303	Standard Specification for Cast-in-Place Architectural Concrete

##### *American Society of Testing and Material (ASTM)*

ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 1077	Practice for Laboratories Testing Concrete and Concrete Aggregates

##### *ANSI/ISO\*/ASQC†*

ISO 8402:1994	Quality Management and Quality Assurance Vocabulary
ISO 9000-1: 1994	Quality Management and Quality Assurance Standards—Part 1: Guidelines for Selection and Use
ISO 9001	Quality Systems—Model for

	Quality Assurance in Design/Development, Production, Installation, and Servicing
ISO 9002	Quality Systems—Model for Quality Assurance in Production, Installation, and Servicing
ISO 9003	Quality Systems—Model for Quality Assurance in Final Inspection and Test
ISO 9004-1	Quality Management and Quality Systems Elements—Guidelines

\*ISO = International Organization for Standardization.

†ASQC = American Society for Quality Control.

*National Ready Mix Concrete Association (NRMCA)*  
NRMCA Quality Control Manual, Section 3: Certification of  
Ready Mix Concrete Production Facilities

*Prestressed/Precast Concrete Institute (PCI)*  
PCI Prestressed Concrete Institute Quality Control Manual

#### *ACI Certification Programs*

ACI Concrete Field Testing Technician Grade I  
ACI Concrete Laboratory Technician Grades I & II  
ACI Concrete Construction Inspector  
ACI Concrete Craftsman

The above references may be obtained from the following  
organizations:

American Society for Quality Control (ASQC)  
611 East Wisconsin Avenue  
P.O. Box 3005  
Milwaukee, WI 53201-3005  
Phone: (414) 272-8575  
Fax: (414) 272-1734

National Ready Mix Concrete Association (NRMCA)  
900 Spring Street  
Silver Spring, MD 20910  
Phone: (301) 585-1400  
Fax: (301) 585-4219

Precast/Prestress Concrete Institute  
175 West Jackson Blvd.  
Chicago, IL 60604  
Phone: (312) 786-0300  
Fax: (312) 786-0353

American Society of Testing and Materials (ASTM)  
100 Barr Harbor Drive  
West Conshohocken, PA 19428-2959  
Phone: (610) 832-9693  
Fax: (610) 832-9555

American Concrete Institute (ACI)  
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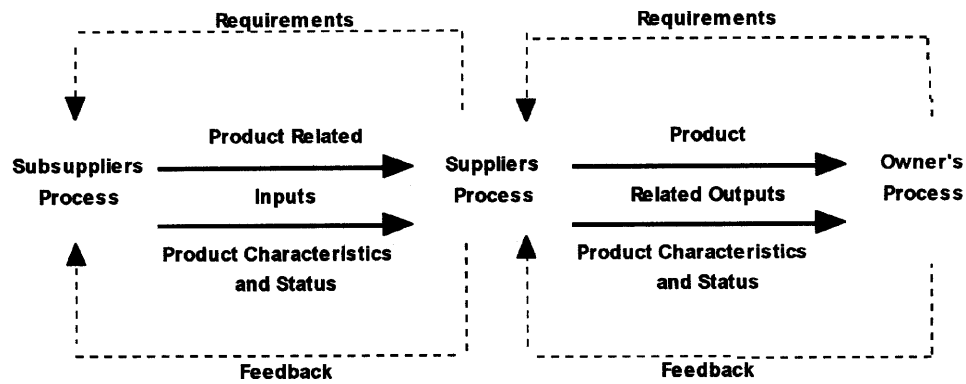


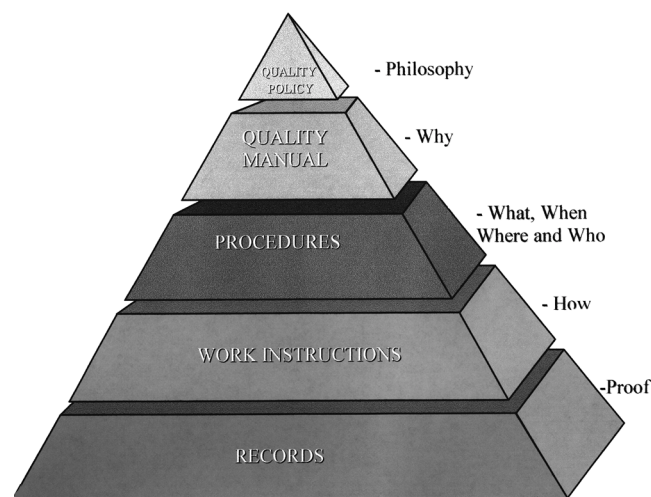
Fig. 1—Flow chart of "process."

### APPENDIX A — ISO CONCEPTS

A quality system is based on the concept that all work is a process. Every process has inputs and outputs. This provides an opportunity to make measurement of the inputs and outputs at various places in the process. Examples of inputs and outputs are:

TYPE	EXAMPLE
<u>Product related</u>	<ul style="list-style-type: none"> <li>• Raw materials</li> <li>• Intermediate product (concrete)</li> <li>• Sample product</li> <li>• Final product</li> </ul>
<u>Information related</u>	<ul style="list-style-type: none"> <li>• Product requirements</li> <li>• Product characteristics</li> <li>• Measurement data from sampled product</li> <li>• Feedback on performance</li> </ul>

In flowchart form, the process is shown in Fig. 1.



The pyramid can best illustrate the relationship of policy, organization, and procedures.

The ISO Quality Management System provides a framework around which an organization can build its organization.

As of January 6, 1996, there were 130,000 ISO certificates awarded worldwide and 91 countries have adopted ISO as their choice of quality management certification. There were more than 20,000 certified companies in the U.S. as of January 1998.